Article

Systematic Stakeholder Inclusion in Digital Agriculture: A Framework and Application to Canada

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Abstract: This study provides a model that supports systematic stakeholder inclusion in agricultural technology. Building on the Responsible Research and Innovation (RRI) literature and attempting to add precision to the conversation around inclusion in technology design and governance, this study develops a framework for determining which stakeholder groups to engage in RRI processes. We developed the model using a specific industry case study: identifying the relevant stakeholders in the Canadian digital agriculture ecosystem. The study uses literature and news article analysis to map stakeholders in the Canadian digital agricultural sector as a test case for the model. The study proposes a systematic framework which categorises stakeholders into individuals, industrial and societal groups with both direct engagement and supportive roles in digital agriculture. These groups are then plotted against three levels of impact or power in the agri-food system: micro, meso and macro.

Keywords: digital agriculture; inclusion; stakeholder; RRI; ecosystem; innovation; identification; categorisation

1. Introduction

Agricultural production is deeply entangled within social, economic, environmental, cultural and technological systems. It is believed that digital agriculture will deliver benefits to society [1] and stakeholder inclusion can ensure these benefits are equitable to a broader range of society avoiding favouring already powerful stakeholders [2]. As noted in the introduction to this special issue, there are profound concerns about the social sustainability of agriculture, especially with regard to social and economic divides related to the commercialisation of farming. The transition to so-called “digital agriculture” [3] amplifies such concerns, potentially exacerbating inequities in the food system by creating divisions in access to or skill with computational technologies. Developing practices and policies that take into consideration the social and equity concerns of technological transitions in agriculture will require the meaningful inclusion of the perspectives of a diverse and inclusive group of stakeholders affected by the digital transition.

The field of Responsible Research and Innovation (RRI) has developed theory and methods relevant to the inclusion of stakeholders in innovation processes but it is arguably underdeveloped in its application to the agri-food context [4,5].

Responsible Research and Innovation (RRI) is defined as achieving mutual responsiveness between societal actors and innovations before (rather than after the fact of) commercialisation [6]. From a societal perspective, innovative technologies are capable of changing the social conditions of the environment in which they operate [7]. RRI thus places emphasis on neglected ethical considerations in the ecosystem context, such as inequalities [8]. Rooted in societal concerns and a desire to anticipate the implications of
Based on their review of the RRI literature, Eastwood et al. [4] outline the conceptualisation of RRI into two main frameworks. The first framework encompasses the four principles of anticipation, inclusion, reflexivity and responsiveness which are also known as the AIRR framework. This framework is sometimes complemented with the fifth principle of transparency [4]. The second framework encompasses five elements: societal actor engagement, gender equality, open access, ethics, and science literacy and education. This framework is also sometimes complemented with the sixth element of governance [4].

The concept of engaging with a wide range of stakeholders is highlighted in this latter approach as a prerequisite to identifying and accommodating public concerns throughout the development process, and this then is best captured by the principle of inclusion [10]. The concept of inclusion and societal actor engagement both refer to stakeholders—where inclusion is leaning towards individual and commercial stakeholders—and societal actors’ engagement which leans towards ecosystem-level stakeholders.

In this paper we apply the term “stakeholders” to refer to both elements of innovation and societal actors’ engagement, which appear within the two RRI frameworks outlined by Eastwood et al. [4]. The concept of inclusion in the RRI literature is arguably more comprehensive than in other similar bodies of theory such as corporate social responsibility; this is in part because within RRI often stakeholder inclusion is meant to indicate attention to marginalised rights holders [8]. Yet, the conceptualisation of inclusion still needs further clarification in the literature to serve the various ways that societal stakeholders engage with technologies as well as various forms of stakeholder [5]. Justice, for example, is highlighted in recent studies as essential for the full characterisation of inclusive and responsible innovation [11].

Building on the Responsible Research and Innovation (RRI) literature and aiming to add precision to the conversation around inclusion in technology design and governance, this study aims to develop a framework for determining which stakeholder groups to engage in RRI processes. We developed the model using a specific industry case study: identifying the relevant stakeholders in the Canadian digital agriculture ecosystem. Being among the global leaders in digital agriculture [12], Canada has a fast developing digital agriculture ecosystem, and thus can be expected to have representation from most relevant stakeholder groups. Our study provides a foundation for systematic inclusion of a diversity of stakeholder groups by developing a framework for stakeholder identification and testing it against the Canadian context.

2. Responsible Research and Innovation and Stakeholder Inclusion

While RRI is intended to guide the development and introduction of responsible innovations [10], recent studies suggest there is more work needed to specify what we mean by the inclusion of stakeholder perspectives [4]. The literature emphasises the necessity of an exchange of views on the direction of technology development among stakeholders [7]. In some cases, studies outline the democratic but also the practical potential in collaboration among stakeholder groups—researchers, advisers and farmers—arguing that deliberation will enhance the chance of successful adoption of digital agricultural technologies [13]. However, there is little concrete guidance as yet concerning how in RRI processes one might identify the relevant stakeholders for interaction, which is arguably a precondition of inclusion.

While we acknowledge that in practice engagement of stakeholders has become more common in policymaking [4], our review shows that a systematic process or framework for stakeholder identification and inclusion remains to be clearly outlined. There is a tendency in the current literature to offer solutions for the mechanism of engagement with stakeholders rather than, as a first step, offering a means to identify and systematically categorise different stakeholder groups. The mechanisms currently highlighted for engagement include workshops, user-centred design, forums, embedding social scientists within
inter-disciplinary projects, and meeting with stakeholders [1,4,5,14,15]. Carolan [16] has also noted that there is no method to follow when it comes to stakeholder identification in ecosystems other than “heterogeneous assemblage” [16]. To some extent, this may be a function of the heterogeneous nature of stakeholders in agriculture ecosystems [2,17,18]. Across several agricultural contexts, scholars have adopted snowballing techniques to identify stakeholders from early identification of most obviously relevant stakeholder groups [3,14–16,19–21]. Such an exploratory method is argued to facilitate the development of broad-based inclusion [15].

We build on existing guidance in the RRI literature in this paper, synthesising the literature (see Table 1) into a three-level hierarchical approach to stakeholder identification and analysis: micro, meso and macro. These levels correspond broadly to the economic and decision-making power of each stakeholder group. We combine this with a multi-thematic approach that categorises stakeholder groups into themes such as technical, social, and organisational themes [14]. Both of these are discussed in the following paragraphs.
| Reference | Research Domain | Methods & Geography | Research Objectives | Key Stakeholder Groups |
|-----------|-----------------|---------------------|---------------------|------------------------|
| Andrieu et al. (2019) [14] | Co-designing systems | Interviews, Workshops Honduras | To present a seven-phase methodology to allow family farmers to co-design and adopt climate-smart agriculture (CSA) | Thematic categorisation - Technical - Social - Organisational |
| Busse et al. (2014) [18] | Innovation mechanisms | Interviews, Delphi Two-step survey Germany | Identification of barriers of the innovation processes | Themes with sub-categories: - Farmers/contractors - Input suppliers: agricultural engineering companies, seed companies, agrochemical industries - Public/private services: financial services, soil sampling, yield mapping - Intermediates: unions, associations, media - Public and private research institutions and universities - Federal state departments and agricultural federal institutes - Public and private agricultural advisory |
| Carolan (2018a) [22] | Socio-economic, governance | Interviews Consumer focus groups U.S. | How Big Data techniques and technologies govern our ability to imagine food worlds. | Thematic categorisation - Products - Retail - Habitus |
| Reference                  | Research Domain                        | Methods & Geography                              | Research Objectives                                                                                                    | Key Stakeholder Groups                                                                 |
|---------------------------|---------------------------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Carolan (2020a) [16]      | Innovation pathways Governance         | Interviews Field notes from participant observations U.S. and Canada | How to better incentivise adoption                                                                                     | Heterogenous assemblage:<br>  • Programmer<br>  • Engineer<br>  • Firm Leadership, e.g., CEO/Vice President/Director<br>  • Crop Specialist<br>  • Agronomist<br>  • Computational Biologist<br>  • Statistician<br>  • Farmers |
| Carolan (2020c) [23]      | Innovation political economy           | Interviews U.S.                                  | Whether/how the digital signifier affects issues related to symbolic and material gentrification And land.            | Heterogenous assemblage:<br>  • Farmer<br>  • Community organiser<br>  • Investor<br>  • Gadgets Entrepreneur:<br>  • Tech start-up<br>  • Restauranteur<br>  • Planner<br>  • Politician<br>  • Developer<br>  • Real estate agent |
| Eastwood et al. (2017)    | Innovation system                      | Interviews Australia                             | To identify potential collaboration<br> To enhance innovation system functions.                                         | Hierarchical categorisation:<br>  • Farm level<br>  • Near farm<br>  • Global scales |
| Eastwood et al. (2019b)   | Responsible research and innovation    | Interviews New-Zealand                          | To what extent, and why, have elements of RRI been considered to date to address socio-ethical challenges in NZ smart dairying development?<br> What are the broader lessons for RRI application in smart farming? | Heterogenous assemblage:<br>  • Economics and Viability<br>  • Environment<br>  • Skilled people<br>  • Lifestyle and business<br>  • Community acceptance and connection<br>  • Animal welfare<br>  • Technology performance and infrastructure |
| Reference                  | Research Domain                        | Methods & Geography | Research Objectives                                                                 | Key Stakeholder Groups                                      |
|---------------------------|----------------------------------------|---------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------|
| Fielke et al. (2019) [15] | Agricultural innovation systems (AIS)  | Interviews Australia| How do innovation communities perceive technology and policy in relation to a socio technical transition toward the digitalisation of the Australian AIS? | • Culture • Markets • Industry • Technology • Policy • Science |
| Higgins & Bryant (2020) [21] | Governance                             | Interviews Australia| (1) how do meso-scale actors frame smart farming technology implementation (2) in what ways do those frames variously afford and/or constrain industry sovereignty over how technological change is implemented? | Heterogenous assemblage: • Agri-service providers • Agronomists • Consultants • Extension agents • Managers • Researchers |
| Klerkx et al. (2012) [17] | Innovation system Relation with policy and institutional | Conceptual No specific location | (1) evolution of systemic approaches to agricultural innovation (2) assessing key factors for innovation system performance (3) formulating an agenda for future research. | Thematic categorisation • Environment: Social, Political, Economic, Agro-climatic • Innovators • Farmers • Scientists |
| Klerkx et al. (2017) [25] | Co-innovation                           | Interviews, Document analysis, Interactive working session Denmark, France, Germany, Netherlands | (1) how do different institutional conditions at different levels in four European countries influence the enactment of a shared set of participatory principles and methods by researchers and advisers working in the same international project? (2) how do differences and similarities in institutional conditions matter for the design of large international participatory research projects? | Hierarchical categorisation • Personal • Community and organisation • National agricultural innovation system (AIS) |
| Regan (2019) [1]         | Socio-economic, governance              | Interviews Ireland | Risks and benefits arising from the development of Smart Farming | Thematic categorisation • Subjective: Agtech Industry, Farming Representative • Mandated: Government/Policy, Support Agency • Objective: Social Scientist, Computer Scientist, Agricultural/Food Scientist |
Table 1. Cont.

| Reference       | Research Domain          | Methods & Geography         | Research Objectives                                                                 | Key Stakeholder Groups                      |
|-----------------|--------------------------|-----------------------------|-------------------------------------------------------------------------------------|---------------------------------------------|
| Wolfert et al.  | socio-economic challenges| Conceptual                  | (1) What role does Big Data play in Smart Farming?                                 | Heterogenous assemblage:                    |
| (2017) [26]     |                          | No specific location        | (2) What stakeholders are involved and how are they organised?                     | • AgBusiness                                |
|                 |                          |                             | (3) What are the expected changes that are caused by Big Data developments?         | • AgTech players                            |
|                 |                          |                             | (4) What challenges need to be addressed in relation to the previous questions?     | • Data start-ups                            |
|                 |                          |                             |                                                                                   | • Farming Alliances                         |
|                 |                          |                             |                                                                                   | • Farming cooperatives                       |
|                 |                          |                             |                                                                                   | • Farms                                     |
|                 |                          |                             |                                                                                   | • Tech companies                            |
|                 |                          |                             |                                                                                   | • Tech-start ups                            |
|                 |                          |                             |                                                                                   | • Venture capital                           |

Table developed by the authors 2020.
2.1. Hierarchical Categorisation

The hierarchical approach has been applied to capturing the stage of innovation within an RRI context [27], and in studies with ecosystem orientation in non-RRI bodies of work such as social innovation [28]. Typically, this approach refers to the three levels of micro (individual), meso (institutional) and macro (socio-political and macroeconomic) levels of analysis.

Micro-level stakeholder analysis is addressed in many studies on digital agriculture [3,18,29]. Emphasising the role of micro-level stakeholders, Phillips et al. [30] argue there is a strong bottom-up effort in researching digital agriculture innovations that are largely isolated from the global innovation ecosystem. Scholars acknowledge the importance of micro-level stakeholders. Rose et al. [7] assert that micro-level stakeholders such as farmers are the centre of change in the digitalisation of agriculture. Others highlight farmers’ pivotal role in the adoption of digital agriculture innovations [2,31]. Despite their proactive role in innovation, the literature highlights how micro-level stakeholders are often omitted in the meso and macro level considerations. For example, scholars such as Bronson [29] point out a tendency among government-level stakeholders to invest in large-scale innovations driven by private sector which thus fail to support digital agriculture innovations suitable to or serving micro-level stakeholders.

Meso-level stakeholder analysis relates to service and other enabling stakeholders and is concerned with firm-level interactions and processes [28]. The meso-level includes industrial stakeholders such as consultants who are involved in the planning and implementation of digital agriculture [21], companies that are specialised in data management, as well as stakeholders such as regulatory and policy actors [26]. From a farm risk management perspective, farm advisories are considered by scholars to be a main stakeholder group [4]. From a leadership perspective, Stilgoe et al. [9] emphasise the role of research councils as key stakeholders in developing and implementing RRI principles and processes. From a service perspective, Busse et al. [18] remark on the role of service providers such as distributors and agriculture input providers. The meso-level is argued to be associated with inter-level interactions among stakeholders, particularly between meso- and micro-level stakeholders like farmers [32]. To overcome the differences among stakeholders, Higgins and Bryant [21] argue the necessity of understanding the stakeholders’ negotiation processes and how stakeholders are connected at meso-level in an RRI context.

Macro-level stakeholders are the top-level stakeholders with the most power to effect change in the agri-food system such as governmental agencies and macro-level institutions like the World Bank [33]. Fielke et al. [15] argue that digital innovations need to be addressed as a component of an overarching context at the macro-level of analysis. Based on their subject of analysis, some studies outline the importance of macro-level stakeholders for the overall innovation ecosystem. For example, in the context of managing macro-level socio-ethical challenges, Eastwood et al. [4] argue for the leadership role of the government and other (macro-) top-level actors such as funding bodies to embed RRI and influence the R&D activities and innovation processes to enhance stakeholder engagement. [30] highlight the roles of government in generating policies and engaging in regulation. The role of institutions is argued to be crucial for the implementation of innovation platforms, strategy development and adoption processes [14]. The role of government is also discussed in terms of regulating access to data and privacy concerns [26,30].

While existing studies on digital agriculture include micro-, meso- and macro-level stakeholder analysis, the terms used to refer to these levels show variation even while the meanings remain consistent (see Table 1). For example, Eastwood et al. [24] applied a three-level hierarchical framework to analyse the role of private-public stakeholders. Their framework includes farm-scale analyses which spell out the interests of micro-level stakeholders, such as one-to-one training and advisory services for farmers. The near-farm analysis level spells out meso-level stakeholders such as service providers. The global scale analyses address the general adequateness of technology in farming systems. Eastwood et al. [24] explain the role of the public in a way that captures macro-level
stakeholders’ interests. In the context of co-innovation in agriculture, Klerkx et al. [25] apply a three-level hierarchical framework that includes a personal level encompassing micro-level stakeholders; a community and organisation level that encompasses meso-level stakeholders; and a national level that compasses the macro-level stakeholders. Although the framework developed by Klerkx et al. [25] can be applied to categorise stakeholders, their focus remains at the broader level of the agriculture sector in general, not digital agriculture specifically. Andrieu et al. [14] apply three dimensions—technical, social and organisational—in discussing co-design of digital agriculture systems with local stakeholders. The study includes three thematic dimensions concerning the interests of the three stakeholder groups, two of which can be listed according to the three hierarchical levels. The technical and organisational dimensions refer to meso-level stakeholders and the social dimension discuss micro-level implications for farmers. The study of Andrieu et al. [14] does not include macro-level stakeholders as the authors focus on local stakeholder engagement, and it does not expand to spell out technical and organisational stakeholders.

2.2. Thematic Categorisation

Reviewing the literature reveals that rather than the three-level approach we develop in this paper there is instead a methodological approach of thematic categorisation adopted more commonly. In this approach, themes are selected based on heterogenous assemblage, but similar stakeholders are categorised into relevant themes, such as technical, social and organisational [14]. For example, applying the RRI approach, identifies three thematic groups of subjective, mandated and objective stakeholders for digital agriculture. Carolan [22] identifies products, retail and habitus, and Fielke et al. [15] apply markets, industry, technology, policy and science categories. In terms of the taxonomy of themes, similar to the three levels of hierarchy, the same variation in terminology is observed for this categorisation of stakeholders. For example, studies such as [4,15,21–23,26] have all provided a list of involved stakeholder groups for their studies, but they do not apply similar labels to groups that might be considered similar. In particular studies such as [1,17,18] group stakeholders into themes but label the themes differently. We build on this literature to adopt a three-level thematic approach for the proposed framework where similar stakeholders are grouped into the same thematic category.

3. Framework and Discussion

The stakeholder inclusion framework presented here has two dimensions. The basis is a distinction between three types of stakeholder groups—individuals, industry and ecosystem stakeholders—and more specifically, for each group we distinguish stakeholders with direct engagement in digital agriculture and those with supportive roles. The framework then highlights that each stakeholder group may have impacts on one of three levels—micro, meso and macro. The framework is presented in Figure 1 (numbers in brackets show results from the validation case study presented below).
Figure 1. Framework for Systematic Stakeholder Inclusion. Figure developed by the authors 2020.

3.1. Individual Stakeholders
3.1.1. Micro-Level Impact

The first category of the model includes individual stakeholder groups with micro-level impact like farmers, programmers, engineers, innovators, computer scientists, and investors. Farmers represent key individual stakeholders with a direct interest and engagement in digital agriculture but with limited impact on the current innovation ecosystem. In the context of digital technologies, compared with other stakeholders, farmers are usually considered among the least powerful stakeholders. At the same time, in the literature, farmer impact is analysed and discussed at the farm level as being the baseline of technology adoption [4]. In the context of adoption, the farmer’s role is acknowledged as an impediment since digital agriculture innovation may be resisted by farmers who are reluctant to adopt [4]. This group of stakeholders face several challenges. For instance, to an extent, it is said that digital agriculture innovations may be substituting farm labourers [8]. Based on a set of survey studies, Bronson [29] concluded that despite the potential of digital agriculture, not all farmers are enthusiastically engaging with digital innovations. It is suggested that due to the deskilling of humans [34], farmers are losing degrees of decision-making capability in reference to digital agriculture. In some countries, this group is argued to have a tense relationship with other digital agriculture stakeholders such as private companies [4] or to have a lack of awareness that impacts the adoption of digital agriculture [35]. Ref [2] outlined farmers’ challenges as overlapping decisions between commercial, biophysical limits and new farm practices. Despite their currently marginal power status, the literature highlights the necessity of farmers’ inclusion in different aspects of digital agriculture within the RRI approach.

Other stakeholder groups of this category include customers, programmers, engineers, innovators and investors. Similar to farmers, these stakeholders have a micro level of impact. For example, while customers’ values are considered the optimum goal of chain systems [26], there is no clear method developed for customer inclusion outside of market based strategies like focus groups which concentrate on the goal of private gain/commercial success. Hence, we categorise consumers among stakeholders with supporting roles and not among those with direct engagement in digital agriculture. Investors are increasingly required to consider the ethical and societal concerns of other stakeholders in their decision-making [28]. Individual investors can have an impact on meso-level stakeholders such as

| Micro Level | Meso Level | Macro Level |
|-------------|------------|-------------|
| Farmers     | Ag. Scientists | Lobbyists  |
| Programmers | Computer Scientist | Politicians |
| Engineers   |                      | Economists |
| Innovators  |                      | Social Scientists |
| Customers   |                      | International competitors |
| Food retailers |                      | Finance (6/41) |
| Other retailers (cannabis) |                      |  |
| Co-operatives |                      | Academia (5/43) |
|                     |                      | Government / Policy (44/108) |
|                     |                      | Government-International (54/7) |
|                     |                      | International Institution (2/13) |
|                     |                      | Media (5/29) |

Note: Stakeholder Group
by funding new digital agriculture start-ups [26], yet we argue the impact of the private investor will remain at the micro level as it is less likely this group of stakeholders can make a vast and diversified investment that has an impact on the sector at meso level. Another stakeholder group of the meso level includes innovators. Innovators are argued to not always receive a proportionate return on their efforts [30]. Nevertheless, investors and innovators are gaining importance in the RRI approach [27]. Engineers and other expert individuals such as software developers have a recognised role in developing digital agriculture innovations [16,18]. Although the inclusion of individual experts in the RRI approach is imperative [8], we argue their impact stays within the micro level, namely at the farm level, as their scientific efforts are largely dictated by firm level goals and commitments [29].

3.1.2. Meso-Level Impact

In the category of individuals with meso-level impact, stakeholders such as individual consultants and firm leadership have more direct engagement and interest in digital agriculture. Although the literature highlights the role of all level of mangers as important for RRI [11], case studies are centred on the role of senior-level executives and middle managers in digital agriculture [22]. Scholars such as Carolan [16] use the term “leadership” to refer to this group of stakeholders. Farm managers are argued to be responsible for production [36] and thus have the power to leverage the capability of digital technologies towards a digital transformation in agriculture [16]. The main challenge facing this stakeholder group in the RRI context is to make long-term projections towards environmental and social practices and set RRI Key Performance Indicators (KPIs) to monitor outcomes [37]. Independent consultants and farm advisors are individual meso-level stakeholders with a recognised role in managing digital agriculture uncertainties [21]. Scholars posit this group ought to lead responsible innovation and thus they have to be involved in discussions on the future of digital agriculture [5].

Certain researchers are described as having meso-level impact—those which contribute to defining policies on the farm [14]. These actors are recognised as those that can change the focus of the industry such as the recent shift from innovation adoption research that prioritises the agency of farmers [7]. With the expansion of participatory processes in digital agriculture, academic researchers can understand and outline the associated implications and provide a platform for RRI exercises and thus the input of a host of stakeholders [4]. Further, to interact with other stakeholders, researchers are expected to transform their identities, roles and routines and develop new skills to be effective in these contexts [25]. Another stakeholder group in this category includes agricultural and computer scientists. These stakeholders are involved in knowledge and technology development [38], including in developing solutions for testing and monitoring specialised aspects of farm monitoring such as on fertilisers and nutrients [36]. There is currently a call for bottom-up, self-governing science and laboratory practice that may lead to further impact among this group [29]. We argue at present, without the support of other stakeholders such as policymakers, the impact of these stakeholders cannot reach to the macro level.

3.1.3. Macro-Level Impact

Our analysis of news articles and literature (Table 1) did not yield individual stakeholders with macro-level impact. However, we list lobbyists as possible stakeholder groups falling into the category of individual stakeholders with direct engagement in digital agriculture. The role of lobbyists is recognised in food-related industries in terms of creating legitimacy [24], influencing societal agendas and advocating particular technological solutions [17]. Thus, the impact of this group of stakeholders can expand to include macro-level influence. The role of lobbyists in digital technologies likely includes work on sensitive issues such as the labour market, as well as the migrant/immigrant workforce, in agriculture [39]. Scholars often highlight the negative impact of lobbyists as a possible abuse of power by this group in areas such as genetically modified organ-
isms (GMOs) [26]. Politicians are a group of individual stakeholders concerned with and having power over macro-level interests in areas such as public health [40], hence they have a supportive role in our framework. The acceptance of politicians, together with NGOs and users, is argued to be vital for digital agriculture expansion [41]. In the same category, economists are another group that did not appear in our analysis of the news, but we know from other technological areas related to agri-food that economists play a role in identifying RRI-related issues such as inequalities in the ecosystem [42] as they outline the future outcomes of technology-led societal changes [43]. Thus, we argue that economists are an important group that needs to be taken into account in the innovation ecosystem. Certain key researchers that point out concerns regarding the impact of digital agriculture on the inclusion of marginalised stakeholders can play a role in highlighting the macro-level political and economic concerns that influence digital agriculture development and implementation [21]. Policy-relevant sociologists or researchers are thus included in our model.

3.2. Industrial Stakeholders

3.2.1. Micro-Level Impact

Food retailers are the first category of industrial stakeholders with direct engagement and interest in digital agriculture and micro-level impact. Despite their potential role in supporting and promoting digital agriculture [21,31], industry experts consider these groups of stakeholders rather unimportant [18]. While the application of digital technologies, such as big data analytics, is well-discussed in agriculture, consumption and retail have lagged behind [22,44] and their impact remains limited to the micro level. This stakeholder group can provide support for consumption and customer inclusion by providing platforms for sharing views [30] and thus they ought to be integrated in RRI discussions.

3.2.2. Meso-Level Impact

Our analysis shows the vast majority of stakeholder groups are industrial stakeholders with meso-level impact. Stakeholders of this category were extracted from the news analysis.

The category of industrial stakeholders with meso-level impact and direct engagement in digital agriculture activities includes many large enterprises. These stakeholders are sometimes referred to as service providers with direct interest and engagement in digital agriculture [18]. These actors play a key role in digital agriculture and their activities are considered central. For example, field experts outline agricultural enterprises with agriculture technology as the most important stakeholder groups for leading innovations in the field [18]. However, these often-large agriculture enterprises are sometimes criticised for exploiting their market dominance to promote the adoption of certain technologies at the expense of smaller enterprises [4,8,18]. This power seems to be rooted in the particular infrastructure of the agriculture sector; it is argued most of the agri-food infrastructure-like storage facilities, processing and transportation in the developed countries, including Canada, are designed to serve large-scale production [40]. This has resulted in the dominance of the large agri-food players who can control the ecosystem and veto change [30,40]. Hence, including these large stakeholders in discussions with other stakeholder groups, such as farmers, is required to exchange feedback and to reach a mutual understanding in the field [8,18], yet may represent particular challenges with regards to trust and disclosure of trade secret information.

The meso-level category also includes stakeholders such as agriculture enterprises that focus on mass-producing or acquiring crops as commodity and commercialisation activities. Agriculture equipment enterprises are stakeholders that provide machinery used at different stages of digital agriculture. Agricultural input suppliers are considered a traditional stakeholder group [26] that provide the necessary inputs such as fertilisers, pesticides, chemicals, seeds, crops and livestock care and who advise on the needed tools and technologies for production as well as other aspects of digital agriculture.
equipment and machinery are increasingly becoming digitally connected and act as a source of data collection for planning [16,26]. Hence, this stakeholder group is gaining more importance in policy-related discussions such as food security and sustainability [26]. However, scholars also note digital or “precision” equipment is becoming too complex for many farmers in the existing farming system [2]. Agriculture technology stakeholders also includes enterprises that provide digital technologies such as sensors, data processing solutions, big data analytics, global positioning systems (GPS), map and image processing theologies. Several consultancy companies assist industry with the different skills required by digital agriculture practice on issues that can influence other stakeholders [4]. The role of consultancy companies is regarded as intermediary in the translation and exchange of knowledge for problem-solving and innovation [17]. Compared to research organisations, advisory services are considered to create institutional contexts that are conducive to co-innovation with other stakeholders [25]. However, digital agriculture is transforming the role of consultancy companies and exposing them to new challenges in proving effective supports to farmers [21]. Consultancy enterprises are now required to deliver advisory services based on information and knowledge at the farm level in its local-specific context [26]. This role transformation is argued to be a challenging process [45] that consequently may impact other stakeholders.

The other industrial stakeholder with meso-level impact are companies that do not directly engage in digital agriculture activities but provide the necessary support required for the success of the digital agriculture ecosystem. This group includes food manufacturers, wholesalers, venture capitalists and insurers. Food manufacturers, similar to other stakeholders like retailers, are adopting digital technologies and innovation to collect data on consumption patterns [46]. While the customer becomes more aware and sensitive towards issues like GMOs, it is argued that digital agriculture serves this interest by enabling more food traceability and transparent production [1]. Thus, this group of stakeholders links the interest of social and societal stakeholders with stakeholders on the industrial and production side. Consequently, this can empower and engage micro-level stakeholders such as consumers with other groups [1]. One possible challenge for agri-food producers is the availability of machinery that may not be optimally tuned to local needs and expectations which can, in turn, mitigate their social value [30]. Due to their role in linking different stakeholders and supporting societal values, we advocate for including this group in an RRI approach. At the same level, the category of supportive actors includes Information Technology (IT) solutions groups which provide applied technologies to digital agriculture and IT infrastructure groups that provide the required infrastructures of IT services. Since most of the digital agriculture technologies and innovation rely on IT-based platforms, the role of these enterprises becomes vital in this field [47]. Technology and specifically Information and Communication Technologies (ICT) are considered a priority topic in the agri-food sector [1]. Aspects such as open-source ICT development, data movement between platforms and protection of farmer privacy are deemed crucial in the RRI context [4]. The wholesale stakeholder group represents an enormous buying power in the ecosystem. It is argued that wholesalers can grow to form monopsony conditions where only a few powerful buyers leverage their bargaining power over less powerful stakeholders such as farmers [19]. Thus, including this group of stakeholders becomes necessary for RRI practice. Venture capitals are considered another key stakeholder in the digital agriculture ecosystem [1]. Venture capitalists, in addition to funding digital agriculture businesses [30], play a role in ensuring the interests of other stakeholder groups such as investors and social stakeholders [27]. Scholars posit venture capitalists are now increasingly interested in investing in agriculture technology companies [26] and we argue this group play a crucial role in the field and must be included as a key stakeholder group. Insurance companies or insurers is another stakeholder group with a supportive role. Insurers supports digital agriculture by developing information-based business models for risk management [3]. They also play a role in data acquisition and sharing as well as alliances with international insurers [30].
3.2.3. Macro-Level Impact

In the category of industrial stakeholders with macro-level impact, we listed international competitors as stakeholders with direct engagement in digital agriculture and finance enterprises as stakeholders with supportive roles. International competition is considered a motive for innovation [18] as it can lead to product development and innovation pipelines [48]. However, although international competitors represent a powerful macro-impact on the entire ecosystem, scholars argue that in the long-term the main competition remains at the micro level/local level over land, labour and capital [30]. In the context of competition, participation in an RRI approach can be beneficial for competitors and environmental analysis [11]. And due to international competitors’ roles in shaping local competition, we included this group of stakeholders in our proposed model. Finance stakeholders play a central role in funding digital agriculture projects. Our news analysis yielded stakeholders like banks and investing agencies. Scholars assert that digital agriculture needs large capital investments that can influence the adoption decision [1,31]. Capital can substitute framers’ knowledge and downgrade their role on the farm [2]. From this perspective, this group’s activities have social implications with macro-level impact and we argue for including this group.

3.3. Societal Stakeholders

3.3.1. Micro-Level Impact

The category of stakeholders with societal objectives and direct engagement in digital agriculture includes cooperatives. The role of cooperatives is acknowledged in supporting local growers and workers, and also helping farmers connect produce to local markets [49]. From this perspective, we argue their impact is limited to micro-level analysis. The category of micro impact and mandated stakeholders with a supportive role includes actors such as community organisers and animal welfare advocates. Both stakeholder groups are argued to be often neglected in digital agriculture discussions [4]. Hence, we include them in our proposed model and call for better inclusion of these stakeholders in the RRI approach in digital agriculture.

3.3.2. Meso-Level Impact

The category of stakeholders with meso-level impact and direct engagement in digital agriculture includes associations, farming representatives and science and technology development agencies. Our literature analysis did not yield adequate discussions of the role of associations. One possible reason for this dearth of coverage in the literature suggests associations are not involved in innovation activities and rather pursue other mandated interests of their respective stakeholders [18]. However, since this group of stakeholders is directly engaged in digital agriculture by representing the interest of industrial players, we advocate including it in the RRI stakeholder inclusion model. Farming representatives have a direct engagement in digital agriculture and possess experiential knowledge of the topic [1]. The inclusion of this group is considered pivotal for future discussions about the direction of the industry and the exchange of views with other stakeholder groups [7].

At the same level, Non-Governmental Organisations (NGOs) are considered a stakeholder group with a supportive role. However, this group did not emerge from the analysis. NGOs are known to play a facilitating role in securing other stakeholders’ interests [14] and this group can question the RRI processes and advocate for societal interests [27]. Based on their objectives and characteristics, the impact of NGOs can vary from micro level [14] to macro level [28]. NGOs are among the stakeholders that can influence the success of digital agriculture [41]. Thus, we consider NGOs a key stakeholder group and list them in the meso-level analysis in the proposed stakeholder categorisation model. Since the impact of NGOs is size-sensitive, not every NGO can influence the macro-level discussion. On the other hand, those that have such capacity can be considered an international institution and would be placed in the macro-level category.
3.3.3. Macro-Level Impact

Our analysis did not capture societal stakeholders with direct engagement in digital agriculture at the macro level. This could be due to the political–economic structure of Canada. Yet, the macro-level category includes mandated stakeholders with a supportive role such as government and policy stakeholders, academia, media and international institutions. Academia and other research institutes are concerned with delivering long-term and fundamental research and are considered the most important among the non-firm stakeholders [18]. In developed countries, academia in collaboration with the other ecosystem’s stakeholders such as political actors is expected to contribute to the development of technological and social innovation [50]. Government and policy stakeholders represent a wide range of players. These stakeholders are considered to be capable of providing strategic insight into digital agriculture [1]. Thus, in the context of an RRI approach to digital agriculture, there is a necessity of policy leadership [4]. This leadership role is concerned with facilitating policies and mechanisms, engaging in privacy and regulation issues and providing cybersecurity at the national level [30]. However, despite having a democratic mandate to ensure societal wellbeing, biased investment practice by government stakeholders has been shown to be promoting large-scale industrial farming at the expense of other food production strategies and actors [8]. This bias is due to the influence of industry stakeholders such as designers and scientists on the government and funding agencies compared to the influence of stakeholders outside the industry [29]. On the other hand, governmental practice in areas such as environmental protection laws or product and process traceability can spur innovation in digital agriculture [18].

Media are involved in public inclusion activities by linking digital agriculture with wider public stakeholders [4]. In recent years, due to advances in telecommunication technologies, the traditional concept of media is transforming towards more interactive platforms of communication like social media. There is evidence that big data acquired through social media analysis and web cookie tracking are applied to model patterns of behaviour, consumption, views and opinions on sensitive societal issues such as elections [51]. Some digital agriculture stakeholders have already developed methods for food marketing and managing consumer interests through social media analysis [46]. Scholars argue that these data practices may lead to privacy and ethical concerns by non-media stakeholder groups like consumers and the government [29]. Thus, we argue that the impact of this group can influence the entire ecosystem.

In the same category, two groups of international government and international institutions represent macro-level stakeholders with supportive roles. The importance of including foreign governments lies in their impact on international institutions and international competition, and this is especially true for countries like the United States of America (USA) that wield considerable global power. Hence, we argue for including these governments as a stakeholder group. International institutions include stakeholders such as the Intergovernmental Panel on Climate Change are recognised as enhancing innovation in the agriculture context [17]. These stakeholders have interests that transcend the national level to include global-level issues such as the demand for a more just and sustainable food system [52]. While these stakeholders influence digital agriculture, the expansion of digital agriculture is also transforming the role and power leverage of these institutions [3]. In the context of responsible innovation, these institutions are now often required to move beyond compliance with established regulation to cover international objectives such as global warming and climate change [14]. We argue that a powerful stakeholder like the European Union (EU) can have an impact on the entire ecosystem of digital agriculture in non-European countries by demanding a higher level of standards in business transactions that set a standard for practice elsewhere. Thus, we advocate the inclusion of this group in the stakeholder categorisation model.
4. Application: Canada’s Digital Agriculture Stakeholders

4.1. Application Context

To validate the framework and exemplify its application, we present the case of digital agriculture stakeholders in Canada.

At present, Canada is acknowledged as a leading country in terms of efficiency of digital agriculture [12], and Canadian farms are among pioneer farms from the USA, Europe, Australia and China in embedding digital technologies in agriculture [53]. The Government of Canada has approached the application of digital technologies in agriculture as a driver for societal wellbeing [54], which suggests that one can expect even greater development of digital agriculture practices in Canada over the coming years. Further, the Canadian government is currently supporting research relating to the next wave of digital technologies, including Artificial Intelligence (AI) with substantial investments, relating to agriculture. The application of “responsible” AI has been recently highlighted at the top level of policymaking in Canada [55] but with less guidance on what this means in practice. This type of guidance is expected to incorporate societal values, needs and expectations [4]. In the context of digital agriculture, these may include solutions to issues such as privacy, use and ownership of information; sustainability; human-related concerns such gender, minorities, justice, human values, power and control concerns; and impact on international relation concerns [4]. Solutions necessitate pressing efforts to inform policymakers, funders, technology companies and researchers about the perspectives of a wide variety of stakeholders towards digital agricultural innovations. These social forces on policy and industry efforts are argued to be beneficial at both productivity and efficiency, and ecological levels [31].

4.2. Application of Materials and Methods

The focus of the case study is to identify the main stakeholders in the Canadian digital agriculture ecosystem and align them with the framework presented above. To this effect, we analysed the news coverage of digital agriculture in Canada with the purpose of identifying organisational stakeholders, applying natural language analysis methods.

The base data set is extracted from the news data base Factiva (Available online: http://www.factiva.com/sources/facts.asp (accessed on 20 September 2020)), using keyword searches related to digital agriculture. Factiva is a leading database including worldwide, full-text coverage of news [56], and it includes both leading national newspapers and smaller regional publications. Print media remain an important avenue of public discourse and continue to be utilised for discourse analysis and similar text-based studies [57].

We focused on digital agriculture news published by Canadian media over the last 10 years. This timeframe reflects the emergence of digital agriculture within the past decade [12]. The timeframe covered the period of 1 January 2010 to 20 September 2020 (the date of performing the query). The query yielded 2581 results, 843 of which were duplicate news articles and 1698 articles were unique.

To extract the key organisational stakeholder, we apply text mining algorithms provided by Factiva to extract the most cited entities within the results. A summary of the top 100 entities is given in Table 2. The entities were manually reviewed in their related news contexts to ensure their relevance to digital agriculture. At this stage, two entities were removed.
Table 2. Media Analysis Results—Canadian Digital Agriculture Stakeholders.

| Entity                                           | Freq. | Entity                                         | Freq. | Entity                                                   | Freq. | Entity                                                   | Freq. |
|--------------------------------------------------|-------|-----------------------------------------------|-------|----------------------------------------------------------|-------|----------------------------------------------------------|-------|
| Agrium Inc                                       | 421   | Land O’Lakes Inc                              | 12    | United States Department of Agriculture Western Economic Diversification Canada | 8     | The Bank of Nova Scotia                                  | 5     |
| AgJunction Inc                                   | 329   | University of Guelph                         | 12    | Brock University                                         | 8     | European Union                                           | 5     |
| Nutrien Ltd.                                     | 134   | GVIC Communications Corp                      | 11    | Canadian National Railway Company                        | 7     | Innovation, Science and Economic Development Canada    | 5     |
| Bee Vectoring Technologies International Inc.    | 104   | Mitsui & Co Ltd                              | 11    | Canadian Space Agency                                    | 7     | Canada                                                  | 5     |
| Deveron Corp.                                    | 80    | Raven Industries Inc                         | 11    | Dalhousie University                                     | 7     | Novozymes A/S                                            | 5     |
| Braingrid Ltd.                                   | 71    | Accenture PLC                                | 10    | ICL Group Limited Intergovernmental Panel on Climate Change | 7     | OmniEarth, Inc.                                          | 5     |
| Government of Canada                             | 44    | Clean Seed Capital Group Ltd.                 | 10    | Innovation, Science and Economic Development Canada      | 7     | Ontario Securities Commission                           | 5     |
| Monsanto Company                                 | 43    | NovAtel Inc                                  | 10    | Inovia                                                   | 7     | PartnerRe Ltd.                                           | 5     |
| UrtheCast Corp                                   | 35    | Glacier Media Inc                            | 10    | Input Capital Corp.                                       | 6     | AGCO Corporation                                        | 4     |
| Association of Equipment Manufacturers            | 27    | Trimble Inc                                  | 10    | Pond Technologies Holdings Inc.                          | 6     | The Andersons Inc                                        | 4     |
| Agriculture and Agri-Food Canada                 | 23    | China Ministry of Commerce                   | 9     | Namaste Technologies Inc.                                | 6     | Beijing Unistrong Science & Technology Co., Ltd.        | 4     |
| The Climate Corporation                          | 23    | Buhler Industries Inc                        | 9     | RBC Dominion Securities Inc DuPont de Nemours Inc        | 6     | Calian Group Ltd.                                        | 4     |
| Deere & Company                                  | 23    | Affinor Growers Inc                         | 9     | Intrinsyc                                                  | 6     | Cargill, Inc.                                            | 4     |
| Competition Bureau Canada                        | 21    | Patent and Trademark Office                  | 9     | DigitalGlobe Inc.                                         | 6     | Draganfly Inc.                                           | 4     |
| Novariant Inc                                    | 20    | Avrio Capital Inc                            | 9     | Draganfly Inc.                                           | 6     | Export Development Canada                               | 4     |
| Bayer AG                                         | 18    | Ag Growth International Inc                  | 8     | Netafim Ltd.                                              | 6     | Hexagon AB                                               | 4     |
| Federal Trade Commission                        | 17    | Arab Potash Co Ltd                           | 8     | Health Canada                                               | 6     | Environment Protection Agency                           | 4     |
| BASF SE                                         | 16    | Canadian Radio-television and Telecommunications Commission | 8   | Merrill                                                   | 6     |                                                           |       |
| Transport Canada                                 | 16    | Farms.com, Ltd.                              | 8     | Netafim Ltd.                                              | 6     |                                                           |       |
| Village Farms International, Inc.                | 16    | Mahindra & Mahindra Ltd.                     | 8     | CNH Industrial N.V.                                       | 6     |                                                           |       |
| Kleiner Perkins Caufield & Byers                 | 16    | Sociedad Quimica y Minerade Chile SA         | 8     | Rocky Mountain Dealerships Inc.                          | 6     |                                                           |       |
| University of Saskatchewan                      | 15    |                                               |       | McGill University                                         | 6     |                                                           |       |
|                                                 |       |                                               |       |                                                           |       |                                                           |       |
Table 2. Cont.

| Entity Freq. | Entity Freq. | Entity Freq. | Entity Freq. |
|--------------|--------------|--------------|--------------|
| PreveCeutical Medical Inc. | 13 | Toronto-Dominion Bank | 8 | WeedMD Inc. | 6 | Ontario Ministry of Agriculture, Food and Rural Affairs | 4 |
| Natural Sciences and Engineering Research Council of Canada | 13 | Thompsons Limited | 8 | American Vanguard Corporation | 5 | Itafos | 4 |

Table developed by the authors 2020.

Subsequently, the stakeholder inclusion framework presented above was applied to all stakeholders, labelling each stakeholder with the appropriate category. In a final step, for each stakeholder group the number of stakeholders in the data set, as well as the frequency of their mentions, were added up and included in the brackets in Table 1. For example, the agricultural equipment stakeholder group—Ag Equipment (12/98)—comprised 12 companies in the data set, which were mentioned a total of 98 times in the ten years in the news articles that digital agriculture covered.

It is important to note that the media analysis method is only designed to identify organisational stakeholders, and as such the columns representing individuals are not captured.

4.3. Application of the Framework

As evident from the numbers in Table 1, the stakeholder inclusion framework presented encompasses all stakeholders identified through the media analysis. The framework serves to demonstrate that the media analysis captures the main stakeholder groups active in digital agriculture. It also highlights that not all smaller stakeholders are captured. This finding is aligned with insights from the literature, namely that smaller stakeholders do not receive the same coverage as big commodity-crop firms [8].

The frequency with which each stakeholder group is mentioned in the media reinforces the finding that a small number of stakeholder categories are garnering the majority of media attention. Industry actors at the meso level are mentioned more often than others, and within this group, the directly involved companies are more frequently mentioned than other groups. Some societal actors are mentioned, however the only societal stakeholder group that received much media attention was at the macro level, and in particular government actors were mentioned frequently. Thus, both from the perspective of number of actors mentioned and the analysis of their share of the media space on digital agriculture, it becomes clear that there is a bias in the public discourse towards the industry and meso level.

In addition to supporting academic analyses, the framework also enables practitioners interested in addressing such biases to identify groups that should be included to achieve comprehensive representation. This might be of interest, for example, to journalists aiming to cover the field of digital agriculture comprehensively, or to government or other bodies conducting consultations.

Applying the framework in the context of building a representative sample or identifying participants for consultation processes would involve mapping selected respondents onto the framework and then systematically aiming to identify respondents from the missing categories.

5. Conclusions

This study offers a systematic framework for stakeholder identification and categorisation in the context of a digital agriculture ecosystem. In our proposed model, based on the structure, stakeholders are grouped into individual, industrial and societal stakeholders.
Then, these groups are plotted against the micro, meso and macro levels of impact or power in the agri-food system. Within each category of the framework, stakeholders are grouped in a thematic manner. Such a categorisation can facilitate including new stakeholders based on their characteristics. To demonstrate the application of this framework, we provided an analysis of Canadian print media, identifying relevant stakeholders and placing them within the framework.

Recent scholarship has argued for the necessity of developing a more comprehensive and systematic approach for responsible innovation in digital agriculture [5,29,30]. Compared to the current methods applying snowballing approaches where the interviewed stakeholder introduced other stakeholders, the proposed framework may be less prone to bias.

The framework can be applied both in academic research, for example, to ensure systematic representation and inclusivity in empirical research, as well as in practical contexts including government policy and program consultations, the development of sector initiatives such as living labs, and inclusive innovation and commercialisation efforts.

Future work could enhance the framework further by including the structure of the entire agri-food sector or devising a stakeholder map that captures the engaged stakeholder groups across the industry’s supply chain, value chain and the integration of broader ecosystem-level stakeholders. Future work could also test this model against other jurisdictions.

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