GRASPING THE DIGITAL TRANSFORMATION OF AGRI-FOOD SYSTEMS

THROUGH RESPONSIBLE SENSE-MAKING

KELLY RIJSWIJK

Propositions

1. Digital disruption only exists in the eyes of the beholder. (This thesis)
2. Digital transformation is a means to a non-existing end. (This thesis)
3. Science itself has created the increasing undervaluing of its role in society.
4. Team science makes the current form of doctoral degrees irrelevant.
5. Obtaining a doctoral degree is a paradox: the candidate needs to fit in, but the output needs to stand out.
6. The education system exacerbates inequalities in society.
7. Increasing diversity and inclusion starts with the realisation that a skin coloured pencil is not the same as a salmon coloured pencil.

Propositions belonging to the thesis titled:

Grasping the digital transformation of agri-food systems through responsible sense-making

Kelly Rijswijk
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Grasping the digital transformation of agri-food systems through responsible sense-making

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Grasping the digital transformation of agri-food systems through responsible sense-making

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Thesis

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Voor Noor & Cato

Blijf nieuwsgierig, ontdek de wereld en volg je hart.

Remain inquisitive, explore the world and follow your heart.

Table of contents

Summary

In the past years digital technologies and there use have become ubiquitous that it is difficult to see a future without digital technologies. Yet using the broad variety of an ever evolving and expanding amount of digital technologies is not a matter of 'plug and play'. These technologies come with their own set of challenges and are often considered pervasive and disruptive. Digital technology use is part of a process called digital transformation, a process which actors at different system levels go through. A process that also comes with expectations and uncertainties and requires sense-making for and by actors. Not in the least sense-making about the terminology used: digitisation, digitalisation or digital transformation, or 4.0, smart farming and digital agriculture in the agri-food sector. These terms are used to describe the potentially transformative processes that impact both on- and off-farm.

Digital technologies are often seen as an opportunity to enable sustainable futures in agriculture and rural areas. The impact often goes beyond use of the digital technologies, but for example also includes social, economic and institutional aspects. These kinds of impacts can be difficult to foresee and understand. Hence the *research objective* of this thesis is to develop insights and understanding of the challenges encountered by organisations, value chains, and the agricultural knowledge and innovation system (AKIS) in their ability to make sense of digital transformation of agri-food systems. This objective leads to the following overall research question: *How do actors within agri-food systems make sense of digital transformation?*

The following sub-research questions will help to address this overall research question:

1. *How do actors within agri-food systems perceive digital transformation?*
2. *What are key elements for actors within agri-food systems to make sense of and respond to digital transformation responsibly?*

Chapter 1 sets the scene in more detail and introduces the core concepts of this thesis, namely digi-grasping and Responsible Research and Innovation (RRI). The former can be considered a form of sense-making whereby actors actively gain awareness and get involved in the digital world, through building an understanding of both the digital and the physical world and the ability to imagine alternative futures. This will help them to deal

the earlier mentioned uncertainties, expectations and challenges and in doing so they may move across different digi-grasping modes (e.g., ignorance, awareness, empowerment and transformation). For the latter, RRI, can help to consider unseen and unknown (positive or negative) aspects of digital transformation. This approach aims to uncover the (un)intended consequences and impact of innovation using four main principles: anticipation of these (un)intended consequences; inclusion of all relevant actors and the wider public through deliberative processes; responsiveness, i.e. through transparency allowing for change, also of institutional and governance structures; and reflexivity, i.e. being mindful of the different value systems behind decisions around research and innovation.

Chapter 2 dives deeper into the concept of digi-grasping and uncovers how agricultural knowledge providing organisations, such as farm advisors and science organisations, understand and respond to digital agriculture. The concept of 'organisational identity' is used to describe both initial understandings of and emerging responses to digital agriculture, which together show how organisations digi-grasp. The understanding is described using aspects of identity change (i.e. the nature, pace, source and context of digital agriculture), while the responses are outlined through the various attributes of organisational identity (i.e. capabilities, practices, services, clients, partners, purpose and values). Through semi-structured interviews with different types of agricultural knowledge providers in the context of context of New Zealand it becomes clear that digitalisation is often understood as farm-centric, despite being considered disruptive both on- and off-farm. These understandings influence organisations' responses to digital agriculture, which were often ad-hoc. Organisations would start with adapting organisational capabilities, practices and services as required by their clients and partners, rather than using a strategic approach allowing for more flexibility of roles and processes and changing business models. This ad-hoc approach appears to be a response to uncertainty as digital agriculture is in its early stages of development. This chapter is looking from the 'inside-out': it is focussed on the perceptions and responses of a single organisation to digitalisation and reflects on what this means from a broader AKIS perspective. It shows that AKIS should better support agricultural knowledge providers as they digi-grasp and develop a digitalisation strategy, by anticipating possible futures and reflecting on the consequences of these for value propositions, business models and organisational identities of agricultural knowledge providers.

Chapter 3 builds on the aspect of uncertainty, in particular in the interaction between actors, and this connects it to the concept of trust in a value chain context. This chapter investigates how trust relations (interpersonal trust, trust development and institutional trust) affect digitalisation, and how digitalisation vice versa affects trust relations among value chain actors, using the Dutch flower sector as a case study. The findings show that the sector has a high level of interpersonal trust, but limited institutional trust, as the relationships between companies are highly competitive and transactional. In this specific context, limited trust hinders digitalisation in multiple and mutually reinforcing ways, inducing a vicious cycle whereby existing distrust or limited trust results in limited digitalisation. This, in turn, causes more distrust due to uncertainties around the digitalisation process, which is further increased by existing (technological) path dependencies. A main theoretical implication is that a better awareness of mutually reinforcing (dis)trust dynamics and vicious (or virtuous) cycles in relation to digitalisation are needed. This indicates a need for developing 1) higher levels of understanding of what digitalisation entails (i.e. digi-grasping) and 2) organizational ambidexterity in the value chain, i.e. striking a balance between exploiting the old or current situation, while having sufficient space to grasp uncertain new and future possibilities. This could allow actors to step out of their regular patterns of competition and collaboration (or rather co-opetition) and to explore new levels of collaboration for digitalisation.

Chapter 4 then continues to zoom out by taking an agri-food systems perspective on digital transformation. The chapter aims to gain a better understanding and anticipation of the often-unknown impacts of the digital transformation process, as digital technologies are mostly seen as an opportunity to enable sustainable futures in agriculture and rural areas. However, the technologies and related transformation are not inherently good as they impact on many aspects (e.g. economic, environmental, social, technological, institutional) and the relations between these aspects. Building on the RRI approach, a framework was developed that allows insight on the relations between the social, the cyber and the physical dimensions of digital transformation, i.e. a *Socio-Cyber-Physical System* perspective to unravel how digital transformation plays out in the agri-food system and rural areas more broadly. Additionally, the conditions for digital transformation of such a system are also described (e.g. access conditions, design choices and system complexity). This framework, illustrated by an example of digital dairy farming, allows for a better problematisation of digital transformation, as well as a better understanding of who is responsible and /or accountable for the identified (positive or negative) impacts, i.e.

responsibilisation. Thus, Chapter 4 addresses a weakness of RRI on the problematic practical applicability of RRI, due to a mismatch between the ideal of responsibility and the realities of existing innovation processes, by making it clearer who is responsible in what way, at different system levels.

Chapter 5 builds on this idea of the normativity of digitalisation. Digital transformation processes are, as said, not inherently good, and in practice digitalisation comes with trade-offs whereby potential benefits and harm are not equally distributed. This chapter provides a broader conceptual reflection on digitalisation, aiming to unravel how processes of digitalisation in agriculture may lead to *inclusion* and *exclusion* of people and organisations in the present or future, illustrated with examples from an European Union context. A broad variety of inclusion and exclusion factors are discussed across three levels: specific digital technologies; digital innovation packages; and the digital innovation system, linking those with the conditions for successful digital transformation that were identified in the preceding chapter. In doing so, this chapter breaks with the normative assumption that inclusion is always positive and exclusion always negative. Instead, when it comes to the use of digital technologies in agriculture, inclusion and exclusion are more than a binary distinction between 'who is in' and 'who is out,' or what is 'good' and what is 'bad'.

Chapter 6, then provides and general discussion and conclusion to the preceding chapters. It describes the main conclusions and implications. At an organisational level this thesis shows that digitalisation is less disruptive than expected due to (organisational) perceptions that hamper the process. The heterogeneity among actors in terms of their digi-grasping abilities and modes, however, shows that disruption is only experienced in relation to other (competing) actors. To deal with the uncertainties of digitalisation organisations need to be more flexible and re-consider their organisational identity.

At an AKIS and value chain level, thus far, there is limited support for the digital transformation. Additionally, often there is limited trust between competing and dependent organisations, which hampers the necessary collaboration and openness for digital transformation, at most there is co-opetition. It would therefore require four key elements of collaboration, trust, reciprocity, and ambidexterity to deal with dominant responses to the uncertainties of digital transformation, such as reinforcement of existing power structures, competitive behaviour and technological lock-in. At a system level this

means joint digital transformation strategy building with support of different kinds of transition intermediaries. These intermediaries could perform a range of tasks, including creating a sense of urgency and facilitating the (re)shaping of a collective identity; developing alternative system configurations; and making use of supportive and tentative governance models.

For the overall agri-food system this thesis shows that it is important to assess the appropriate level of digital transformation for the set of heterogeneous actors involved. It requires a rethinking of digital transformation, or even innovation processes more broadly, which includes not only the responsibilisation and inclusion and exclusion factors, but ultimately allows space for alternative pathways in both content and process. Therewith this thesis extends both the concepts of digi-grasping and RRI.

Samenvatting

In de afgelopen jaren heeft het gebruik van digitale technologie een enorme vlucht genomen en is het moeilijk geworden om ons een toekomst zonder digitale technologie voor te stellen. De constante ontwikkeling van de technologie zelf, maar daarnaast ook van het gebruik, de bijbehorende uitdagingen en de potentiële positieve of negatieve impact van dit gebruik zijn onderdeel van een proces genaamd 'digitale transformatie'. In de agri-food sector wordt digitale transformatie veelal *agriculture 4.0*, *smart farming* of digitale landbouw genoemd. Daarbij wordt digitale technologie vaak gezien als een kans om een duurzame toekomst voor de agrarische sector en rurale gebieden te bewerkstellingen.

Door de grote verscheidenheid aan digitale technologieën is het gebruik hiervan geen kwestie van *'plug and play'*. Digitale technologieën gaan namelijk gepaard met een breed scala aan technologische en sociale uitdagingen, welke leiden tot verwachtingen en onzekerheden voor actoren (betrokken partijen zoals personen en organisaties bijvoorbeeld in een keten). De toepassing van digitale technologie omvat daarom vaak naast technologische en economische aspecten ook sociale en institutionele aspecten. De impact van deze laatste twee aspecten is vaak moeilijk te voorspellen en zijn slecht te overzien.
De onoverzichtelijkheid van het digitale transformatie proces, met andere woorden de uitdagingen, verwachtingen, onzekerheden, en impact die voor elke actor anders kunnen zijn, noodzaakt verdere duiding van dit proces op verschillende niveaus, te weten organisaties, (waarde)keten, en het systeem niveau. Met een systeem wordt het geheel van actoren en fysieke elementen bedoelt welke door allerlei technologische, economische, sociale en institutionele aspecten onderlinge samenhang hebben rondom een onderwerp. Het doel van dit proefschrift is dan ook om meer inzicht te verkrijgen in de uitdagingen voor organisaties, waardeketens en het Agrarische Kennis en Innovatie Systeem (AKIS) en om grip te krijgen op de digitale transformatie van agri-food systemen. Dit leidt tot de volgende onderzoeksvraag: *Hoe begrijpen actoren in agri-food systemen digitale transformatie?*

De volgende twee sub-onderzoeksvragen ondersteunen de beantwoording van de algemene onderzoeksvraag:

1. *Hoe nemen actoren in agri-food systemen digitale transformatie waar?*

2. *Wat zijn de hoofd elementen die actoren in agri-food systemen ondersteunen in het, op een verantwoorde manier, begrijpen en reageren op digitale transformatie?*

Hoofdstuk 1 geeft meer achtergrond informatie en introduceert de belangrijkste concepten van dit proefschrift, namelijk *digi-grasping* (oftewel grip krijgen op digitale transformatie) en *Responsible Research and Innovation* (RRI – oftewel Verantwoord Onderzoek en Innovatie). Het eerste concept kan worden gezien als een vorm van betekenis geven, waarbij actoren zich actief bewust worden van, en betrokken raken bij de digitale wereld. Dit helpt actoren om te gaan met de eerder genoemde verwachtingen, onzekerheden en uitdagingen. Tijdens dit digi-grasping proces gaan ze door verschillende digi-grasping modes, namelijk onwetendheid, bewustwording, emancipatie en transformatie.

Het tweede concept, RRI, helpt met het duiden van onvoorziene en onbekende positieve of negatieve aspecten van digitale transformatie. Deze aanpak heeft als doel om de (on)bedoelde consequenties en de impact van innovatie aan het licht te brengen door middel van vier principes: anticiperen van (on)bedoelde consequenties; inclusie van alle relevante actoren en het bredere publiek; responsiviteit, in andere woorden ruimte laten voor verandering en om daarop te reageren; en reflexiviteit, dan wel het bewustzijn van de verschillende onderliggende waarde systemen achter de besluiten rondom onderzoek en innovatie).

Hoofdstuk 2 gaat dieper in op het digi-grasping concept en laat zien hoe leveranciers van agrarische kennis, zoals vertegenwoordigers, adviseurs en kennis instellingen, digitale landbouw waarnemen en erop reageren. Door middel van meer inzicht in de identiteit van de organisaties die deze agrarische kennis leveren, en hoe de identiteit mogelijk verandert onder invloed van digitalisering, ontstaat er een overzicht van de initiële percepties en reacties op digitale landbouw. Met andere woorden, de veranderende organisatie identiteit laat zien hoe deze organisaties proberen grip te krijgen op hun digitaliseringsproces. Uit interviews met agrarische kennisleveranciers in Nieuw Zeeland komt naar voren dat digitalisering vooral als een proces op de boerderij wordt gezien, hoewel dit ook veranderingen in hun eigen organisatie veroorzaakt. Er werd vaak ad-hoc gereageerd op digitaliseringsvragen en benodigdheden van partner organisaties of klanten. Organisaties starten vaak pas met het aanpassen van hun kennis, kunde en diensten wanneer deze vraagstukken zich aandienen, in plaats van een meer strategische en lange termijn aanpak te

gebruiken waarbij er de nodige flexibiliteit rondom hun eigen rol, processen, en business model zou ontstaan. Deze ad-hoc aanpak komt voort uit onzekerheid over de (on)mogelijkheden van digitalisering. Dit hoofdstuk geeft vooral een intern perspectief, vanuit de positie van verschillende organisaties. Om deze organisaties te ondersteunen in het digitaliseringsproces is er echter ook ontwikkeling van het bredere Agrarische Kennis en Innovatie Systeem nodig. Actoren die op dit systeem niveau opereren zouden onder meer een gezamenlijke digitaliseringsstrategie kunnen ontwikkelen waarin rekening wordt gehouden met mogelijke verschillende toekomstperspectieven. Ook kan er gekeken worden naar de consequenties van deze verschillende perspectieven voor de waarde propositie, business modellen, en organisatie identiteit van agrarische kennisleveranciers.

Hoofdstuk 3 bouwt voort op de onzekerheid rondom digitale transformatie. In het bijzonder wordt gekeken naar de onzekerheid in de (digitale) interactie tussen organisaties, oftewel wat de rol van vertrouwen is in een digitaliserende waardeketen. Als casus zijn de vertrouwensrelaties tussen verschillende partijen in de Nederlandse sierteelt sector onderzocht. Uit de interviews blijkt dat er veel vertrouwen is op persoonlijk niveau (tussen werknemers van verschillende organisaties), maar slechts beperkt vertrouwen op organisatie niveau. Dit komt doordat de bedrijven in de sierteelt sector sterk met elkaar concurreren en vooral contact hebben rondom specifieke (financiële) transacties. Er is geen, of enkel beperkt, sprake van gelijkwaardigheid en wederkerigheid in de vertrouwensrelaties tussen organisaties. Dit hindert het digitaliseringsproces omdat er een vicieuze cirkel ontstaat waarbij het bestaande beperkte vertrouwen tevens resulteert in beperkte digitalisering. Daarop volgend wordt nog meer onzekerheid en wantrouwen gecreëerd. Dit proces wordt verder versterkt door de reeds bestaande (technologische) afhankelijkheden in de sierteelt sector die ervoor zorgen dat men vastzit in een bepaald stramien. Om de vicieuze cirkel te doorbreken is het van belang dat er 1) meer bewustwording en inzicht komt over de (on)mogelijkheden van digitalisering, en dat er 2) ruimte is voor 'ambidexteriteit', oftewel het vinden van een balans tussen het voortzetten van oude of huidige praktijken, alsook ruimte bieden voor het ontdekken van nieuwe mogelijkheden. Hierdoor kunnen actoren buiten hun reguliere patronen van concurrentie opereren en meer samenwerken om digitalisering te bewerkstelligen.

Hoofdstuk 4 zoomt uit van een organisatie en waardeketen perspectief naar een agri-food systeem perspectief op digitale transformatie. Het doel van dit hoofdstuk is vanuit de theorie de onvoorziene en onbekende impact van digitale transformatie beter te begrijpen en hierop

te anticiperen. Hoewel digitale technologie vaak wordt gezien als een kans voor een duurzame toekomst voor de agrarische sector en rurale gebieden, weten we ook dat de technologie en de bijbehorende veranderingen niet alleen maar positief en goed zijn. Gebruikmakend en voortbordurend op de RRI aanpak is er een conceptueel kader ontwikkeld dat meer inzicht geeft in de relaties tussen de sociale, cyber, en fysieke dimensies van digitale transformatie, oftewel het *Socio-Cyber-Physical System (SCPS)*. Dit kader helpt met het duiden van de impact van digitale transformatie voor de agri-food sector in de breedste zin. Daarnaast blijkt dat er bepaalde voorwaarden kleven aan een succesvolle digitale transformatie van een agri-food systeem. Deze voorwaarden gaan over toegang tot digitale technologie, de keuzes omtrent het ontwerp van de technologie, en de complexiteit van het SCPS (oftewel het aantal en type relaties tussen de verschillende sociale, cyber en fysieke dimensies en de overzichtelijkheid daarvan). Het conceptuele kader, geïllustreerd door een voorbeeld van digitalisering in de melkveehouderij, laat zien dat meer inzicht in de dimensies van het systeem en de voorwaarden voor digitale transformatie ook resulteert in een beter begrip van wie er verantwoordelijk en aansprakelijk is voor de positieve en negatieve impact van digitale transformatie. Dit wordt ook wel *responsibilisation* genoemd.

Hoofdstuk 5 gaat dieper in op het idee dat digitale transformatie niet alleen maar positief en goed is. Er zijn vaak compromissen nodig waardoor de potentiële voor- en nadelen niet eerlijk worden verdeeld over actoren. In dit hoofdstuk wordt gekeken hoe digitalisering van de agri-food sector van Europa kan leiden tot inclusie en exclusie van mensen en organisaties zowel nu als in de toekomst. Vaak worden inclusie en exclusie gelinkt aan de directe toegang van mensen tot (het gebruik van een) digitale technologie. Dit wordt beïnvloedt door factoren als financiële middelen, opleidingsniveau, gender, etc. De gevolgen en de impact van digitale transformatie zijn echter op meerdere niveaus zichtbaar en niet perse plaats en tijd gebonden; bijvoorbeeld data van een Nederlandse boer die altijd toegankelijk blijft doordat het is opgeslagen binnen een Amerikaans data center. Dit laat zien dat in een digitale context inclusie niet altijd positief is en exclusie niet altijd negatief, en tevens dat de processen die inclusie en exclusie veroorzaken niet altijd zichtbaar zijn. Mensen kunnen er ook pas na verloop van tijd achter komen dat ze ergens wel of niet van in- of uitgesloten zijn. In het kader van digitale transformatie van agri-food systemen vraagt dit om een heroverweging van de huidige binaire verdeling tussen wie er wel bij hoort en wie niet, en wat wordt beschouwd als goed en wat als slecht.

Op basis van de voorgaande hoofdstukken worden de resultaten in hoofdstuk 6 samengevat en bediscussieerd. Hierop volgen enkele conclusies en implicaties, die tezamen een antwoord verschaffen op de gestelde onderzoeksvraag. Op organisatieniveau laat dit proefschrift zien dat digitalisering minder disruptief is dan tot op heden werd gedacht doordat de percepties van organisaties over digitalisering het digitaliseringsproces zelf afremmen. Er is echter wel veel heterogeniteit tussen de organisaties en de digi-grasping modus waarin zij zich bevinden. Dit laat zien dat disruptie vooral wordt ervaren in relatie tot andere (concurrerende) actoren. Om met de disruptie en onzekerheden om te gaan zullen organisaties meer flexibel moeten worden en hun organisatie identiteit moeten heroverwegen.

Op het niveau van de waardeketen en AKIS zien we tot dusver weinig ondersteuning voor digitale transformatie. Door beperkt vertrouwen tussen concurrerende organisaties en afhankelijkheidsposities worden voor digitale transformatie noodzakelijke samenwerking en openheid afgeremd. Er zijn vier elementen nodig, te weten samenwerking, vertrouwen, wederkerigheid, en ambidexteriteit, om dominante percepties over de onzekerheden van digitale transformatie te overwinnen. Deze onzekerheden gaan met name over bestaande machtsverhoudingen, concurrentieposities, en het technologisch stramien waarin organisaties, waardeketens, en het AKIS zich bevinden. Het aanpakken van deze onzekerheden zou gedaan kunnen worden met behulp van intermediaire personen of organisaties. Deze intermediairs kunnen urgentie creëren; een gezamenlijke identiteit vormgeven; na denken over alternatieve systeem configuraties; en gebruik maken van experimentele en tijdelijke bestuursvormen om zo een gezamenlijke digitale transformatie strategie te ontwikkelen.

Samenvattend heeft dit onderzoek aangetoond dat het voor het gehele agri-food systeem belangrijk is om het juiste en meest geschikte niveau van digitale transformatie vast te stellen voor de heterogene groep van betrokken actoren. Dat vereist het heroverwegen van digitale transformatie processen, of zelfs van innovatie processen in het algemeen. Die heroverweging zou dan de responsibilisation (verantwoordelijkheid en aansprakelijkheid voor de positieve en negatieve impact van digitale transformatie), nieuwe inclusie en exclusie factoren, en tevens alternatieve toekomstperspectieven voor zowel de inhoud als het proces van digitale transformatie moeten omvatten. Daarmee draagt dit proefschrift bij aan de ontwikkeling en uitbreiding van zowel het digi-grasping als het RRI concept.

Prologue

During 2015, when I started considering if I wanted to do a PhD, digitalisation was not a topic of interest or relevance to me, and probably not to many people. It was also a topic that in my mind was linked to the real 'nerds' who, besides their IT related day-job, organise hackathons in the weekend for fun, love endless gaming in the middle of the night, or enjoy programming software in their spare time. For most of us, however, digitalisation was writing e-mails and doing 'stuff' on your computer all day every day in an office context. In fact, the term digitalisation was probably still non-existent in the dictionary of everyday life.

In conversations with my supervisors, digitalisation, as well a few other topics, came up as a potential topic to do the type of research that I was interested in. Namely understanding how (research) organisations adapt to new perspectives and outside influences, what this means for their processes and aims, and how, and above all why, this might differ from country to country or context to context.

Ideally this would be researched in an agricultural setting and taking a so-called 'systems' approach, two topics that I have been involved in since my bachelor study in Rural Development. The agricultural sector is a dynamic and complex sector facing a variety of different challenges such as climate change, while having to deal with ever-increasing regulations around animal welfare, environmental compliance, etc., and also wanting to respond to changing needs and growing expectations of consumers. A systems approach allows for unpacking this complexity without losing it. Once you have developed 'system thinking' it becomes difficult to see the world in a different way.

So, this is where my PhD and digitalisation journey began at the end of 2015, reading articles about Big Data to understand what it actually was, followed by a steep learning curve about technologies such as Internet of Things, Blockchain, and whatever else seemed to be relevant at the time. All in aid of moving away from all the real 'nerdy' technological aspects and focus on what the social impact of those technologies could be on individuals, organisations and systems. And vice versa, how individuals, organisations and the 'system' change and shape the digital transformation process and thereby (indirectly) digital technologies. In a way, I also had to go through a similar digi-grasping process as will be described in the various chapters of this thesis!

Chapter 1

General introduction

1.1 Setting the scene

> *"So keeping it really simple is getting rid of the old paper. I suppose making it more computer orientated, whatever that might look like. In this day and age it might be a device rather than a computer, it could even be something that could fit in your pocket, or something that might fit in a cabin [of a tractor]. … As soon as you start going down that path the world is your oyster I think. So it is just trying to get rid of that [paper], and because of that it is also allowing people to focus on what is happening now and trying to make more informed decisions at a more timely fashion."* – Project manager at a cooperative company in New Zealand, 2017

This quote from the first interviews as part of this PhD shows that at that time digitalisation was a term equated with digitisation, i.e. the "technical conversion of analogue information into digital form" (Autio, 2017, p. 1). In the agricultural context precision agriculture was similarly equated to what was starting to be referred to as digital agriculture. The focus was very much on the adoption of precision agriculture technologies by farmers and how this could improve their production, profitability and most likely, or at least ideally, also their environmental sustainability (Eastwood, Jago, Edwards, & Burke, 2016; Poppe, Wolfert, Verdouw, & Renwick, 2015; Poppe, Wolfert, Verdouw, & Verwaart, 2013; Tey & Brindal, 2012; Verdouw, Tekinerdogan, Beulens, & Wolfert, 2021; Wolfert, Ge, Verdouw, & Bogaardt, 2017). This topic, however, has exploded over the last five years from a technological and economic orientation towards a broader perspective including social and institutional aspects (see for example Barrett, 2021; Birner, Daum, & Pray; Ehlers, Huber, & Finger, 2021; Garske, Bau, & Ekardt, 2021; Herrero et al., 2020; Ingram & Maye, 2020; Shepherd, Turner, Small, & Wheeler, 2020) and has evolved into a 'hot topic', and therefore also a contested topic (e.g. Brooks, 2021; Carolan, 2017a, 2017b, 2018, 2020a, 2020b; Clapp & Ruder, 2020; Fraser, 2019, 2021; Gardezi & Stock, 2021; Gras & Cáceres, 2020; Rotz, Duncan, et al., 2019), in relation to the current operation and transformation of agri-food systems. In policy making and policy-oriented research there has been a surge of attention to digitalisation and digital agriculture, for example in many national and international policy documents, such as the European Commission (2019b) in their Green Deal; the FAO (Trendov, Varas, & Zeng, 2019) or the European Network for Rural Development (2020).

1.1.1 Digitisation, digitalisation and digital transformation

The above shows that there has been a rapidly evolving body of work on digital agriculture, and an evolution of empirical studies and conceptual thinking. Now there is an (theoretical) understanding of the difference between digitisation and digitalisation, and the focus has increasingly shifted towards the overall digital transformation of agri-food systems. In a similar vein there is a realisation that precision agriculture is not the same as digital agriculture. I will now further elaborate on some of these key concepts.

As already alluded to above, *digitisation* can be described as analogue information being converted into a digital form, in other words, transforming physical entities into digital objects (Rijswijk et al., 2020), this process is often linked to automation (see for example Carolan, 2020b; Lunner-Kolstrup, Hörndahl, & Karttunen, 2018; Rodriguez-Bustelo, Batista-Foguet, & Serlavós, 2020; Zator, 2019), and could allow for remote or autonomous processes regarding the production, processing or logistic activities (Porter & Heppelmann, 2014; Rijswijk et al., 2020). Digitisation is often linked to a single or a small number of digital technologies implemented at business level and often referred to as the third industrial revolution (Greenwood, 1997; Schwab, 2017). In an agricultural context digitisation is often seen in the form of a digital technology being implemented on-farm, making use of (mainly spatial) data to feed decision support tools for farmers, such as milking and harvesting robots and other precision agriculture technologies (Hansen, Bugge, & Skibrek, 2020; Klerkx, Jakku, & Labarthe, 2019).

Digitalisation describes the socio-technical processes surrounding the use of (a large variety of) digital technologies that have an impact on social and institutional contexts that require and increasingly rely on digital technologies (Tilson, Lyytinen, & Sørensen, 2010). Digitalisation follows digitisation, and is thus seen as the fourth industrial revolution (Schwab, 2017), also referred to as Industry 4.0 (Meyer, 2019; Sommer, 2015a), or Smart Industry (Team Smart Industry, 2014). This revolution is based on a combination of automation and (ubiquitous) connectivity, leading to increased coordination and integration of (digital) activities (Porter & Heppelmann, 2014). Digitalisation thus goes beyond the technical conversion and the level of a single business or entity. It has an impact on all aspects of society, including the agricultural sector and rural areas (Poppe et al., 2013), where we also see an increased use of sensors for (big) data collection, Internet of Things, Artificial Intelligence, Blockchain, Digital Twins, etc. that support the exchange of all sorts of data, knowledge, services, and products through digital platforms

(see for example Alm et al., 2016; van Wassenaer, Verdouw, & Wolfert, 2021; Verdouw et al., 2021; Verdouw, Wolfert, Beulens, & Rialland, 2016; Zhao et al., 2019). Such a platform can, for example, coordinate demand and supply in value chains, linking on- and off-farm data and managements tasks, which are enhanced by context- and situation awareness and triggered by real-time events (Rose & Chilvers, 2018b; Wolfert, Goense, & Sørensen, 2014). Digitalisation in agriculture is therefore often connected to broader concepts such as digital agriculture, 'Smart farming', 'Smart Rural Development', 'Smart rural areas', and even the broader concept of Agriculture 4.0, (Herrero et al., 2020; Klerkx et al., 2019; Klerkx & Rose, 2020; Naldi, Nilsson, Westlund, & Wixe, 2015). Thus, precision agriculture can be seen as an on-farm digitisation process whereas digital agriculture is linked to digitalisation, encompassing the entire value chain with the intent to cause broad change in the agricultural sector.

Following Rijswijk et al. (2020), both digitisation and digitalisation are considered part of a *digital transformation* process of agri-food systems (see Figure 1.1), which allows for a broad spectrum of digitisation and digitalisation activities, which increasingly connect and intersect. This means that over time not only the variety and uses of digital technologies increase, but also the associated complexity, i.e. interactions between social-technical aspects, such as actors (e.g. individuals and organisations), institutions, the surrounding environment, and of course the (digital) technology itself increase. Additionally, this also multiplies the related, either positive or negative, impacts on society, resulting in an ongoing and iterative process (Nochta, Badstuber, & Noura, 2019).

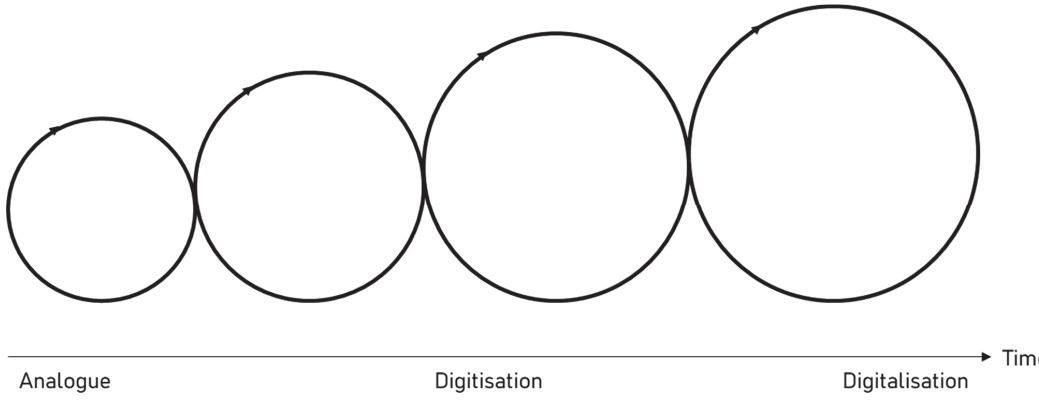

Figure 1.1 The digital transformation process (Rijswijk et al., 2020, p. 7)

The description of the concepts of digitisation, digitalisation and digital transformation can, therefore, be linked to different 'levels of aggregation' of a system. A system can be defined as "a mental representation of given aspects of reality for analysis and control purposes. Through the system concept, reality is represented as a set of entities that interact together through (jointly) performing activities." (Rijswijk et al., 2020, p. 9). Hence a farm can be seen as a system in which the farmer, various (digital) technologies, and the animals or plants interact together. At a larger scale one can see an agri-food system, which becomes more complex as more actors with different perspectives and needs interact with each other and with a multiplicity of technologies, other physical entities and external influences (Rijswijk et al., 2020). Additionally, there can be systems within systems, such as a farm (system) operating within a value chain (system), and this sits within the broader agri-food system, which all have a relatively clear (physical) boundary around them. There are, however, also systems that can be supportive to the digitisation, digitalisation and digital transformation of farm systems, value chains and the agri-food system. These systems are for example the Agricultural Knowledge and Innovation System which refers to "complex arrangements and interactions between actors, knowledge organizations (agricultural research, extension, and education organisations) as well as the informal networks of heterogeneous actors (supply chains, policy makers etc)." (Ingram & Maye, 2020, p. 2). With regards to digital transformation of agriculture more specifically the concept of Digitalisation of Agricultural Innovation System (DAIS) (Fielke et al., 2019b), and the Socio-Cyber-Physical(-Environmental) System (SCPS) have also been coined (Klerkx et al., 2019; Lioutas, Charatsari, La Rocca, & De Rosa, 2019; Rijswijk et al., 2020). The former is a concept that concerns the supportive infrastructures that enable digital transformation (but are also affected by it as I will show in the thesis), and the latter is a concept to develop a better understanding of what transforms in processes of digitisation, digitalisation, and more broadly digital transformation.

1.1.2. Disruption and uncertainty

Although the terminology around digital technologies has evolved over the past years, and the body of work has grown exponentially, what has not changed is the need to understand

what impact digital technologies have on individuals, organisations and society as a whole (see for example Balsmeier & Woerter, 2019; Carolan, 2020a; Chakravorti & Chaturvedi, 2017; Floridi, 2014; George & Paul, 2020; Obwegeser & Bauer, 2016; Robinson et al., 2015) and how society, and the individuals and organisations within it, shape the digital transformation (Higgins & Bryant, 2020; Jakku et al., 2019; Jonsson, Mathiassen, & Holmström, 2018; Wittman, James, & Mehrabi, 2020). While the adoption of precision agriculture and digital technologies on farm and related advisory and extension services has been for more than a decade (Aker, Ghosh, & Burrell, 2016; Anastasios, Koutsouris, & Konstadinos, 2010; Eastwood, Ayre, Nettle, & Dela Rue, 2019; Eastwood, Chaplin, Dela Rue, Lyons, & Gray, 2016; Eastwood, Jago, et al., 2016; Eastwood & Renwick, 2020; Floridi, Bartolini, Peerlings, Polman, & Viaggi, 2013; Higgins, Bryant, Howell, & Battersby, 2017; Kutter, Tiemann, Siebert, & Fountas, 2009; Reichardt, Jürgens, Klöble, Hüter, & Moser, 2009; Tey & Brindal, 2012), there are still many (known and unknown) unknowns (Logan, 2009; Pawson, Wong, & Owen, 2011; Rumsfeld, 2002) related to, for example, digital policy making, digital agricultural systems and transitions, or digital agriculture geography (Klerkx et al., 2019). These unknowns are caused by and simultaneously can create so-called disruption, i.e. the process whereby a disruptive technology or innovation disrupts (i.e. positively or negatively affects) actors and the wider systems (i.e. farm system, value chain, agri-food system, AKIS) in which they operate in unforeseen ways (Kilkki, Mäntylä, Karhu, Hämmäinen, & Ailisto, 2018; Millar, Lockett, & Ladd, 2018; Schuelke-Leech, 2018). This is seen elsewhere with Apple disrupting the -Microsoft dominated- personal computer market, sharing platforms like Uber disrupting the transportation sector, and Airbnb the real estate and accommodation sectors, or in the financial sector being overhauled by FinTech such as electronic payments, bitcoin and robotic advice based on artificial intelligence (Califf, Brooks, & Longstreet, 2020; Crittenden, Crittenden, & Crittenden, 2019; de Reuver, Sørensen, & Basole, 2018; Palmié, Wincent, Parida, & Caglar, 2020). This disruption, i.e. the inability to accurately predict the future, linked to digital transformation is often a combination of (the fast-moving pace of) digital and technological developments and the (in)ability of systems, such as the agri-food system and its actors, to accurately and rapidly respond (Ho & Chen, 2018) to the event(s) that triggered this change (Sutherland et al., 2012).

Disruption thus changes, replaces or even increases (the range and type of) uncertainties that individuals, organisations and society have to deal with (Bryant & Higgins, 2021; Eastwood & Renwick, 2020; Meijer & Hekkert, 2007) in any process of innovation and

transformation. Meijer, Hekkert, Faber, and Smits (2006) have developed a framework describing this range of uncertainties, which encompasses the relationships and collaboration between organisations (suppliers, processors and competitors); required resources (e.g. material, human, financial, etc.), the rules and regulations related to the product, service or process or broader market and institutional arrangements (see also Kobos, Malczynski, Walker, Borns, & Klise, 2018; Millar et al., 2018), but can also be directly related to the technology and its (technological) infrastructure. The uncertainties about digital transformation are both about the process and the outcomes, and create challenges to, for example, business models or the reliability of the digital infrastructure (Bouncken, Kraus, & Roig-Tierno, 2019; Caputo, Pizzi, Pellegrini, & Dabić, 2021; Kahin, 2007; Nambisan, Wright, & Feldman, 2019; Schneider & Kokshagina, 2021; Teece & Linden, 2017), while also raising ethical questions such as: "Who do you trust with your data and in what way?" and "Do I have a choice to opt out?". These types of questions and related uncertainties apply to a broad range of sectors and contexts (see for example Myskja & Steinsbekk, 2020; Pashkov & Pelykh, 2020; Roßmann, Canzaniello, von der Gracht, & Hartmann, 2018), while at the same time they are also context specific, i.e. linked to the digital transformation of agriculture (e.g. Jakku et al., 2019; Jakku, Taylor, Fleming, Mason, & Thorburn, 2016; van der Burg, Bogaardt, & Wolfert, 2019a; van der Burg, Wiseman, & Krkeljas, 2020; Wiseman, Sanderson, Zhang, & Jakku, 2019).

Thus facing, and maybe riding, the wave of disruption caused by digital technologies is most certainly not easy and likely not for everyone, as some actors will not want or be able to engage with it. Hence there are different perspectives on how the digital transformation of agriculture will unfold. Some authors take a *techno-optimistic* or *techno-centric* approach, believing that digital technologies will solve current sustainability issues in agriculture whilst remaining profitable (Eastwood, Jago, et al., 2016; Poppe et al., 2015; Poppe et al., 2013; Tey & Brindal, 2012; Verdouw et al., 2021; Wolfert, Ge, et al., 2017). At the other end of the spectrum there are critical authors, i.e. *techno-pessimists*, who perceive digital transformation in agriculture as a continuation and reinforcement of the current economic and technologic orientation, with digital technologies aggravating the already distorted agri-food system (Brooks, 2021; Carolan, 2017a, 2017b, 2018, 2020a, 2020b; Clapp & Ruder, 2020; Fraser, 2019, 2021; Gardezi & Stock, 2021; Gras & Cáceres, 2020). The *techno-pessimistic* group of authors suggest a move towards agroecology as an alternative future (IPES-Food & ETC Group, 2021). In between these utopian and dystopian perspectives there are those that have a *techno-pragmatist*

tendency, whereby they see the possibilities of digital technology use while highlighting the challenges, uncertainties and consequences thereof (Barrett & Rose, 2020; Bronson, 2015, 2018, 2019b; Eastwood, Klerkx, Ayre, & Dela Rue, 2019; Fielke et al., 2021; Fleming et al., 2021; Garrard & Fielke, 2020; Klerkx et al., 2019; Klerkx & Rose, 2020; Rose & Chilvers, 2018a; Rose, Wheeler, Winter, Lobley, & Chivers, 2021; van der Burg et al., 2019a; van der Burg et al., 2020). Hoping that through providing balanced accounts, insights and sometimes potential solutions (e.g. agroecology with use of digital technologies (Ajena, 2018; Maurel & Huyghe, 2017; Rotz, Duncan, et al., 2019; Wittman et al., 2020)), these issues will be overcome in a suitable, sustainable, and responsible manner.

1.1.3 Expectations and digi-grasping

The previous section shows that there is a need for understanding the developing process of digitalisation and digital transformation and insofar as possible anticipate future consequences in order to deal with uncertainties and impacts of digitalisation. Although there is a growing body of literature looking at the *actual* impacts of the digital transformation of agriculture (Pesce et al., 2019; Trendov et al., 2019), research often tends to be based on expectations (Berkhout, 2006; Borup, Brown, Konrad, & Van Lente, 2006; Brown & Michael, 2003), i.e. the *potential* opportunities, challenges, and impacts of digital technologies and the broader digital transformation (Eastwood, Edwards, & Turner, 2021; Fleming et al., 2021; Sparrow & Howard, 2020). These expectations, or imaginaries, i.e. "collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Jasanoff & Kim, 2015, p. 4, see also Meyer, 2019 and Lajoie-O'Malley et al., 2020), are part of, and support the further envisioning or sense-making of the challenges and uncertainties related to digital transformation (Meyer, 2019). Sense-making, the process of defining, interpreting and constructing a situation from the perspective of the actor (Meyer, 2019), allows for dealing with uncertainties, expectations and related (institutional) challenges, but can also be challenging. Navigating this so-called 'fuzzy front-end' of digital transformation requires adaptation of work practices, culture, and ways of collaborating (Berghaus & Back, 2017; Tate, Bongiovanni, Kowalkiewicz, & Townson, 2018).

Dufva and Dufva (2019) have called this sense-making process '*digi-grasping*', a concept that describes and analyses the awareness and involvement in the digital world. Thus, it is active sense-making and participation in the digital transformation process. It requires

understanding of both the digital and the physical world and the ability to imagine alternative futures. The authors (2019) describe four modes of digi-grasping, with the first mode being *ignorance*; i.e. perceiving digital technologies as uncomplicated and not being aware of the influence of digital technologies on our everyday lives, let alone question this influence. The second mode is *awareness*; understanding how the digital world and the physical world interact and influence each other, for example through social media. Being aware of the current situation could develop into *empowerment*, the third mode of digi-grasping. This mode encompasses questioning the current situation and considering how it could be. That is, it allows for agency to change the current situation, which may eventually lead to "futures different from the current dominant vision" (Dufva & Dufva, 2019, p. 9). The fourth and final mode then discusses the *transformation* process whereby the direction of future developments is shaped, not only in an ethical sense, like the third mode, but also in a more practical sense.

While this description of digi-grasping remains rather conceptual Fielke et al. (2021) have built on, adapted, and tested this concept in the context of the Australian sugar cane industry. They recognize that "the modes of digi-grasping present within agricultural systems will directly influence the likelihood of successful digital technology adoption, ongoing use and iteration." (Fielke et al., 2021, p. 678). They have shown that different agricultural actors may be at different stages of digi-grasping, which not only helps to determine potential social risks and divides between these actors (expectations), but also that the modes of digi-grasping are useful in supporting the identification of the required resources and actions to achieve impact (Fielke et al., 2021). Ayre et al. (2019) similarly developed the concept of digiware, to understand how impact is realised from digital technologies by, in this case, farm advisors engage with digitalisation in terms of hardware (e.g. actual technology), software (e.g. skills), and orgware (e.g. institutional arrangements). In particular, the latter are challenging to farm advisors as they need to understand the 'symbolic' practices around data management.

These two examples show that digi-grasping is not only relevant at an organisational level, but also in the wider context of agri-food systems, as being aware is crucial for the ethical and moral responsibility towards the consequences of digital transformation (Dufva & Dufva, 2019) of agriculture, as it is not an inherently good and value free process, but involving winners and losers (Brooks & Loevinsohn, 2011; Herrero et al., 2020; Thompson & Scoones, 2009; Vanloqueren & Baret, 2009). To enact the sense-making

process of digi-grasping and informing action, in the next subsection I will discuss a methodology that has been developed for this purpose.

1.1.4 Responsible Research and Innovation

Understanding the (ethical) consequences of digital transformation fits seamlessly with a *Responsible Research and Innovation* (RRI) approach, which can help to consider unseen and unknown (positive or negative) aspects of digital transformation (Scholz et al., 2018) and has been applied in a wide range of sectors and technologies (e.g. synthetic biology (Macnaghten, Owen, & Jackson, 2016), information and communication technologies (ICT) (Stahl, Eden, & Jirotka, 2013), and nano-technology (de Bakker, de Lauwere, Hoes, & Beekman, 2014)). This approach aims to uncover the (un)intended consequences and impact of innovation using four main principles: anticipation of these (un)intended consequences; inclusion of all relevant actors and the wider public through deliberative processes; responsiveness, i.e. through transparency allowing for adaptive change, also of institutional and governance structures; and reflexivity, i.e. being mindful of the different value systems behind decisions around research and innovation (Owen, Macnaghten, & Stilgoe, 2012; Stilgoe, Owen, & Macnaghten, 2013). There are, however, challenges related to the overall applicability of the RRI approach to the practice of innovation (Blok & Lemmens, 2015), such as uncertainty about who is going to take responsibility, lack of systematic mapping of the actual innovations and related challenges (Rose & Chilvers, 2018a) and a need to further develop the RRI approach based on (empirical) research (Blok & Lemmens, 2015; Burget, Bardone, & Pedaste, 2017; Forsberg, Shelley-Egan, Ladikas, & Owen, 2018; Lubberink, Blok, Van Ophem, & Omta, 2017).

For agriculture and rural areas it has been widely argued that the RRI approach should be implemented (Barrett & Rose, 2020; Bronson, 2018, 2019b; Eastwood, Klerkx, et al., 2019; Klerkx & Begemann, 2020; Lajoie-O'Malley, Bronson, van der Burg, & Klerkx, 2020; Regan, 2019b; Rose & Chilvers, 2018a; Rose et al., 2021; van der Burg et al., 2019a) or even adapted to a rural context (Cowie, Townsend, & Salemink, 2020), as thus far smart farming or digital agriculture efforts tend to focus on the on-farm level only considering the technological development without the taking the broader social-ethical implications and its relevant actors into account (Bronson, 2015, 2018, 2019b; Eastwood, Klerkx, et al., 2019; Eastwood, Klerkx, & Nettle, 2017). Applying RRI would be a key task within AKIS, as the support system for innovation. Eastwood, Klerkx, et al. (2019) so far found limited readiness for applying the RRI approach to smart dairy farming in New Zealand. Regan (2021) also

explored the RRI approach in the context of research organisations in Ireland showing that scientists were interested and willing to address long term unintended consequences of digital agriculture, as well as the more prominent short term on-farm usability of technologies, however they were concerned about the impact on their roles and responsibilities. These two studies indicate that there is limited readiness for RRI and thus for a responsible and sustainable digital transformation of agriculture.

These examples of actors' limited RRI readiness or ability to digi-grasp (section 1.1.3) within an agri-food system show similarities and overlap in both concepts. Although both concepts tend to focus on a different 'level', with digi-grasping mainly considering an organisational perspective of dealing with the implications of digital technologies and RRI focussing on a more aggregated system level of any type of research and innovation, they both consider it important to be aware of the potential (un)intended consequences, to consider alternatives and to act upon it in a sustainable manner. As RRI is also a methodological approach it can support the enactment of digi-grasping. These two concepts are key in informing this thesis and will be further explored in the chapters (see Figure 1.2).

1.2 Research objective and questions

The previous section shows that there is an increasing awareness of the need for a better understanding of the interplay between digital technologies and the social and physical context in which these technologies are used. This has been researched across a broad variety of sectors such as health, textile, manufacturing, energy, and transport (Balasubramanian, Shukla, Sethi, Islam, & Saloum, 2021; Fromhold-Eisebith, Marschall, Peters, & Thomes, 2021; Kiel, Arnold, & Voigt, 2017; Kolloch & Dellermann, 2018; Mugge, Abbu, Michaelis, Kwiatkowski, & Gudergan, 2020; Myskja & Steinsbekk, 2020; Sraml Gonzalez & Gulbrandsen, 2021; Tijan, Jović, Aksentijević, & Pucihar, 2021); from many different technological and social perspectives (e.g. adoption, trust, governance, ethics) (Hansen et al., 2020; Jakku et al., 2019; van den Broek & van Veenstra, 2018; van der Burg et al., 2019a); at different system 'levels' and perspectives (e.g. value chain, agri-food system and AKIS) (Agyekumhene et al., 2018; Barrett et al., 2020; Ingram & Maye, 2020)); and involving different types of actors (e.g. farm advisors, scientists, farmers) (Eastwood, Ayre, & Dela Rue, 2018; Shepherd et al., 2020; Wiseman et al., 2019). Yet there is a need for a deeper scrutiny and comprehensive analysis of sense-making of digital transformation of agriculture through the lenses of different perspectives (digi-grasping, RRI), system

levels (e.g. farm level, value chain, AKIS) and actors therein (e.g. organisations). This indicates that (continuously) grasping all the potential known and unknown impacts of digital transformation at the level of an organisation, the value chain and agri-food systems remains a subject worth investigating. Hence the *research objective* of this thesis to develop insights and understanding of the challenges encountered by organisations, value chains and the agricultural knowledge and innovation system (AKIS) in their ability to make sense of digital transformation of agri-food systems. This objective leads to the following overall research question: *How do actors within agri-food systems make sense of digital transformation?*

The following sub-research questions will help to address this overall research question:

1. *How do actors within agri-food systems perceive digital transformation?*
2. *What are key elements for actors within agri-food systems to make sense of and respond to digital transformation responsibly?*

1.3 Research design

This thesis consists of multi-site qualitative research, which will be described in more detail in each of the chapters. The locations of, in particular, Chapter 2 and 3, namely New Zealand and the Netherlands, were chosen because both countries are digitally advanced (Chakravorti & Chaturvedi, 2017; European Commission, 2020b), they are similar with regards to their economic approach to agriculture, aiming to increase exports through more collaboration between research, industry and government and having (largely) privatised AKIS (Knierim et al., 2017a; Ministry for Primary Industries, 2012; Turner, Landini, Percy, & Pires Gregolin, 2021). Policies like the Top sectors in the Netherlands (Ministry of Economic Affairs, 2016) and the Industry Transformation Plans in New Zealand (Ministry of Business Innovation and Employment, 2020) are examples of this. Further, the economy of both countries largely depends on many small to medium enterprises (SMEs) (Davenport & Bibby, 1999; Ministry of Economic Affairs, 2016; Turner, Klerkx, Rijswijk, Williams, & Barnard, 2016). With regards to agriculture, both countries are in the top five dairy producing and exporting countries (Kloosterman, 2020).

Chapter 4 and 5 zoom out from a country level to focus on a -mainly- European level. This thesis is hence oriented towards developed countries, although recognizing that similar challenges of digi-grasping occur in developing countries albeit at a different pace and

scale or regarding different types of digital technology (see e.g. Agyekumhene et al., 2018; McCampbell et al., 2018; Munthali et al., 2018).

Additionally, the multi-site research design is also influenced my interdisciplinary background, as I have been involved in several research projects during the course of the PhD trajectory. This also shows the collaborative nature of the research, which in turn is fitting for the topic of digital transformation. These projects were:

- The Adoption and Practice Change project of AgResearch Ltd. financed through the Strategic Science Investment Fund of the Ministry of Business, Innovation and Employment in New Zealand
- The New Zealand Bio-economy in the Digital Age programme of AgResearch Ltd., financed through the Strategic Science Investment Fund of the Ministry of Business, Innovation and Employment in New Zealand
- The DaVinc3i Community project, funded through the Netherlands Organisation for Scientific Research (NWO) and the Dutch Institute for Advanced Logistics (TKI DINALOG) (grant No. 438-15-625).
- The DESIRA project, which receives funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 818194. The content of this thesis does not reflect the official opinion of the European Union nor other funders. Responsibility for the information and views expressed therein lies entirely with the author(s).

These projects were often participatory and action-oriented (Green & Thorogood, 2009; Kumar, 2018), and thus my involvement as a researcher in these different projects, as well as other prior knowledge and my 'demographic' as a person (Swartzh-Sea & Yanow, 2012), will have inevitably shaped and influenced the research in this thesis, from data collection, data analysis to the writing of the chapters. This thesis is thus a product of interpretive research influenced by my own positionality, in collaboration with (the positionality of) my interviewees and co-authors, who all are "human-beings with their own specific histories, capacities and characteristics" (Swartzh-Sea & Yanow, 2012, p. 67).

Furthermore, the interdisciplinarity is not only shown through my involvement in the different projects and their set-up, but also through a variety of (social science) disciplines from which I have borrowed concepts to analyse the data, including organisation studies,

knowledge management, innovation studies and Science and Technology Studies (STS) and to a lesser extend the ICT and business literature. In turn I hope that through combining different concepts and perspectives I can contribute to and broaden the above-mentioned disciplines, thus allowing for another form of sense-making about digital transformation.

1.3.1 Data collection and analysis

Chapter 2 and 3 are empirical chapters whereby semi-structured interviews were the main method of data collection. Semi-structured interviews allow for the interviewer to set an agenda of topics, while the interviewee has the space to respond to the topics on the basis of their own interest and priorities, also providing the interviewer the flexibility to explore interesting responses in more depth (Green & Thorogood, 2009). It was therefore was selected as the main method of data collection for both chapters as it supports getting in-depth insights of the (different) digi-grasping processes and modes of the interviewees. The interview topics and questions in both chapters were based on the analytical framework also described in these chapters. In both cases purposive sampling was applied to identify interviewees (Green & Thorogood, 2009). For both cases the interviewees were selected due to their involvement and/or interest in digitalisation within their organisation. In Chapter 2 the interviewees position in the organisation and the sector they were involved in mattered, while in Chapter 3 the relation to a project and the type of value chain actor influenced the choice of interviewees. In each case snowball sampling (Kumar, 2018) was used to achieve a broader range of relevant interviewees after the initial selection, whereby the same selection criteria were applied. The sampling of interviewees continued until no new information was generated, i.e. saturation was reached (Green & Thorogood, 2009).

The interviews were all recorded, with consent of the interviewees, subsequently transcribed and sent back to the interviewees for approval. The confidential interview data was then analysed using Atlas.ti software for qualitative data analysis. The analytical framework, which was used to inform the interview topics and questions underpinning both Chapter 2 and 3, also formed the basis for the coding structure used to analyse the interviews. While both chapters thus are based on thematic content analysis, in Chapter 2 this coding structure was more strictly followed, while in Chapter 3 more space was left for additional themes from an initial exploration of the interview data, which then subsequently was coded for (Green & Thorogood, 2009).

As the first piece of research undertaken as part of this thesis, Chapter 2 has an exploratory nature and therefore includes different types of agricultural knowledge providers, across a variety of agricultural sectors and with different roles in that sector, including farm advisors, science organisations, as well as technology providers, in the context of New Zealand. For a more detailed description of the interviewees, interview questions and data analysis see Table 1.1 below and Chapter 2.

Chapter 3 builds on and deepens earlier work done within a project focussing on digitalisation in the Dutch flower sector (see Salvini, Hofstede, Verdouw, Rijswijk, & Klerkx, 2020). The research therefore has a case study approach, which forms the basis for data collection. Interviewees were (initially) connected to this project and vary from growers, transporters and traders to representative organisations and service providers. See Table 1.1 below and Chapter 3 for a more detailed description of the case study and the data collection and analysis.

Table 1.1 Overview of empirical methods

Chapter	Method	Amount	Type	Data collection period	Data analysis method
Chapter 2	Semi-structured interviews	29 interviews	Knowledge providers across a range of agricultural sectors involved in digitalisation.	2017	Coding using Atlas.ti software
Chapter 3	Semi-structured interviews	18 interviews	Value chain actors in the Dutch flower sector involved in digitalisation.	2019	Coding using Atlas.ti software

The other two chapters (4 and 5) are of a more conceptual nature and are grounded in, and illustrated by, the relevant literature on the respective topics of digitalisation combined with RRI, or in- and exclusion, in an agricultural context. This literature was identified through narrative literature reviews (Ferrari, 2015; Snyder, 2019), using both scientific and grey literature (e.g., policy documents, etc.) In Chapter 5, in particular, 105 variables were used to gain deeper insights into factors of in- and exclusion related to digitalisation.

1.4 Thesis outline

This thesis combines the concepts of digi-grasping and RRI as overall guiding concepts. In Figure 1.2 there is an overview of these concepts and how each chapter connects to them. Additionally, for each chapter there is an indication of the system level it predominantly focusses on.

Chapter 2 provides an initial overview of the perceptions and actions of agricultural knowledge providing organisations, such as advisors and science organisations, in relation to digitalisation, or digital agriculture more specifically. This chapter focussed on the AKIS level, of New Zealand, and the relevant actors within it. The concept of *organisational identity* is used to describe both initial understandings of, and emerging responses, to digital agriculture, which together show how organisations digi-grasp, i.e. make sense of and enact digitalisation in their organisations. The organisational understanding is described using aspects of identity change (i.e. the nature, pace, source and context of digital agriculture), while the responses are outlined through the various attributes of organisational identity (i.e. capabilities, practices, services, clients, partners, purpose and values). These concepts are applied in the context of the New Zealand Agricultural Knowledge and Innovation System (AKIS), giving a first insight into the potential challenges that may occur as the boundaries of traditional AKIS roles blur due to digitalisation.

Chapter 2 looks at a variety of knowledge providing organisations, looking from 'inside-out': it is focussed on the perceptions and responses of a single organisation to digitalisation and reflects on what this means from a broader AKIS perspective. The chapter provides initial insights of what these individual organisations think digitalisation, or rather digital agriculture, implies for their relationship with clients and partners (e.g. suppliers, processors, consumers etc.). *Chapter 3* continues on that line and looks at the implications of digitalisation at the value chain level. It discusses the relation between *trust* and digitalisation in the context of the Dutch flower sector, aiming to provide a holistic understanding of the connections between trust and digitalisation. This chapter investigates how trust relations (interpersonal trust, trust development and institutional trust) affect digitalisation, and how digitalisation affects trust relations among value chain actors.

Chapter 4 continues to zoom out in terms of the scale, taking an agri-food systems perspective on digital transformation. The chapter aims to gain a better understanding and

anticipation of the often unknown impacts of the digital transformation process, as digital technologies are mostly seen as an opportunity to enable sustainable futures in agriculture and rural areas. However, the technologies and related transformation are not inherently good as it impacts on many aspects (e.g. economic, environmental, social, technological, institutional) and their relations. Building on the RRI approach, a framework was developed that allows insight on the relations between the social, the cyber and the physical dimensions of digital transformation, i.e. a *Socio-Cyber-Physical System* perspective to unravel how digital transformation plays out in the agri-food system and rural areas more broadly. Additionally, the conditions for digital transformation of such a system are also described (e.g. access conditions, design choices and system complexity). This framework, illustrated through an example of digital dairy farming, allows for a better problematisation of digital transformation, as well as a better understanding of who is responsible and /or accountable for the identified (positive or negative) impacts, i.e. *responsibilisation*. Thus, Chapter 4 addresses a weakness of RRI indicated by Blok and Lemmens (2015) on the problematic practical applicability of RRI due to a mismatch between the ideal of responsibility and the realities of existing innovation processes, by making it clearer who is responsible in what way, at different system levels.

Chapter 5 builds on this idea of the normativity of digitalisation. Digital transformation processes are, as said, not inherently good and in practice, digitalisation comes with trade-offs, whereby potential benefits and harm are not equally distributed. This chapter provides a broader conceptual reflection on digitalisation aiming to unravel how processes of digitalisation in agriculture may lead to *inclusion* and exclusion of people in the present or future, illustrated with examples from an European Union context. A broad variety of inclusion and exclusion factors are discussed across three levels: specific digital technologies; digital innovation packages; and the digital innovation system, linking with the conditions for successful digital transformation identified in the previous chapter. In doing so, this chapter breaks with the normative assumption that inclusion is always positive and exclusion always negative.

These four chapters lead to a concluding chapter, *Chapter 6*, in which the two sub-research questions will be answered, including cross-cutting themes, as well as reflections on this thesis involving (theoretical and policy) implications, limitations and suggestions for future research.

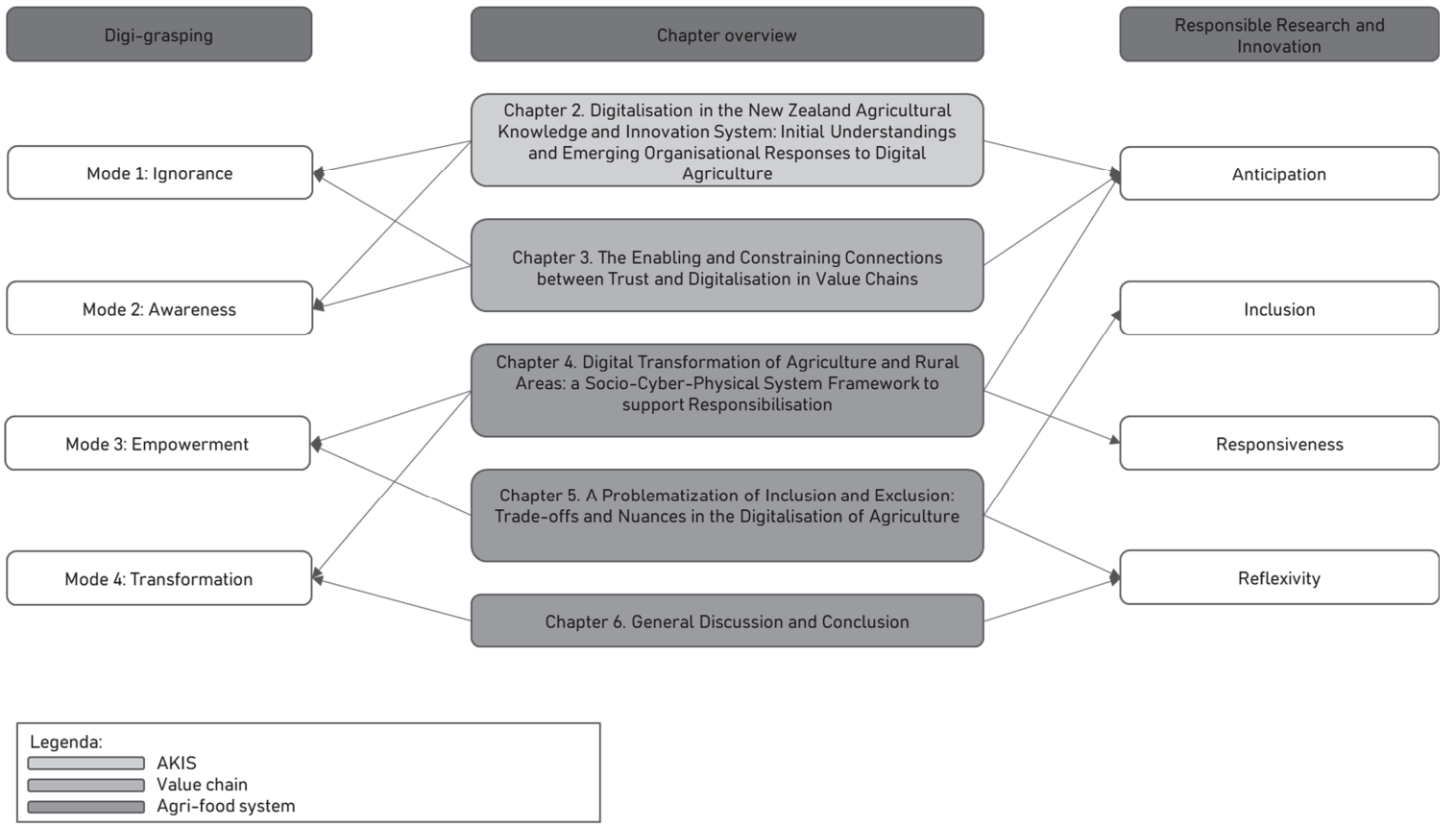

Figure 1.2 Overview of the thesis chapters and their connections to the two core concepts digi-grasping and RRI, as well as the system level to which these chapters predominantly focus (i.e. AKIS, value chain, and overall agri-food systems), which shows the nested nature of the analysis in the overall thesis.

Chapter 2

Digitalisation in the New Zealand AKIS: Initial understandings and emerging organisational responses to digital agriculture

Abstract

Digital agriculture is likely to transform productive processes both on- and off- farm, as well as the broader social and institutional context using digital technologies. It is largely unknown how agricultural knowledge providing organisations, such as advisors and science organisations, understand and respond to digital agriculture. The concept of 'organisational identity' is used to describe both initial understandings of and emerging responses to digital agriculture, which together show how organisations 'digi-grasp', i.e. make sense of and enact digitalisation in their organisations. The understanding is described using aspects of identity change (i.e. the nature, pace, source and context of digital agriculture), while the responses are outlined through the various attributes of organisational identity (i.e. capabilities, practices, services, clients, partners, purpose and values). We explore this question in the context of New Zealand through 29 semi-structured interviews with different types of agricultural knowledge providers, including farm advisors, science organisations as well as technology providers. The findings show that that digitalisation is often understood as farm-centric, despite being considered disruptive both on- and off-farm. These understandings influence organisation's digitalisation responses to digital agriculture. These responses were often ad-hoc starting with adapting organisational capabilities, practices and services as their clients and partners require, rather than a strategic approach allowing for more flexibility of roles and processes and to changing business models. This ad-hoc approach appears to be a response to uncertainty as digital agriculture is in early stages of development. This indicates that AKIS should better support agricultural knowledge providers as they digi-grasp and develop a digitalisation strategy, by anticipating possible futures and reflecting on the consequences of these for value propositions, business models and organisational identities of agricultural knowledge providers.

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2.1 Introduction

Agricultural knowledge and innovation systems (AKISs) have changed significantly over the last decades. In this chapter the focus is on agricultural knowledge providers, which are organisations in AKIS whose core business is the direct or indirect provision of knowledge for use by farmers and other actors in agricultural value chains (Klerkx & Jansen, 2010; Klerkx & Proctor, 2013). These include more obvious knowledge providing organisations such as research organisations and universities, advisory services providers, as well as agribusiness consultancies and technology providers, such as Google, Microsoft, Cisco and IBM. These companies provide for example (Big) data-based tools and other digital technologies, as well as corresponding knowledge-based services. They are emerging as a new provider of inputs and services to farmers (Eastwood et al., 2017b), alongside traditional providers of services and goods (seeds, animal genetics and health, fertiliser, agricultural advice (Nettle, Crawford, & Brightling, 2018; Prager, Labarthe, Caggiano, & Lorenzo-Arribas, 2016)). Furthermore, organisational forms such as multi-stakeholder platforms are also increasingly providing knowledge and information (Schut, Klerkx, Kamanda, Sartas, & Leeuwis, 2018), and can be considered networked organisational forms as opposed to more traditional organisation forms such as companies or state organisations (Provan & Kenis, 2007).1 Important developments in the past decades affecting agricultural knowledge providers include privatisation of research and advisory services, diversification of farming in terms of functions, production styles and entrepreneurial orientations, a need to address food safety and sustainability issues and increasingly the connected regulatory requirements, globalisation and financialization of agriculture (Faure, Desjeux, & Gasselin, 2012; Klerkx & Leeuwis, 2008; Klerkx & Proctor, 2013; Knierim et al., 2017b; Spoelstra, 2013). These developments have led to organisational changes and to larger repertoires of functions and roles for agricultural knowledge providers. Moreover the nature of knowledge provider activities changed from an expert role to broader facilitation and intermediation roles, aimed at fostering multi-actor innovation networks and knowledge co-production (Hall, Rasheed Sulaiman, Clark, & Yoganand, 2003; Knierim et al., 2017b; Koutsouris, 2014; Nettle et al., 2018; Turner et al., 2016). In view of all of these dynamics, there is a need for agricultural knowledge providers to continuously update both their subject-matter expertise, stakeholder collaboration competences, and advisory techniques to best support the agricultural sector in facing new challenges (Klerkx & Proctor, 2013; Spoelstra, 2013).

[1] Agricultural education providers are also part of agricultural knowledge providers but were not considered in this study.

One emerging global development likely to influence AKIS is the increasing use of digital technologies in the agricultural sector (Hajkowicz & Eady, 2015), which is part of a wider process called the digitalisation of the economy (Autio, 2017; Nambisan, Lyytinen, Majchrzak, & Song, 2017; Tilson et al., 2010; Yoo, Boland, Lyytinen, & Majchrzak, 2012), i.e. Industry 4.0 (Meyer, 2019; Sommer, 2015b), or Smart Industry (Team Smart Industry, 2014). In agriculture this has led to the emergence of so-called digital agriculture (also referred to as smart farming and agriculture 4.0), whereby digital technologies such as artificial intelligence, robotics, Big Data and Internet of Things (Alm et al., 2016), have increasing autonomy, combining monitoring, controlling and optimisation activities (Porter & Heppelmann, 2014). This likely results in decreased human involvement in terms of time and effort in operational activities and requires involvement at a higher level of intelligence (Kempenaar et al., 2016).

Undertaking digital agriculture thus involves large amounts of data, necessitating agricultural data science (Kamilaris, Kartakoullis, & Prenafeta-Boldú, 2017) which can offer new analytical possibilities and also produce new sorts of decision support tools for advisors (Antle, Jones, & Rosenzweig, 2017), as well as new services that connect to digital technologies (such as social media, mobile phone apps, drones, and robots) (Eastwood, Klerkx, & Nettle, 2017; Eichler Inwood & Dale, 2019; Frankelius, Norrman, & Johansen, 2017). Digital agriculture thus induces and requires a process of digitalisation of agricultural knowledge provider organisations. Digitalisation is often used to describe the socio-technical processes surrounding the use of digital technologies that impact on social and institutional context that require and increasingly rely on digital technologies (Tilson et al., 2010). According to Nambisan et al. (2017) digitalisation can change market offerings, business processes, or models through the use of digital technologies. In this study digitalisation is therefore defined as the process an agricultural knowledge provider goes through to become digitalised in order to support clients and partners moving to and operating in a digital agriculture context. It may lead to changes in subject-matter expertise and how knowledge is developed, delivered and expected of agricultural knowledge providers, and may also cause intra-organisational changes (Ayre et al., 2019; Kitchin, 2014; Shepherd et al., 2020).

Opportunities from digital agriculture for agricultural knowledge providers (i.e., through undertaking digitalisation processes) include, for instance, the development of platforms to enable supply chain actors access and insight into demand and supply of high quality products and processes; providing tailor-made advice and guidance to farmers based on their crops' responsiveness to fertilizers, herbicides and pesticides; developing tools for

both yield and demand predictions (Kamilaris et al., 2017), and rapid development of new information from multiple datasets (Shepherd et al., 2020). However, challenges of undertaking digitalisation processes have also been observed. These are often linked to data management, e.g. incompatibility or lack of standardisation of software and lack of data storage (European Innovation Partnership AGRI, 2015; Higgins et al., 2017); uncertainty around the value of data (Poppe et al., 2013); suitability of existing large databases (Eastwood, Klerkx, & Nettle, 2017); lack of trust in the quality of industry databases (Jakku et al., 2019; Minet et al., 2017; Roßmann et al., 2018); data ownership issues (Bronson & Knezevic, 2016; European Innovation Partnership AGRI, 2015; Poppe et al., 2013); and ethical implications (van der Burg et al., 2019a).

Despite these studies on opportunities and challenges of digital agriculture for agricultural knowledge providers, to date only some scholars have empirically studied the initial understanding of, and emerging digitalisation responses to, digital agriculture and how these shape functions, activities and roles of agricultural knowledge providers (Eastwood et al., 2018; Eastwood, Chaplin, et al., 2016; Munthali et al., 2018; Shepherd et al., 2020). However, these studies mostly look at changes in the professional identity of individuals, such as the changes in skills sets of knowledge providers or interactions with clients, rather than taking an organisational perspective. For example, Eastwood et al. (2019) indicate that individual agricultural knowledge providers need new skills in determining technology value propositions alongside farmers and or linking data for better decision making on farm. Likewise, Shepherd et al. (2018) identify the need for scientists to understand potential socio-ethical implications of digital agriculture alongside technical implications. This chapter aims to fill the knowledge gap regarding initial understanding by agriculture knowledge providers of digital agriculture and their emerging responses through potential digitalisation of their organisations. It investigates a range of agricultural knowledge providers from different agricultural sectors using an organisational point of view. We analyse the topic of emerging digitalisation responses of agricultural knowledge providers to digital agriculture through the lens of organisational identity. This enables us to move beyond the individual staff within agricultural knowledge provider organisations (Albaladejo, Couix, & Barthe, 2007) and their changing practices (Nettle et al., 2018), to consider the implications of digitalisation such as changes in organisational purpose and values as a whole, or new mixes of internal capabilities and formation of new partnerships with clients and other knowledge providers.

We focus on agricultural knowledge providers in New Zealand. On the one hand, New Zealand provides an exemplar case as it is argued that it is digitally advanced and exhibits high momentum. This means that the supply, e.g. infrastructure; and demand conditions, e.g. uptake, for digital technologies are promising, as well as the enabling institutional and innovation context, e.g. a policy-led digital strategy (Chakravorti & Chaturvedi, 2017). On the other hand, the agri-food sector is only recently contemplating the disruptive effects of digital agriculture and digitalisation (Kelly et al., 2017). In order to understand how digitalisation affects knowledge providing organisations we pose the following research questions: 1) How do different types of agricultural knowledge providers in New Zealand understand digital agriculture; 2) what are their emerging organisational responses in terms of digitalisation, and 3) how does this potentially affect their organisational identity?

The chapter proceeds as follows, we first provide an analytical framework linking insights from digital agriculture and digitalisation literature to the concept of organisational identity, which allows us to unravel several aspects of what digital agriculture and digitalisation implies for agricultural knowledge providers. This is followed by a description of the methods used to collect and analyse the data. The results are split into initial understandings of digital agriculture by agricultural knowledge providers and an overview of digitalisation responses to these understandings of digital agriculture by type of knowledge provider and the potential impact of these responses on their organisational identity. This is followed by a discussion and conclusion examining the findings and identifying implications for agricultural knowledge providers and AKIS more broadly.

2.2 Analytical framework: Structuring digitalisation processes through the lens of organisational identity

To respond as an organisation to the emergence of digital agriculture, agricultural knowledge providers will need to give attention to their own digitalisation process. In this section we will first describe organisational identity and aspects of identity change, followed by an outline of what the literature on digitalisation and digital agriculture has said about the impacts of digitalisation on organisations (section 2.2.2), after which we connect this to a framework of organisation identity in Table 2.1. Together, this provides an analytical lens to interpret and structure the empirical data.

2.2.1 Organisational identity and digital agriculture

To enable a structured analysis of how organisations are understanding and responding to digital agriculture and thus engage with digitalisation, we use the concept of organisational identity. Albert and Whetten (1985) have described organisational identity as that which is central, enduring, and distinctive about an organisation's character. It "…provides a guide for what an organisation's members should do and how other organisations should relate to it" (Gioia et al., (2013, p. 161, p.161). Organisational identity includes tangible and intangible attributes. Tangible identity refers to 'what things are done' and is semi-permanent as attributes are specific, tied to particular times and contextual conditions. The attributes of tangible identity can be further split into what have been called back-office and front-office activities (Labarthe & Laurent, 2013; Lyytinen, Yoo, & Boland Jr, 2016). Back-office activities are the capabilities of the organisation's members and the practices they perform on a daily basis, such as training advisors; technology monitoring; accumulating technical references, e.g. building and using databases, etc.; and the production of knowledge, e.g. through experimentation and R&D (Labarthe & Laurent, 2013), in order to meet the needs of their clients and partners by providing quality services. These services, clients and partners are considered the external facing activities, or front-office (Labarthe & Laurent, 2013). Intangible identity is the purpose and philosophy of an organisation, addressing 'why and how things are done' (Gioia et al., 2013). In line with Gioia et al. (2013) we operationalise intangible identity as the purpose and values of an organisation.

As described in the introduction, digital agriculture is a major driver of change in the New Zealand agricultural sector (Kelly et al., 2017), which in turn evokes and necessitates a digitalisation response by agricultural knowledge providers as the environment they operate in changes (further explained in detail in section 2.2.2). For organisations it is challenging to adapt and remain relevant in a changing environment, while at the same time keeping a level of stability for internal coordination of insiders, such as employees, and external interaction with outsiders, such as clients (Gioia et al., 2013). To be able to strike a balance between fluidity and sameness, it is essential to for organisations to understand what they are responding to, i.e. what is changing and what drives their change. Gioia et al. (2013) identify four aspects of change that affect organisational identity. These are: pace of change (shorter time horizons vs. longer periods, e.g. the time it takes to change), nature of change (continuous vs. discontinuous, e.g. are organisations at once taking up completely new activities or are the changes more subtle and incremental), source or impetus for change (internal vs. external, for example change of

organisations' management or government regulations) and context of change (such as technological changes, high-velocity environments, mergers) (Gioia et al., 2013). These aspects of change are used to structure agricultural knowledge provider understanding of digital agriculture, and show how this understanding provokes emerging responses in terms of organisational digitalisation. Making sense of change with regards to digital agriculture and digitalisation responses, can be considered part of a process referred to as 'digi-grasping'; understanding and making sense of the digital and physical world in its current state and to imagine alternative futures (Dufva and Dufva, 2018; Fielke et al., 2019). Digi-grasping is also about enacting change, and encompasses various stages of a digitalisation process: from simply replacing analogue technologies for their digital counterpart (e.g. from written farm data to having digital farm data which is also directly connected to knowledge provider databases), which is often referred to as automation, through to questioning the current situation, and considering alternative futures and implementing those. The latter stage can also be described as having reclaimed agency (i.e. using digital technology has become a means to an end rather than the end goal), and a position between the digital and physical interfaces (i.e. making conscious decisions about when and how to use digital technologies for what purpose) and actually shaping future developments, for example through actively developing online platform cooperatives (Dufva and Dufva, 2018).

2.2.2 The impacts of digitalisation on organisational identity

As argued in section 2.2.1, digital agriculture may trigger processes of digitalisation within organisations, and this may impact both tangible and intangible identity. This is a process of sensemaking and enacting changes, referred to as 'digi-grasping'. The literature has already reflected on effects of digitalisation and what 'digi-grasping' practically entails for tangible and intangible attributes of organisational identity. Sousa and Rocha (2019) argue that, to digitalise, it is necessary for organisations to modify internal capabilities through upskilling, and keep up with a fast-moving business environment. Changes in organisational structures and processes can occur by improving customer experiences through new interfaces; optimising internal processes using cloud computing or robotics; developing digital services; becoming more data driven; and creating an agile work environment using virtual teams (Cockburn & Highsmith, 2001; Kamilaris et al., 2017; Snow, Fjeldstad, & Langer, 2017). Moreover, it has been argued that digital agriculture means the needs of, in this case agricultural knowledge providers' clients, e.g. needs of farmers or other agricultural actors, are becoming more heterogeneous, because digital products and services are not limited to a specific form or function (Koch & Windsperger,

2017). This necessitates digitalisation by knowledge providers to deliver 'tailor-made' services, developed with strong involvement of the client (Leminen, Rajahonka, Westerlund, & Siuruainen, 2015), for example through increasing joint, e.g. knowledge provider and client, processes of data gathering and analysis (Karpouzoglou et al., 2016; Voinov et al., 2016), or forms of citizen science and crowdsourcing (Buytaert et al., 2014; Minet et al., 2017). Clients thus become potential collaborators, which may affect the organisational identity (Gal, Lyytinen, & Yoo, 2017), as it for example supports moving towards new, customer-driven, rather than product-driven, business models (Kiel et al., 2017; Koch & Windsperger, 2017; Teece & Linden, 2017).

The literature on the influences of digitalisation on organisations indicates that it implies a period of exploration of potential implications and opportunities for organisations, the so-called 'fuzzy front-end of innovation', which can be chaotic, ill-defined, and difficult (Berghaus & Back, 2017). While there are different strategies to manage the fuzzy front-end of digitalisation it seems to require a high level of flexibility from an organisation (Berghaus & Back, 2017; Tate et al., 2018). This requires organisations to keep up with, and integrate, digital technologies into their organisation while continuing to use current methods and knowledge (Dougherty & Dunne, 2012a), thus having to adapt their practices, skills, and roles (OECD, 2016; The Economist, 2016; Tumbas, Berente, & Brocke, 2018) to remain relevant and avoid potential redundancy of expertise and services (Hirst & Humphreys, 2015b).

Taking the insights from section 2.2.1 and 2.2.2 together, Table 2.1 shows the operationalisation of organisational identity attributes, the meaning of each attribute and how the digitalisation process may impact on organisational identity attributes. We use the framework in the following way: first we use the four aspects of change affecting organisational identity to gain more insight into organisations' understanding of digital agriculture as an influence on digitalisation in their organisation. This will allow us to better understand the emerging digitalisation responses of the agricultural knowledge providers, and how it potentially affects different tangible and intangible attributes of organisational identity. As this chapter is about initial understandings and emerging responses, we are not necessarily looking at completed or full identity change processes.

Table 2.1 Attributes of organisational identity (Albert & Whetten, 1985; Gioia et al., 2013) and examples of the potential impacts of digitalisation on these organisation identity attributes.

Organisational identity			**Description**	**Examples of potential impacts of digitalisation on organisational identity attributes**
Tangible identity	Back-office	Capabilities	Knowledge & skills within an organisation, made tangible through employee skills and their job descriptions	▪ Hiring new employees with 'digital' skills, e.g. data analysists (Sousa & Rocha, 2019) ▪ Upskilling of existing employees (Eastwood, Ayre, et al., 2019) ▪ Redundancy of 'non-digital' skills and expertise (Hirst & Humphreys, 2015a) ▪ New and changing roles and responsibilities, e.g. Chief Information Officer (Tumbas et al., 2018)
		Practices	Daily activities undertaken within an organisation, made tangible through services provided to clients	▪ Change in organisational structures, e.g. less hierarchical (Berghaus & Back, 2017) ▪ Broader range of skills/people involved in daily activities (OECD, 2016) ▪ Automation and digitisation of processes, e.g. reduction of human elements (Hirst & Humphreys, 2015a) ▪ Greater resourcing and activity related to data management (Roßmann et al., 2018) ▪ Data-driven decision-making (Eastwood, Ayre, et al., 2019; Tian, 2017) ▪ Shifting balance from 'old non-digital' to 'new digital' practises (Dougherty & Dunne, 2012b)
	Front-office	Services	Support of an organisation's clients, made tangible by the (economic) transaction between organisations	▪ New and/or improved services based on digital technologies and data, e.g. real-time farm performance data from sensors to provide location specific information about client farms (Eastwood, Ayre, et al., 2019) ▪ Ability to provide more modular services directed toward individual and specific client needs (Koch & Windsperger, 2017)

				▪ Ability to tailor-make services, e.g. adapt a basic service towards a client's specific needs (Kamilaris et al., 2017; Snow et al., 2017)
		Clients	Those paying for the services, made tangible by the transaction and interaction between organisations	▪ Blurring of boundary between client and provider, i.e. greater involvement of clients in business processes (Leminen et al., 2015) through usage of client data to improve and personalise services (Buytaert et al., 2014) and co-creation of new services (Karpouzoglou et al., 2016)
		Partners	Collaborating organisations, made tangible through the interactions between organisations	▪ Diversification of collaboration, e.g. involving technology providers or organisations with digital capabilities (Poppe et al., 2013; van den Broek & van Veenstra, 2018) ▪ Blurring of boundaries between organisations due to greater data exchange (Yoo et al., 2012).
Intangible identity		Purpose	Reasons and ambitions of an organisation. Intangible but expressed through the underlying organisational capabilities, practices, and services	▪ Cross-organisational collaboration mediated through digital technologies may affect the (intangible) identity (Gal et al., 2017) ▪ Automation, extension or transformation of business models (Li, 2020)
		Values	Principles and standards of an organisation. Intangible but expressed through employee practices and capabilities.	▪ A change in organisational culture change towards a more people centred, collaborative and agile working environment (Cockburn & Highsmith, 2001)

2.3 Methods

As indicated in the introduction, we studied the case of New Zealand. To assess how New Zealand agricultural knowledge providers understand and respond to digital agriculture, qualitative data was collected through semi-structured interviews with key individuals, i.e. the person within the organisation directly linked to, and responsible for digitalisation (e.g. Chief Information Officer, Team Managers) or for influencing or setting organisational strategic direction (e.g. Chief Executive Officer, Director, thought leaders). Semi-structured interviews were used to allow flexibility for both the interviewer to focus more on interesting comments and to explore these, and for the interviewee to talk about topics of interest, thus creating a more in-depth interview (Green & Thorogood, 2009). This support the research aim of exploring and gaining insight into the agricultural knowledge providers' understanding of and responses to digital agriculture.

Digitalisation means that a broad range of actors have made an entry to the 'agricultural knowledge market', including the 'traditional' research organisations; independent farm advisors, advisors tied to advising on particular services, products or goods, such as agricultural input providers (Klerkx & Jansen, 2010; Klerkx & Proctor, 2013, pp., p.13); as well as business to business consultants in the agricultural sector, multi-stakeholder innovation platforms, and technology providers (e.g., organisations which collect and process agricultural data on- and off-farm to develop and provide, for example, digital models and management programs to other knowledge providers, agri-businesses or directly to farmers). Increasingly technology providers not only provide technologies, but also collect data with these technologies, and are beginning to process this into usable information and knowledge to support decision making, i.e. to create additional value (Kelly et al., 2017).

In total 29 different knowledge providing organisations (see Table 2.2) were interviewed. The number of interviewees was determined by when saturation in responses occurred. The interviewed organisations can all be considered knowledge providers in the New Zealand context as they all provide knowledge directly to farmers or to other agricultural businesses (Ministry for Primary Industries, 2012). The interviewees ranged from applied research organisations (6); industry bodies (3); agricultural cooperatives (4); technology providers (4); universities (3); farm advisors (2); agri-business consultants (4); and multi-stakeholder innovation platforms (3). The latter category consists of one platform involving only science organisations whereby digital agriculture was part of the research focus, while the other two involved various types of actors to develop new technologies.

All three though are tasked with influencing improvements in agricultural production, and hence include stakeholder facing activities (e.g. knowledge dissemination or connecting with agricultural advisors).

The interviewees were CEOs/directors, managers of teams or departments, or for example scientists involved in digitalisation as project managers. While we are aware that these interviewees are not necessarily those within an organisation experiencing the consequences of digitalisation, and thus acted in a capacity of informants providing a strategic view, most of the interviewees were also aware of that and reflected on this during the interview. Interviewees were also asked what they thought it meant for a broad range of employees in their organisation. Additionally, after speaking to these interviewees it was clear that a lot of organisations were still in the early stages of digitalisation and therefore the full scope of consequences for the organisation was not yet visible. This is also reflected in our research question, looking at initial understandings of digital agriculture, emerging responses in terms of digitalisation by agricultural knowledge providers, and emerging implications for organisational identity of these potential digitalisation responses. Hence, in this chapter we do not seek to give a full indication of how organisational identities change due to digitalisation.

The aim was to interview a broad variety of organisations across different sectors (e.g. dairy, red meat, forestry, cropping and horticulture) to get an overview of how the understandings of digital agriculture shaped organisations' digitalisation processes across the whole agricultural sector. Although some organisations were involved in one agricultural sector (mainly the industry bodies and advisors), most organisations covered two or more sectors. The organisations were selected based on their interest or involvement in digital agriculture using the different sectors and type of knowledge provider as additional selection methods. The organisations were not selected based on a particular digital technology as we wanted to gain insight in what digital agriculture in broad terms may imply for organisational digitalisation and consequently their organisational identity, rather than the implications of a single digital technology on these. Most organisations, and interviewees, were identified within existing networks, followed by further snowball sampling.

The interview questions were informed by the analytical framework, while allowing space for other themes and issues to emerge. The interviews focussed on digital agriculture as a driver of change, i.e. described in terms of interviewee perceptions of the pace, nature, source and context of digital agriculture, how this is understood by the interviewee, and

what this means for the interviewee's organisation, i.e. the digitalisation responses and the emerging consequences for organisational identity. Thus, questions were asked about the process of digitalisation in the organisation; the reasons for undertaking this process in response to digital agriculture; if and how this changes attributes of organisational tangible and intangible identity, i.e. (types of) capabilities, practices, services, clients, partners, as well as the organisation's purpose and values. Finally, the questions also explored the challenges and opportunities of digitalisation.

The interviews were transcribed and sent back to the interviewees for approval. The analysis was done using the scientific software ATLAS.ti, using the analytical framework as the basis for the coding structure, with additional codes based on preliminary results. To give a clear overview of the responses of different types of knowledge providers the interviewees were further categorised as science organisations (both universities and public and private research institutes); farm advisory services; technology providers (e.g. global software companies as well as local specialist technology developers); and agri-business consultancies (which also engage with the other knowledge providers and agri-businesses other than farms). Most cooperatives and industry bodies are part of the advisory services category, while one cooperative and two of the three innovation platforms are digital technology providers. The third innovation platform was added to the science organisations category. One industry body fitted in the agri-business consultancy category (see Table 2.2).

Table 2.2 Overview of interviewees

Category	Type of organisation	Role	Interviewee identification
Science organisations	Public research institute	CEO	Scientist 1
	Private research institute	Manager	Scientist 2
	University	Director	Scientist 3
	Public research institute	Manager	Scientist 4
	Public research institute	Manager	Scientist 5
	Public research institute	Project manager	Scientist 6
	University	Manager	Scientist 7
	University	Director	Scientist 8
	Public research institute	Manager	Scientist 9
	Public innovation platform	CEO	Innovation platform 1
Farm advisory services	Cooperative company	Manager	Cooperative 1
	Cooperative company	Project manager	Cooperative 2
	Cooperative company	Manager	Cooperative 3
	Private advisory company	CEO	Advisor 1
	Private advisory company	Manager	Advisor 2
	Public extension organisation	Manager	Industry body 1
	Public extension organisation	Project manager	Industry body 2
	Public extension organisation	Project manager	Industry body 4
Technology providers	Public innovation platform	Project manager	Innovation platform 2
	Public innovation platform	CEO	Innovation platform 3
	Private company	Manager	Technology provider 1
	Private company	CEO	Technology provider 2
	Private company	CEO	Technology provider 3
	Private company	Manager	Technology provider 4
	Private company	Manager	Cooperative 4
Agri-business consultancies	Private advisory company	CEO	Advisor 3

	Private company	Project manager	Consultant 1
	Private company	CEO	Consultant 2
	Private company	Director	Consultant 3

2.4 Results

In section 2.4.1 the different aspects of change that affect organisational identity (nature, source, pace and context) (Gioia et al., 2013) will be shown in relation to knowledge providers' understanding of digital agriculture being a disruptive force inducing digitalisation responses in their organisations. Section 2.4.2 describes the responses of different categories of knowledge providers to digital agriculture, by describing their digitalisation responses and their perceived influence of digitalisation on each of the organisational identity attributes.

2.4.1 Aspects of change affecting organisational identity: Understandings of digital agriculture

Interviewees provided a spectrum of definitions of digital agriculture from having improved software and technologies while undertaking precision agriculture activities, through to a hi-tech fully automated farm, which can be monitored and controlled from a distance by the farmer (see Table 2.3 for a summary of the understandings). Most of the interviewees defined digital agriculture as somewhere in between; being more connected, e.g. using modern technologies, such as drones and sensors, to collect more data and sharing this data for better (on-farm) decision making.

The common thread was that interviewees all described digital agriculture as a change occurring on farms (i.e. farm/farmer-centric) and focussed mainly on the automation of current practices on farm. The link of digital agriculture with the value chain was often implicit or described in more general terms by the interviewees: different service providers, farm suppliers, or processors need to enable data collection, storage and analysis. This is illustrated by the following quote:

> *"Digital agriculture to me means more of industry level picture of data and devices and connectivity." (Industry body 2)*

These different data sources ideally need to be connected and shared, according to the interviewees, which will for example support tracking and tracing of products to ultimately meet consumer needs and market demands.

Nature of digital agriculture

All interviewees agreed that the nature of digital agriculture is to disrupt the agricultural sector, despite one interviewee clearly indicating that he did not know what this specifically will look like in the future, they all could see that digital technologies are already becoming more common place, particularly on- farm with more advanced tractors. Some interviewees thought that this may take over the current jobs of people, both on- and off- farm, although they did think there would always be a role for humans.

With regards to the knowledge providers, interviewees considered the disruption to mainly affect those going through the farm gate, such as farm advisors (see also section 2.4.2.). Technology providers are especially aware of the disruptive nature of digital technologies, but in general all knowledge providers have an intent to limit this disruption for themselves, as well as their clients and partners (see section 2.4.2). Whether digital agriculture is going to disrupt an organisation depended on the interviewee's level of engagement with digital technologies, as shown by this quote:

> *"I think the way I think you deal with disruptive technologies is that you engage early. Some of them won't run the distance, and some of them will. Which ones? Don't know. You've got to engage, you've got to stay neutral, stay open and you've got to embrace it. Best you do that, because if you don't you end up being subjected to them, and that is very difficult. So you just engage early." (Cooperative 3)*

Source of digital agriculture

Many interviewees suggested the main reason for agribusinesses, and especially on-farm, to get involved in digital agriculture needs to be the financial benefits of the digital technologies. Although interviewees do think that digital technologies would allow for more productive and profitable farms, and indirectly also for themselves, they are hesitant to commit to digital technology use as they also believe that there is no proven value proposition yet. Thus, the current drivers for undertaking digitalisation by knowledge providers are external (rather than internal business benefits) to farmers as well as agribusinesses. These external drivers include the need to have less impact on the environment, as well as meeting consumer and government demands. Besides the external drivers, the interviewees point out that a small subset of farmers are considered to have more confidence regarding digital agriculture, as the following quote demonstrates:

"I think that the really good farmers will be leading the pack because those are the guys who are well informed. … there are different groups and I like the definitions of them, some of the first group are called confident self-movers. You know they have the confidence. So [farmer] for example would fit firmly in that category, he's confident in what he's doing." (Cooperative 3)

The overall farm-centric perception of digital agriculture inherently means that it is an externally driven change for the knowledge providers, i.e. if there are changes that farmers are (involuntarily) subjected to, the organisations surrounding the farmer must also adapt to provide support to enable farmers to deal with these changes. This perception of externally driven change appears to be partly influenced by most of the interviewed knowledge providers not developing digital technologies themselves.

Pace of digital agriculture

The timeframe in which digital agriculture is expected to become commonplace varied among interviewees, ranging from 'within 5 years' to 'maybe in 40 years' time', regardless of peoples' background and knowledge of digital technologies. The interviewees who thought near-term were often thinking about the decreasing cost of technologies such as sensors, and the technological progress of individual technologies. While the lack of connectivity and interoperability where of concern to most interviewees, some long-term thinking knowledge providers indicated that the pace of change has more to do with individual and organisational roles in the value chain and AKIS than the technology itself:

"Well, not only do you have to get the science and the experience packaged up in a way which works in the software, you've actually got to make everybody that's in the current chain comfortable with the fact that it is not going to put them out of business. […] You know the agronomists will be concerned that if you could do all this online you won't need agronomist anymore. And so, they'll fight, to not get knocked out of the chain. […] And so, I think it's probably three years on technology and 17 on humans." (Multi-stakeholder platform 3)

Context of digital agriculture

The context in which digital agriculture in the New Zealand takes place is one of increasing consumer demands, regulatory drivers and the 'social license to operate'. Interviewees said digital technologies could make it easier for farmers to comply (or prove compliance) with environmental regulations; improve and monitor health and safety on-farm; and

adhere to animal welfare requirements. This in turn would help to meet (overseas) market demands and consumer needs, for example through traceability, and hence being able to provide a premium product, while leveraging New Zealand's 'clean, green image'. The following quote is an example of the impact of regulatory drivers:

> *"It is when things start really hitting industry, such as environmental and welfare regulations, where there is compliance necessary for you to be given the right to farm, which will come into New Zealand increasingly. Where the ability to use digital agriculture to measure, mark, monitor your livestock right through to the consumer will really become important." (Scientist 7)*

On the other hand, the already existing urban-rural divide and how digital agriculture might exacerbate that provided some concern. The challenges mentioned were the decreasing population in rural areas due to job loss, and the impact of digital agriculture on the rural networks and landscape. Other interviewees considered interpersonal relationships to still be important in the future and thought that digital agriculture may solve the existing problem of finding skilled farmworkers. Above all, most interviewees considered a natural progression towards digital agriculture through a generational shift of farmers.

Table 2.3 Summary of understandings of digital agriculture by interviewed agricultural knowledge providers in relation to aspects of change affecting organisational identity

Aspects of change affecting organisational identity	**Understanding of digital agriculture**
Nature	A farm-centric view of where digital agriculture will have the greatest impact. Linked to specific digital tools, e.g. drones, sensors, etc., rather than overarching digital technologies such as block chain, IoT, machine learning. Digital agriculture is seen as disruptive for the agricultural sector, and advisors saw their role as supporting farmers through this change. Some knowledge providers saw themselves, as becoming a disruptor, and driving the changes from digital agriculture in a direction that suits them and their farmer clients.
Source	The sources of change in the sector are mainly external drivers for farmers, i.e. meeting government requirements and consumer needs through digital technology, instead of internally driven by financial

	benefits or confidence. These drivers for farmers then form an external driver for knowledge providers to respond to.
Pace	There are various views amongst knowledge providers, but in general they expect digital agriculture to rapidly evolve, due to a decrease in costs of digital technologies. Although uptake might be hampered by slow-moving people and organisations.
Context	Digital agriculture is part of a wider set of challenges around the urban-rural divide, improving animal welfare, and meeting international market requirements. Digital technologies were perceived as supporting solutions to these challenges, as well as creating more challenges.

2.4.2 Responses to digital agriculture by agricultural knowledge providers

In the sections below the knowledge provider responses to digital agriculture, and how it affects their digitalisation process are described for each category of knowledge provider identified in New Zealand (science organisations, farm advisory services, technology providers and agri-business consultancies). For each knowledge provider category the digitalisation responses are described in terms of their perceived influence on organisational identity attributes, and are summarised in Table 2.4.

Science organisations' digitalisation responses to digital agriculture

While there is general acknowledgement among the science interviewees that biophysical knowledge remains critical in their work, they expected a need for new digital capabilities to continue to do science. Albeit the type, level and urgency of need for new capabilities varies across organisations, departments and disciplines, it is generally seen to have implications for the practices and services of science organisations. Becoming more data driven, for example, implies new and different methods for collecting and analysing trial data, using data science as an additional discipline. It also allows for presenting and packaging the trial results into new tools and technologies, e.g. an app.

Despite recognition of the need for new capabilities, a change in practices and updated services, the science interviewees were aware that their organisation's digitalisation process is slow. Although some pointed out that in most science organisations there are, however, individuals or pockets of scientists that are quite digitally advanced. This sometimes included themselves. The scientists said the general low uptake is due to a lack of scientists' understanding of digital technologies, who may therefore feel

threatened by it, but also the general lack of investment in, or funding for, research that hampers the development of new skills or purchase of the required technologies.

At the same time the science interviewees did not see these low levels of digitalisation as problematic for current and future collaborations with clients or partners. If anything, it brings more opportunities to involve new types of stakeholders with different skill sets, such as start-ups and technology companies. The low levels of digital technology knowledge and uptake by science organisations were also mentioned by other knowledge providers, who, found this more problematic. They recognised that either they themselves or their clients are ahead of science in their digital technology use, or that they need answers to particular (technological) problems faster than science is currently able to provide them.

The science organisations saw no changes regarding their purpose and values because of digitalisation. Especially the research institutes, who saw their purpose as supporting New Zealand agriculture, and wanted to continue to deliver excellent science, regardless of the technologies required to do so, as indicated in this quote:

> *"…the short answer is no. Because us being a [research institute], our core purpose is to enhance the value of New Zealand's natural resources. And so this is consistent, even if technology changes, that will always be our goal." (Scientist 1)*

Farm advisory services' digitalisation responses to digital agriculture

The farm advisory services category encompasses independent advisors, cooperatives and industry bodies. Each of the interviewees did see it as their organisation's job to inform and support farmers in implementing the latest digital technologies, but they were also aware that the type of work they do will change. They could foresee different types of practices and services, or even roles, for advisors in the future. One, more operational, role for example is to advise farmers which technologies to use on farm and how to use them. Another role would be to also set and develop the requirements for future technologies, ensuring that they add value on farm. Overall it was deemed necessary to gain more knowledge of digital technologies to provide more strategic advice and support to farmers in choosing and implementing technologies.

Independent advisors themselves still value the personal relationship with farmers, but at the same time know that the way they communicate with farmers will change. They expect the team around the farmer to become more collaborative, e.g. meetings with the

farmer, advisor, bank or accountants at the same time. Moreover, the communication would become more efficient allowing advisors to serve more clients, as there is less time spent traveling to farmers and collecting basic farm information before discussing management options with farmers. This is illustrated by the following quote:

> *"And I would love it if we could have video conferences with our farmers. Because some of them, it is a two-hour drive, particularly in the South Island. It could be three or four hours. And you know it is not only a lot of costs and time for us, it is also unproductive time. So with a video conference, with [digital platform x], and probably even with some live video feeds of the farm, there is a lot we can do remotely. I don't think it ever replaces going on farm some of the time, it may be that I am out on farm three or four times a year, and dialling in the other three to four times a year." (Farm advisor 2)*

The cooperatives tend to take more of a technology development approach instead of specifically focussing on relationships. This is often to improve internal processes of the organisation and might go unnoticed by their clients. At the same time cooperatives, in collaboration with start-ups and technology companies, develop their own technologies often in the form of an app, to package information so that it is readily accessible to farmers, thereby aiming to reduce a lot of the more menial tasks of farmers and supporting farm management tasks. These technologies might also be used by other types of advisors, hence resulting in new business models for cooperatives and advisor-cooperative collaborations.

Making the required changes to benefit from digital agriculture was expected to be easier for the cooperatives than for independent advisors as the former already provide on-going training to their staff members on a variety of topics, while the latter tends to lack time and resources to learn about the emerging digital technologies as they often need each worked hour to be billable time. Another reason mentioned by all farm advisor interviewees, as well as other knowledge providers, which would hamper the upskilling of independent advisors was the relatively high average age and therefore the lack of willingness or flexibility to change compared to those working for cooperatives and industry bodies. Even though the independent advisors interviewed mentioned the challenges of age and flexibility too, they did not necessarily include themselves or their organisation. Thus, there appears to be a difference in how this was perceived for individuals versus collectives, which is like how the scientists' perceived their own and their organisation's level of digitalisation. Despite these challenges only a few

interviewees thought that the relevance of independent advisors would decrease in a few years. Several interviewees thought digitalisation could furthermore help with the training of younger (independent) advisors and make the profession more appealing.

The industry bodies, on the other hand, did not seem to be concerned about their own skills and capabilities regarding digital technologies, but were more concerned about the capabilities of farmers to deal with digitalisation. In order to upskill farmers, the industry bodies' practices and services will need to change. They indicated that they would need to have a better understanding of farmers' technological needs and knowledge. This would also lead to a different way of communicating with farmers through, for example, personalised websites and tailored apps. Moreover, they saw it as their role to assess the relevance and added value of a broad spectrum of technologies and brands to maintain their impartial or objective position.

Like the science organisations, the new capabilities, practices, services or partners were not expected to influence the purpose or values of the different types of farm advisors. They still aimed to enhance the production and profitability of their clients in a sustainable way through quality advise and products. This was also mentioned by a cooperative's employee:

> *"... we are a cooperative, so the reason for us being is actually supplying products on time to farmers at a reasonable or low cost and in spec. ... However, our purpose you could say, and it is what we advertise ourselves as, is creating the best on earth. So trying to actually add real value to our customer, but at the end of the day it still comes back to those three guiding principles of why we are here." (Cooperative 2)*

Technology providers' digitalisation responses to digital agriculture

The technology providers category covers a spectrum of organisations. There are incumbent agriculture-oriented organisations that have always supplied technologies to farmers (e.g. milk meters or farm management systems) and within recent years have moved into the digital space. There are also companies that have always been involved in modelling of farm processes and are moving into the big data space. Then there are the multi-stakeholder platforms that were set up to develop new digital technologies for the agricultural sector. And at the other end of the spectrum there is a technology provider that has started to move into the agricultural sector.

Due to this variation the capability needs are quite different. At the more traditional end of the spectrum keeping up with the technology and finding the right people has proven to be challenging, while at the other end of the spectrum the technological capabilities are not really of concern. The following quote is an example of the former perspective:

> *"We knew that we needed to build a team, so we're trying to transform ourselves into a much more digitally fit organisation essentially because we had to. […]. And in essence what we've had to do is go on the market and in New Zealand in particular those skills are in short supply. And so, it took us a long time to build a team and to get the leadership." (Technology provider 4)*

All technology providers acknowledge the need to understand the biophysical and agricultural context in which they operate. However, some prefer technological and digital capabilities and assume that the agricultural knowledge can be taught, whereas others know that they will need to hire the technological capability but stick to their agricultural background.

Besides the agricultural and technological capabilities, a few technology providers also indicated the importance of soft skills, as shown in the quote below. These skills involve interacting and collaborating with partners and clients to understand their problems and needs (even if the partners or clients do not), to build fit-for-purpose technologies and create the right user experience.

> *"I think that we have a role to play in how you transform the knowledge as well. … So, it's not about coming in with a kit bag of tools, even though we are rich with lots, and predetermining that that tool in my bag is going to solve that problem and it's not coming in with that fixed mind set." (Technology provider 1)*

Changing capabilities and roles also implied gradually changing practices and services, from the type of technologies needed to develop the digital products and the communication about, or roll-out of, those products towards clients. The incumbent agricultural technology suppliers and the modelling companies have gradually moved towards digitalisation. Before they were transforming analogue data into digital formats or focussing on automating processes. Digitalisation for technology providers is now about building on those two activities and "digitalise things we kind of did in our head with

intuition", i.e. the next level of data analysis, using artificial intelligence and machine learning.

The actual products and services of these technology providers often tend to be more focussed on farm advisors and other knowledge providers, rather than on the farmer. Technology providers indicated that they do not (want to) fulfil the role of the (mainly independent) farm advisors, but that they collect a lot of data that can impact farm advisors both positively and negatively. Positively in that farm advisors can use the tools to give more strategic advice (see also 4.2.2), but negatively in the way that farm advisors might become redundant. Although the latter seems to depend on the farm advisor's willingness to engage in digitalisation, as most technology providers are keen to collaborate and provide more tailor-made services. Hence, they support all types of farm advisors with tools that allow for an integrated farm systems overview by linking different technologies and data sets together, which ideally can also be used at a basic level by a farmer.

Despite the growing opportunities, the technology providers are aware of technological limitations, such as connectivity and interoperability. In addition to that they see international technology companies moving into the agricultural sector as a new opportunity, which may provide new opportunities, but can also be threatening for market positions. On top of that it is also challenging for technology providers to keep up with the latest digital technologies, or maybe more so as they are more aware of the fast-moving pace of technology compared to the other knowledge providers. For these reasons the technology providers said they wanted to continue with and expand their own niche products and services, while seeing the challenges as an opportunity to collaborate and integrate with other technology providers, including start-ups, and other companies.
With regards to the purpose and values, the technology provider category reacts similarly to the other knowledge providers. They said that it is not why they do what they do (e.g. increasing the efficiency and effectiveness of their clients) that will change, but how they will do it. Even if that involves changing their core business from developing technological products to providing data services, using those products.

Agri-business consultants' digitalisation responses to digital agriculture

The interviewed agri-business consultants undertake several different activities from providing advice to the wider agri-business sector, informing government policies, or being part of collaborative research projects. Often, they also have (in-direct) links to

farmers through the agri-business clients (e.g. suppliers, processors, etc.) they work for. The consultancies range in size and focus but all are involved in providing some fore sighting advice to their clients and/or partners. Some of the consultants do that through (supporting) technology development or bringing together different data sources to inform clients and end-users of technologies. The size as well as the focus of the consultancies creates variability around the digital capabilities they have in-house.

Notwithstanding the variation among the consultants, all see that in the future their work is going to be more collaborative, i.e. involving their partners and clients as well as end-users in the development of, or advice about, products and digital technologies. While they do not necessarily want to develop these tools themselves they perceive their role to be in supporting others in their innovation processes, in which joint learning and capacity building seem to be key foci. The consultants are aware that digital tools can help them to support others and to support collaboration and learning. They are also aware that this requires a change in the way they organise themselves and their practices, in a more 'agile' way for example. Below is an example of the increasingly collaborative nature and the focus on capacity building:

> *"The type of work that I do is highly collaborative, so in my different roles I tend to be very collaborative with research programs or different organisations. […] so I have a portfolio of projects, which span private and public sector. In some I'm involved in research programs, and other I'm involved in providing innovation capacity to companies." (Consultant 2)*

While the consultants do foresee some changes in the relationship with current clients and partners, they do not think that their existing clientele will rapidly change. The consultants are on the look-out for opportunities and use their existing contacts to expand their network. However, this sometimes creates challenges with competing clients/partners around data sharing and interoperability.

For this category of knowledge providers, it also turned out that despite the changes in their activities they did not expect any changes in their purpose or values, if anything digital technologies are helping them to better achieve their purpose. Digitalisation is supporting consultancies to be more adaptive and responsive towards client's needs, by updating their practices and services, hence allowing them to be innovative and provide added value to their clients.

Table 2.4 Overview of emerging digitalisation responses of agricultural knowledge providers to digital agriculture described per attribute of organisational identity

	Tangible identity					**Intangible identity**	
	Back office		Front office				
	Capabilities	*Practices*	*Services*	*Clients*	*Partners*	*Purpose*	*Values*
Science organisations (n=10)	A need for new capabilities, such as data scientists, and more collaboration across disciplines.	New practices are slowly developing. The uptake of digital technologies varies per discipline, department and organisation.	Initial focus on internal collaboration around data science. Services towards clients (mainly agri-business) appear to not be anticipated to change much yet.	The clients, and their questions, appear to not have changed yet. However, there is an inability to serve frontrunners in digital technology.	First steps towards collaboration with technology companies and start-ups have been made.	Continue to focus on supporting and improving New Zealand's agricultural production, profitability and sustainability.	Continue to deliver excellent agricultural science with integrity in a transparent way.
Farm advisory services (n=8)	Upskilling is going to be necessary but challenging, especially for independent farm advisors.	Making use of digital technologies will change communication processes with farmers and allows for more collaboration	All advisors move towards more strategic advice, with different focus points.	Communication with clients will become more tailor-made. Spending less time face-to-face with the farmer.	Cooperatives already have collaborations with technology companies and start-ups. Independent advisors and industry bodies	Continue to focus on enhancing the production, profitability and sustainability of their clients.	Continue to deliver quality advise and add value to their clients via their products and decision support tools.

		with other farm advisors.			to a lesser extent.		
Technology providers (n=7)	Digital and agricultural knowledge is present in various degrees. More emphasis on 'soft' skills.	A shift in focus from technology development towards decision support and data analysis.	Adapting towards tailor-made services and focus on client needs rather than developing a one-size-fits all technology.	The focus is primarily on supporting and collaborating with farm advisors (or other knowledge providers).	Despite high levels of competition, the aim is to collaborate with start-ups or global technology companies.	Continue to focus on increasing the efficiency and effectiveness of their clients through technology.	Continue to develop quality products.
Agri-business consultancies (n=4)	No explicit focus. Increasing awareness and knowledge on the impacts of digitalisation for other businesses.	Making use of digital technologies internally in order to support others.	The content is moving towards digitalisation, using digital tools to support joint learning and capability building.	Opportunities to gain new clients facing digitalisation challenges.	Opportunities to work with technology companies to expand their services.	An expectation that digitalisation will support the purpose of increasing efficiency and profitability of their clients (agri-business).	An expectation that digitalisation will support the existing values of delivering quality information, strategy development and company support.

2.5 Analysis and discussion

Below we reflect upon the findings in view of our main research questions: 1) How do different types of agricultural knowledge providers in New Zealand understand digital agriculture; 2) what are their emerging organisational responses in terms of digitalisation, and 3) how does this potentially affect their organisational identity? Using the concept of digi-grasping (Dufva & Dufva, 2019) in this reflection, we first distinguish how agricultural knowledge providers engaged with the topic of digital agriculture (research question 1). Then we reflect on how this is linked and led to digitalisation responses at organisational-level for the different types of agricultural knowledge providers (research question 2), comparing our findings to the existing literature. This is followed by a reflection on the implications for different tangible and intangible attributes of organisational identity (Gioia et al., 2013) (research question 3). Lastly, we draw out broader overall theoretical and policy implications for individuals, organisations and the wider AKIS.

2.5.1 Initial stages of digi-grasping: a farm-centric understanding of digital agriculture limits a comprehensive approach to digitalisation

Using the four aspects of change affecting organisational identity to gain insight in the understanding of agricultural knowledge providers of digital agriculture which may induce digitalisation processes in their own organisations, the findings show that digital agriculture was often defined in a farm-centric way; referring to the on-farm use of digital tools such as drones, sensors and GPS, i.e. automation and efficiency improvements. The results (see Table 2.3) also show that there was agreement that digital agriculture is disruptive (*nature*) and that the drivers for ensuing digitalisation responses are mainly external *(source*), because the *context* of digital agriculture is the social and regulatory requirements of farmers. In addition, the investigated knowledge providers do not seem to consider implications of digital agriculture for other agricultural value chain actors. Other known drivers for digitalisation, such as (technological) newcomers and start-ups affecting the whole agricultural value chain (Kamilaris et al., 2017) were not considered as part of the context by interviewees.

The findings indicate that at a high level the expectations of digital agriculture were quite unequivocal across the agricultural knowledge providers, e.g., similar understandings that digital agriculture could lead to more productive, profitable and sustainable farms, although this was yet to be proven with a value proposition. However, the variation was in

the details: there were for example very different views on the *pace* of change, the level of disruptiveness and how this was valued. The pace ranging from a couple of years to two decades, and disruptiveness went from being an opportunity for larger organisations to a threat to independent farm advisors. This variation, in combination with the farm-centric focus, indicates that the understanding of digital agriculture by agricultural knowledge providers is partial. The organisations can foresee and expect changes on farm and in the wider agricultural sector, but there is no clarity, let alone a shared perspective, on the details of the unfolding of digital agriculture at farm, organisation or sector level.

This partial understanding of digital agriculture hampers the related and required digitalisation process within knowledge provider organisations, and suggests that they are at early stages of digi-grasping (Dufva and Dufva, 2018) or what has been referred to as the 'fuzzy front-end of digitalisation' (Berghaus and Back, 2017). The challenge of comprehensively grasping digital agriculture and the related digitalisation process by agricultural knowledge providers in New Zealand is on the one hand understandable as digitalisation equals the continuous, fast moving and challenging development of digital technologies (Nambisan et al., 2017; Yoo et al., 2012). The agricultural context adds its own challenges to that, such as the diversity of farm size, management and systems, and complicated parameters like climate and livestock (Bos & Munnichs, 2016; Bronson & Knezevic, 2016; Kamilaris et al., 2017; Wolfert, Ge, et al., 2017). On the other hand a lot of the challenges of digitalisation – including in agriculture -, such as data management, are already known for years and well described in the literature (Bronson & Knezevic, 2016; Cooper & Green, 2015; European Innovation Partnership AGRI, 2015; Higgins et al., 2017; Magee, Lee, Giuliano, & Munro, 2006; Minet et al., 2017; Philip Chen & Zhang, 2014; Poppe et al., 2013; Tractenberg et al., 2015), but have not consistently dealt with by the agricultural knowledge providers in New Zealand included in our study. Nonetheless there do seem to be tentative responses by agricultural knowledge providers towards dealing with digital agriculture, which are discussed next.

2.5.2 Tentative digitalisation responses as a further enactment of digi-grasping

The findings indicate that the first digitalisation response required by organisations was upskilling or hiring new *capabilities*. There is willingness and perceived necessity for having digital capabilities, especially around data management (e.g. collecting, storing and analysing data), by the knowledge providers. While at the same time deciding what capabilities are needed, how to develop them, or where to find them, has proven to be a

challenge for all types of knowledge providers, but even more so for smaller independent farm advisors. The cost of developing or hiring capability is a barrier for them, which might cause them to consider further collaborations with more digitally capable organisations. This, however, is not (yet) common practice.

Changing organisational *practices* is a logical consequence of changing capabilities and the implementation of digital technologies. Berghaus and Back (2017) show that this is an essential but difficult step in the fuzzy front-end of digitalisation, requiring everyone in an organisation to be involved and to collaborate. In line with what Berghaus and Beck (2017) state, changing practices was also deemed difficult by the knowledge providers in our study. The knowledge providers foresaw that changing practices would entail more collaboration both internally and externally (see also Table 2.4). This collaboration was described as new ways of communicating with clients and partners as the basic level, but more likely it would mean involving (new) clients and partners in both the development and execution of tailor-made services. Interestingly while this is what the knowledge providers expect to happen, it was often not yet part of their actual practice. While some collaborations with clients and new sorts of technology companies took place, new collaborative platforms for digital business models as described in the literature (e.g. Koch and Windsperger, 2017; Teece and Linden, 2017, see section 2.2.1) are still limited. This is in line with findings of Eastwood, Ayre, et al. (2019) who also had found that New Zealand farm advisors were already actively upskilling for dealing with digital agriculture.

The digitalisation responses thus far can be described as emerging and tentative for most organisations. Only a few organisations are more advanced and strategic about their digitalisation process, while the majority still operate in an ad-hoc manner and at the level of expectations. In the next section we further explore what these tentative changes may imply for the organisational identity of agricultural knowledge providers.

2.5.3 Organisational identity change is still fragmented and in flux

As shown in the results section and discussed in sections 2.5.1 and 2.5.2, while early digi-grasping is taking place and tentative digitalisation responses exist, digitalisation is not yet at the core of the organisations. It is not yet a consistent part of the *front-office* tangible identity attributes (services, collaboration with clients and partners), nor the intangible identity (purpose and values). Actual new services to clients seem to be relatively limited and still in development for many agricultural knowledge providers. The

changes that do take place are often linked to the *back office*, e.g. creating more efficiency through new capabilities and practices. Despite the fragmented changes related to different organisational identity attributes (see also Table 2.4) and common absence of a digitalisation strategy the knowledge providers all felt that their organisation is (in the process of being) ready for digital agriculture, based on their own understanding.

The ad-hoc organisational changes show that the organisations are only able to deal with the uncertainties of digital agriculture and the related digitalisation process by 'colouring within the lines' and the nature of change is hence seen by most knowledge providers as continuous as opposed to discontinuous (Gioia et al., 2013), which would be in contrast with the often perceived disruptiveness of digital technologies (Bronson and Knezevic, 2016; Kelly et al., 2017; Nambisan et al., 2017; Yoo et al., 2012). In other words, most New Zealand agricultural knowledge providers in our sample are not yet making any radical decisions and exploring new options, but continuing to exploit current activities and gradually changing them. It appears that knowledge providers in New Zealand are maintaining a balance toward sameness, especially in the interaction with clients and partners. There were fewer examples of organisation's being completely fluid to remain relevant in a changing environment. This indicates that one cannot yet speak of a full organisational identity change but that this is still in flux.

2.5.4 Implications for AKIS

As earlier studies have indicated, digital agriculture and digitalisation more broadly provides the opportunity to develop new services and allow for new players within AKIS (Allen & Wolfert, 2011; Ayre et al., 2019; Eastwood, Ayre, et al., 2019; European Innovation Partnership AGRI, 2015; Evans, Terhorst, & Kang, 2017; Fielke et al., 2019a; Lundström & Lindblom, 2018; Poppe et al., 2013). As we have discussed in section 2.5.1 to 2.5.3, in the New Zealand context this is seen as a gradual process of change, in which knowledge providers within AKIS are still coming to grips with this new reality and potentially disruptive and transformative force. Our study indicates several important points of reflection for AKIS to deal with this transition and support agricultural knowledge providers within AKIS in matching their organisational identity within the context of digital agriculture and digitalisation in general.

A first reflection is on how to upskill existing players in AKIS, accommodate new players in AKIS, and support existing players in dealing with and collaborating with these new

players. Besides the recognised need to support people in developing new values, capabilities and roles (i.e. support tangible and intangible organisational identity change), our findings also indicate the blurring of role boundaries, complementing findings of); Eastwood, Klerkx, and Nettle (2017) and Nettle et al. (2018) about the fluidity of public and private roles of knowledge providers in digital agriculture. For example, developing digital technologies by non-technology providers; advising to both farmers as well as agri-businesses on digitalisation at the same time by both advisors and consultancies; or coordinating industry leadership around digital agriculture by technology providers. Although this research did not focus on the individual-level, it is likely that developing new digital capabilities in-house, or engaging with new capabilities elsewhere, will consequently impact on the individual- and professional-level of employees. This could create resistance to change amongst the employees, as pointed out by Schilling et al. (2012) and Albaladejo et al. (2007). This, however, does not seem to be part of agricultural knowledge providers' considerations yet, as it was not mentioned by the interviewees.

This leads to a second reflection, that there are new ways of innovating and new topics of innovation to accommodate digital agriculture and digitalisation more broadly within AKIS, i.e., devising a digitalisation strategy. Despite tentative responses, the agricultural knowledge providers in our study lack a strong digitalisation strategy, and this may also be the case in other countries (see e.g. (Phillips, Relf-Eckstein, Jobe, & Wixted, 2019b). According to Teece (2018) and Teece and Linden (2017) having a strategy and reflecting on the existing business model is essential for capturing value from digitalisation. However, a digitalisation strategy also involves dealing with challenges of digitalisation (see section 2.1) and guiding processes such as creating data standards; resolving data trust issues; and generating new capabilities to upskill people to work in for example a data driven environments. These challenges may contribute further to the uncertainties created by the 'fuzzy front-end' of organisational innovation processes (Berghaus and Back, 2017; Parida et al., 2017; Scholz et al., 2018). This, it seems, is often taken for granted in the literature on digitalisation business models (Kiel et al., 2017; Leminen et al., 2015; Li, 2018; Teece and Linden, 2017).

Digital agriculture and digitalisation challenges existing boundaries between organisations, as the agricultural sector keeps moving towards a more data-driven, open innovation model. Developing a digitalisation strategy thus would benefit from coordination at the overall AKIS level. Following several authors (Bronson, 2018;

Eastwood, Ayre, et al., 2019; Regan, 2019a; van der Burg et al., 2019a) there needs to be organised reflection, incorporating anticipation of and responsiveness to the consequences of digitalisation of agriculture, for example including trust (in the production of) in technologies (Jakku et al., 2019; Rotz, Duncan, et al., 2019), data ownership and security (Bronson & Knezevic, 2016; Rotz, Duncan, et al., 2019), as well as inclusion of all relevant stakeholders to prevent growing inequality within the agricultural sector, e.g. the digital divide (Rotz, Duncan, et al., 2019). Rose and Chilvers (2018a) add that the specificities of digital agriculture require a systemic view that broadens the notion of inclusion, or a re-assessment of what have been called 'ecologies of innovation', incorporating new players perhaps uncommon to agricultural knowledge providers, such as technology firms. While initially this 'responsible' approach towards digitalisation in agriculture (Eastwood et al., 2017) will seemingly slow down progress of implementing digital agriculture, in time it is likely to support agricultural knowledge providers, as well as other stakeholders in AKIS, in their ability to digi-grasp and more rapidly navigate the fuzzy front-end of the digitalisation process.

2.5.5 Limitations

There were several limitations to this study, such as the low number of interviewed consultants and independent advisors and the mainly provider-centric views. Including views of clients or partners of the knowledge providers would give a more balanced picture of the changing organisational identities of knowledge providers.

Additionally, the concept of organisational identity, while it provided a useful perspective to analyse the digitalisation responses of various agricultural knowledge providers, created some challenges. Given the nature of the study not being longitudinal it was difficult to measure change in the actual organisational identity of the organisations. A more systematic approach over a longer time period is recommended for future work to provide a more concrete indication of identity change (an activity that could build upon the research presented here). Instead we used organisational identity conceptually to describe perceived changes by the interviewees, without the need for a benchmark. The distinction between purpose and values as attributes of intangible identity, however, did not prove to be as clear-cut within organisations. Moreover, these attributes seemed to have a high-level and longer-term orientation and were therefore more permanent, but at the same time open enough for interpretation under new circumstances. A first indication of changes in interpretation of the intangible identity was the fluidity of roles

and the existing overlap between the four categories of knowledge providers (science organisations, on-farm advisor, agri-business consultants, and technology providers). Adding *roles* as an intangible identity attribute would further strengthen the analysis.

A similar issue occurred with the distinction between different drivers for digitalisation. The *source*, *nature*, and the *context* of identity change were overlapping, because digitalisation is as much a consequence of change as it is a cause of other changes. This makes it even more complicated for knowledge providers to digi-grasp.

2.6 Conclusion

The aim of this research was to gain insight into the understandings and emerging responses to digital agriculture of different types of New Zealand agricultural knowledge providers. The findings show that understanding of digital agriculture is at an early stage, with limited digi-grasping by which digital futures are being explored and interpreted. Consequently, digitalisation processes within agricultural knowledge providers are at the fuzzy front-end with many uncertainties. This means that digitalisation responses often only involved changing capabilities and related practices and services in an ad-hoc manner. These initial responses did not lead to a change in the purpose and values of an organisation, thus the organisational identities of the agricultural knowledge providers appeared to remain the same.

Agricultural knowledge providers being only in early stages of digi-grasping indicate the need for strategic thinking within organisations about the digitalisation process, so that responses are no longer stand-alone, ad-hoc and mainly linked to the back-office, but also involve changes at the front-office towards tailor-made services with involvement of clients and partners. It is therefore essential to not underestimate as an organisation what this may imply for organisational identity in the longer term, both with regards to the employees (professional identity) but also for the way clients and partners view the organisation.

A main implication for AKIS would be that with new organisational activities and greater involvement and collaboration with clients, partners and new comers (like technology organisations), a blurring of 'traditional' AKIS roles may occur. Responding to digital agriculture calls for a digitalisation strategy to be enacted using a systemic and responsible approach to reveal emerging issues, such as data ownership and to reflect

and respond to potentially undesirable consequences such as the exclusion of certain groups.

Further research could focus on the articulation and implementation of digitalisation strategies within knowledge providing organisations through for example an in-depth study of one or more organisations. More research can be done on specific organisational elements, such as the experiences with digitalisation of individuals and the role of organisational structure in adapting towards digitalisation. A broader analysis of involved stakeholders (e.g. clients, partners, policymakers) within AKIS and the wider context in which digitalisation takes place, could also enhance the understanding of whether there is full organisational identity change because of digitalisation and what is the impact of digitalisation on AKIS.

Chapter 3

The enabling and constraining connections between trust and digitalisation in value chains

Abstract

Digitalisation is a socio-technical process that comes with a range of uncertainties for actors that go beyond the digital technology itself. These uncertainties are related to trust among value chain actors, in digital technologies and in data. In this chapter we aim to develop a holistic understanding of the connections between trust and digitalisation. We investigate how trust relations (interpersonal trust, trust development and institutional trust) affect digitalisation, and how digitalisation affects trust relations among value chain actors, using the Dutch flower sector as a case study. Our findings show that the sector has a high level of interpersonal trust, but limited institutional trust, as the relationships between companies are highly competitive and transactional. In this specific context, limited trust hinders digitalisation in multiple and mutually reinforcing ways, inducing a the vicious cycle whereby existing distrust or limited trust results in limited digitalisation, which in turn causes more distrust due to uncertainties around the digitalisation process, further increased by existing (technological) path dependencies. A main theoretical implication is that a better awareness of mutually reinforcing (dis)trust dynamics and vicious (or virtuous) cycles in relation to digitalisation are needed. This indicates a need for developing 1) higher levels of understanding of what digitalisation entails (also referred to as digi-grasping) and 2) organizational ambidexterity in the value chain, that is striking a balance between exploiting the certain old or current, while having sufficient space to grasp uncertain new and future possibilities. This could allow actors to step out of their regular patterns of competition and collaboration (or rather co-opetition) and to explore new levels of collaboration for digitalisation.

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3.1 Introduction

Digitalisation is a challenging process that comes with a range of uncertainties for actors, both directly and indirectly involved, that go beyond the digital technology itself. Therefore, it is argued that digitalisation should be understood as a sociotechnical transition (Autio, 2017), whereby current technologies and related processes are substituted by technologies such as the Internet of Things, augmented reality, artificial intelligence, blockchain, and digital twins (Alm et al., 2016; Cearley & Burke, 2018). These processes affect not only the technologies themselves, but have the potential to transform markets, businesses and society (Autio, 2017; Nambisan et al., 2017), and the innovation process itself (Haefner, Wincent, Parida, & Gassmann, 2021). Digitalisation thus involves (in many cases radical) technological, social, institutional and economic change and is often synonymous with disruption, meaning that the outcomes significantly affect individuals, businesses, industries or society as a whole (Kilkki et al., 2018; Millar et al., 2018; Schneider & Kokshagina, 2021; Schuelke-Leech, 2018). At the same time, the exact outcomes (e.g. changed strategy, business models, and market positions), as well as the process leading to these, cannot be predicted, resulting in considerable uncertainty (Agogué et al., 2017; Schneider & Kokshagina, 2021).

Uncertainties related to digitalisation thus both encompass the process and outcome, and include unknowns about the digital technologies themselves, e.g. costs; usability; organisational and institutional structures in which technologies are embedded; and strategy, business models, and market positions affected by digital technologies (Kobos et al., 2018; Millar et al., 2018; Schneider & Kokshagina, 2021), all within an uncertain context that has its own specific conditions (Fromhold-Eisebith et al., 2021). Trying to make sense of such unknowns first of all requires understanding and awareness of digitalisation in its current state and imagining alternative futures, i.e. 'digi-grasping' (Dufva & Dufva, 2019). This supports the ability to navigate the 'fuzzy front-end of innovation' to reduce uncertainty by "experimenting, assessing opportunities, and collaborating to define the direction, actors, and approach" (Berghaus & Back, 2017, p. 2), which may lead to changes in the capabilities, practices, and services of organisations (Haefner et al., 2021; Rijswijk, Klerkx, & Turner, 2019).

While digi-grasping and navigating the fuzzy front-end often focus on the innovation process within an organisation, it also includes strengthening collaboration with other

actors (Berghaus & Back, 2017; Parida, Patel, Frishammar, & Wincent, 2016; Snow et al., 2017; Tate et al., 2018). Digitalisation requires collaboration "which has been shown to reduce risk, speed products to market, decrease the costs of solution development and process improvement, and enable access to new knowledge, technologies, and markets" (Snow et al., 2017, p. 6) (see also Barbour, Treem, and Kolar (2017); (Jakku et al., 2019); van den Broek and van Veenstra (2018)). Although Yang, Fu, and Zhang (2021) describe different levels and pathways regarding supply chain collaboration and technological intelligence, collaboration in digitalisation processes is often dependency-driven, as organisations do not have the underlying technology, and as such depend on others to enhance their digital processes (Parida et al., 2016). Digital technologies and applications function on the basis of large, preferably real time, data sets that consist of multiple data sources ideally shared across a value chain (Wolfert, Ge, et al., 2017). In value chains, it is believed that data sharing supports the potential benefits of digital technologies, e.g. transparency and flexibility (Ng & Wakenshaw, 2017; Wolfert, Ge, et al., 2017), as well as more efficiency, increased productivity and sustainability (Jakku et al., 2019; Wolfert et al., 2014). As a result, organisations are becoming technology and data-driven and therefore more connected, both literally and figuratively, further strengthening the already existing strong interdependence among value chain actors.

In the collaboration among interdependent value chain actors trust plays a key role (Falkenreck & Wagner, 2017). A characteristic of trust is that it helps to deal with complexity, that is inherently part of collaboration, and often occurs in new and uncertain situations (Lang & Hallman, 2005). In relation to digitalisation, trust may come into play in several ways. First, digitalisation may put pressure on existing networks and relationships as it has the potential of transforming roles and power relationships (Bronson & Knezevic, 2016; Jakku et al., 2019; Wolfert, Ge, et al., 2017), for example creating uncertainty and decreasing trust in buyer-seller relationships (Falkenreck & Wagner, 2017). Second, digital technologies can mediate trust building to develop cooperative behaviour in value chains, if sufficiently supported by an intermediary organisation (Agyekumhene et al., 2018). Third, trust is often a prerequisite for digital technologies to be adopted (Jakku et al. (2019), while it also plays a key-role in computer mediated interaction (de Vries, van Bommel, & Peters, 2018; Henttonen & Blomqvist, 2005; Jarvenpaa & Leidner, 1999).

Considering these roles of trust in the digitalisation process, trust influences the uptake of digitalisation, and trust relations in turn are affected by digitalisation (Fielke, Taylor, &

Jakku, 2020; Fromhold-Eisebith et al., 2021). Many studies focus on trust in relation to digital technology adoption (Arfi, Nasr, Kondrateva, & Hikkerova, 2021; Califf et al., 2020; Julsrud & Krogstad, 2020; Kopyto, Lechler, von der Gracht, & Hartmann, 2020; Kowalski, Lee, & Chan, 2021; Liu, Chernov, & Mikhaylova, 2021; Luo, Wang, Zhang, Niu, & Tu, 2020; Pérez-Morote, Pontones-Rosa, & Núñez-Chicharro, 2020; Shareef et al., 2021), whereas some focus on how it affects the (digital) innovation process (Elia, Margherita, & Passiante, 2020; Gupta, Mejia, & Kajikawa, 2019; Linde, Sjödin, Parida, & Wincent, 2021; Nestle, Täube, Heidenreich, & Bogers, 2019; Vicente-Saez, Gustafsson, & Van den Brande, 2020). For example, in a study of transformation of the German textile industry, Fromhold-Eisebith et al. (2021) found that distrust between firms obstructs constructive inter-firm collaboration for digitalisation, and Jakku et al. (2019) found that distrust in data and those that control it hinders the setting of effective standards for data infrastructure and management.

Nonetheless, a holistic understanding of the role of trust in digitalisation of value chains as regards both process and expected outcomes remains limited, and studies focussing on the development of the multifaceted aspects of trust in relation to complex digitalisation processes in agricultural value chains are absent. Therefore, this chapter aims to address this gap by studying how trust relations affect digitalisation, and how digitalisation affects trust relations among value chain actors. We will empirically focus on the Dutch flower sector, and the main research question that guides this enquiry is: What role does trust play in digitalisation processes in value chains? In the remainder of this chapter we will first explore an analytical framework to link the concepts of (various forms of) trust to value chains and digitalisation. In the methodology section we will give a more detailed case description of the Dutch flower sector and known uncertainties. This will then support us to share findings about the role of trust in the navigation of the digitalisation process of this sector, and vice versa, how digitalisation impacts on trust. Finally, we will discuss these results in a wider value chain context, followed by a set of conclusions and recommendations.

3.2 Trust development and digitalisation

We will now outline the main concepts and insights from the literature that informed our empirical analysis, starting with different aspects of trust, i.e. interpersonal trust, trust development and institutional trust, followed by a background on how digitalisation affects

value chains and links between various perspectives on trust and digitalisation (see Table 3.1 for an overview).

3.2.1 Interpersonal trust and trust development

Interpersonal trust is generally perceived as a key necessity for collaboration and building relationships (Henttonen & Blomqvist, 2005), and as such has for decades been subjected to scientific studies in a wide range of fields (Rousseau, Sitkin, Burt, & Camerer, 1998a). In these studies, trust is seen as a precondition for collaboration, as well as an outcome of collaboration (Bachmann, 2001; Edelenbos & Klijn, 2007; Zaheer, McEvily, & Perrone, 1998). Trust is commonly defined as the willingness to be vulnerable to somebody's behaviour and decisions, on the basis of positive expectations about another's intentions or behaviour (Mayer, Davis, & Schoorman, 1995; McEvily, Perrone, & Zaheer, 2003; Rousseau, Sitkin, Burt, & Camerer, 1998b). These expectations are based on a collective history, and past experiences of what is known about the others behaviour and intentions (de Vries, van der Zee, Beunen, Kat, & Feindt, 2019).

Based on a cross-disciplinary review of trust, Rousseau et al. (1998) distinguish two main types of interpersonal trust, e.g. calculative and relational trust. In this distinction, calculative trust is based on rational choices and calculative behaviour. Such a form of trust could be referred to as trust based on verification (Lewicki, McAllister, & Bies, 1998a), and the assessments of intentions, for example through a third party source. This form of trust is often focussed on economic transactions (Hardin, 1993; Rousseau et al., 1998a). The second form of trust is relational trust (Mayer et al., 1995), also referred to as affection-based trust or identification-based trust. This type of trust is based on soft relational aspects such as shared values, emotions, and identities. Such forms of trust develop after repeated interactions and shared experiences (Agyekumhene, De Vries, Paassen, Schut, & MacNaghten, 2020; Rousseau et al., 1998a). As such, relational trust is often viewed as a stronger form of trust, in which repeated interactions have resulted in the favourable state that the reason to trust is less clear cut (as with calculative forms of trust) but based on a strong shared relationship or identity.

Trust development in relationships often start with a degree of calculated trust (Rousseau et al., 1998a), especially in cases where there are no previous common experiences, and actors have limited information available about each other. Over time, such forms of trust might gradually morph into trust based on affection and identity as shared positive experiences and history might emerge (Mayer et al., 1995). In such cases, calculative trust

moves to the background and relational forms of trust start to dominate as relationships develop. However, trust development is not a linear process (Agyekumhene et al., 2020), but is dynamic as it is subject to constant change under the influence of new interactions, experiences and actions of both the trustor and the trustee (de Vries et al., 2019). Trust is thus dynamic and often re-assessed, which means it can increase or decrease, gain a more calculative or relational character, or may even develop into distrust (Lewicki, McAllister, & Bies, 1998b; Mayer et al., 1995).

Last, trust development is context specific. Therefore, trust is not only influenced by interactions between individuals, but also by the context in which individuals and organisations operate (Kadefors, 2004; Mayer et al., 1995; Schoorman, Mayer, & Davis, 2007). In other words, the specific trust context shapes the space to trust or not, e.g. new policies may alter actor constellations, affecting with whom you can cooperate and thus trust.

3.2.2 Trust in institutions

Institutional trust generalises beyond interpersonal trust and is part of the context in which interpersonal trust develops. As such, institutional trust can foster trust development between individuals that are not familiar to each other. However, to function this way, institutions themselves need to be trusted. Institutional trust, also referred to as systems trust or confidence is crucial for the functioning of institutions, and their structuring characteristics (Woodhill, 2010). Trust in institutions is defined as the often unconscious expectation that institutions will work as they always did (Luhmann, 1979b, 2000), and is based on long-standing experiences; for instance through procedures. In this way, institutions guide interactions and collaboration (Fuglsang & Jagd, 2015; Luhmann, 1979a; Woodhill, 2010). For example, trust in the value chain as an institution, allows value chain actors to collaborate without the constant need for checks and balances. However, perceived misfunctioning of institutions might result in trust decline (Child & Möllering, 2003), undermining the performance of institutions and fostering the need for increasing checks and balances with all due consequences for collaboration. Especially as trust in institutions is particularly hard to restore.

3.2.3 Value chain digitalisation and trust

Value chains are organised as sets of interdependent actors in a sequence of value adding activities to support end use (Sturgeon, 2001). The success of value chains is dependent on the horizontal and vertical relations among actors (e.g. suppliers, processors, and

ultimately consumers), and how this is organised (Trienekens, 2011). Relationships can take multiple forms, and often there is a combination of competition, cooperation, and collaboration, whereby each form has an increased level of motivation and commitment to work together and share information (Snow, 2015). These relationships, or existing interdependencies, create a degree of certainty, or even predictability. In other words, you know generally what you can expect given a certain set of circumstances. These circumstances relate to the organisations (suppliers, processors and competitors) you work with, the resources required, and the rules and regulations related to the product, service or process (Meijer & Hekkert, 2007). These certainties can be beneficial as they may lower transaction costs (Roba, Lelea, Hensel, & Kaufmann, 2019). However, they may also create constraining path dependencies and uncertainties when circumstances are disrupted (van Assche, Beunen, & Duineveld, 2013), for instance in the process of digitalisation. Below we will zoom in on various aspects of trust and value chain digitalisation, as already touched upon by the literature.

Collaboration & trust in the digitalisation process

Digitalisation changes the nature and mode of information and information sharing (Mas & Gómez, 2021; Misaki, Apiola, Gaiani, & Tedre, 2018a), and as such impacts the relations among value chain actors (Steiner, 2017; van der Burg et al., 2020), for example enabling multi stakeholder platforms and communication (Schiavone, Mancini, Leone, & Lavorato, 2021) or enhancing the predictability of trade partners (Kowalski et al., 2021), and thereby the way value chains are organised (Charvat et al., 2018). Following the increasing scientific attention towards digitalisation in agri-food value chains, some studies underline the benefit of digitalisation for actor cooperation by arguing that digitalisation potentially improves value chain actor relations as it fosters transparency (Kos & Kloppenburg, 2019; Kowalski et al., 2021; Zhao, 2013). However, other studies take a more critical stance when they show that digitalisation may re-enforce existing power structures (Beckeman, Bourlakis, & Olsson, 2013b; Bronson, 2018; Bronson & Knezevic, 2016; Carolan, 2017a), can even reduce trust among actors due to increased inequalities (Steiner, 2017; van der Burg et al., 2020), and that existing trust relations may also hamper the uptake of digital technologies (Balasubramanian et al., 2021; Kopyto et al., 2020; Misaki et al., 2018a). In their review Fielke et al. (2020) argue that trust relations are likely to change under the influence of digitalisation, affecting collaboration, information sharing and use, and the further uptake of digital technologies. As digitalisation disrupts actor interactions and how these interactions are organised, others add that not only trust

among actors is affected, but that trust in the value chain as an institution might be subject to change (Kassem, Shabana, Ghoneim, & Alotaibi, 2020).

Value chain governance and trust

To support or develop trust in the value chain, and in particular in the context of digitalisation, governance is essential. Governance (of data sharing activities) refers to the guidelines, agreements and decision-making processes that steer a group of stakeholders towards a collective goal on the one hand (Wolfert, Bogaardt, Ge, Soma, & Verdouw, 2017). This includes agreements about data security, privacy, and ownership, but also storage, maintenance, costs, accountability, etc. (Jakku et al., 2019; Jouanjean, 2019; Wolfert, Bogaardt, et al., 2017). On the other hand, it also takes the institutional setting into account, e.g. what are the formal and informal rules that change and shape the agreements? This is where (existing) perceptions, communication and trust play a crucial role (Jakku et al., 2019; Wolfert, Bogaardt, et al., 2017).

There are different inter-organisational governance arrangements, as described by van den Broek and van Veenstra (2018), which according to them may lead to competitive advantages through joint learning, pooling of resources, and new or improved products and services. The four governance arrangements they describe vary in flexibility, duration, the relation between involved actors (e.g. dependent or independent) and the type of social contract they hold (e.g. formal, informal and level of trust) (van den Broek & van Veenstra, 2018), amongst other things. The authors show that for example high levels of competition, distrust, hierarchy, and temporary needs can also be facilitated in governance arrangements (van den Broek & van Veenstra, 2018) That is, regardless of the context there is likely to be a governance structure that can accommodate the needs, with the risk that it may not benefit all actors (in the same way) (Giesbers, Adema, Soum, & Van der Burg, 2021) or with such strict rules that it does not facilitate (data) sharing and collaboration, e.g. when data is only shared with one party (Giesbers et al., 2021). Hence, while there is consensus on the need for governance around digital technologies, the way it is implemented and used will affect trust. This is then often linked to collaboration and trust in data and the technology (see previous section).

Digitalisation for trust development

One interesting example that combines aspects of institutional, interpersonal trust as well as governance, is blockchain technology. In the agri-food sector we see that this

technology is often linked to four main areas (van Wassenaer et al., 2021): 1) supply chain management around the tracking and tracing of products; 2) farmer-centric, such as access to services and financial markets ; 3) environment-centric, i.e. the environmental impact of food production; and 4) consumer communication, related to food safety and provenance (Garrard & Fielke, 2020; Kamilaris, Fonts, & Prenafeta-Boldύ, 2019).

This technology is often intended to overcome interpersonal or even institutional trust issues, i.e. it allows for 'trust-free' transactions or data sharing (Hawlitschek, Notheisen, & Teubner, 2020). Centobelli, Cerchione, Esposito, and Oropallo (2021) say that blockchain enhances consumer and partner trust, while Garrard and Fielke (2020) mention that blockchain does not have a lot of added value when there is already existing trust. Kowalski et al. (2021) show that besides improved security of data and transactions; the related enhanced communication; and predictability of trading partners, there is also more benevolence among actors in the finance sector. However, when it comes to more complex social relationships there is still a need for trust development, in and by blockchain technology. This is also echoed by several other authors (Dutch Blockchain Coalition, n.d.; Kopyto et al., 2020). So far, however, research does not provide clear evidence of trust development between actors when they are 'off-chain'.

Additionally, often trust issues around the data input/source and the blockchain technology itself are mentioned. Trust in the technology can be challenging as it often requires individuals to hand over control to a digital technology (Hegner, Beldad, & Brunswick, 2019). It is, for example, important to know the data source, if the data is correct and collected in a proper way, and whether shared data actually has values behind it in the meta data (Barjak et al., 2007; Nandyala & Kim, 2016), e.g. shared data that involves measurements in both the metric and the imperial system without converting them all to the same system. This trust can be developed, but depends on the perceived usefulness, the ability and ease to use and understanding of the digital technology (Hegner et al., 2019; Shareef et al., 2021), in other words the extent to which it is (seen as) a 'black box' by potential users. Trust in data and technology is therefore often linked to technology adoption more broadly (Fleming, Jakku, Lim-Camacho, Taylor, & Thorburn, 2018; Klerkx et al., 2019; Wiseman et al., 2019).

Yet at the same time, farmers and other actors in the agri-food sector are often locked into a certain technological path, hence they tend not to have the option of (dis)trusting

the technology. This in turn causes them to become reliant and even more entrenched in a particular technological trajectory (Clapp & Ruder, 2020). Thus, trust in the data and the digital technology itself are also important and may require an intermediary or a trusted third party, which in the case of blockchain might impact on the decentralized trust that it is intending to create (Garrard & Fielke, 2020; Kamilaris et al., 2019). Thus, while blockchain has the potential to support trust development, this comes with necessary pre-conditions and challenges.

Agyekumhene et al. (2018) furthermore argue that digital platforms could have the potential to enhance trust building and cooperation through decentralisation of data collection and information delivery to smallholder farmers in the Ghanaian maize value chain. Another example of trust development and digitalisation was found in the context of the humanitarian supply chain whereby civic and military organizations need to quickly develop trust and collaboration to undertake their disaster relief operations. Capabilities to undertake big data analytics could overcome (organisational culture related) differences and build trust (Dubey et al., 2019). So far we have not seen any other research on the role of digitalisation in trust development at value chain level.

3.2.4 Trust development and digitalisation

From our theoretical explorations on trust and digitalisation we have learned that digitalisation in the value chain disrupts existing actor interactions and the way they are organised (see Table 3.1). Thus, it affects trust among individual actors as well as in the value chain, potentially affecting further collaboration and the uptake of digital means. Based on the insights from trust literature it became clear that trust in these contexts should be viewed as dynamic; developing over time under the influence of interactions in relation to its specific trust context. In this, trust can have a more calculative and a more relational character in which the latter is more likely to develop after actor relations have intensified. Hence, to understand the link between trust and digitalisation of value chains it is clear that we have to focus on both interpersonal trust and trust (or confidence) in the value chain (e.g. the formal and informal relationships and -information and data related - interactions among value chain actors, both horizontally and vertically); how this develops over time; and how these trust developments influence both horizontal and vertical collaboration around digitalisation within the value chain; and vice versa.

Table 3.1 An overview of different perspectives on trust and digitalisation in the literature

Aspects of trust, digitalisation, and value chains	Enabling factors	Constraining factors	Neutral factors
Collaboration & trust in the digitalisation process	▪ Digitalisation may support value chain actor relations ▪ Digitalisation stimulates transparency. ▪ Digitalisation enables multi-stakeholder platforms and communication. ▪ Digitalisation enhances the predictability of trade partners.	▪ Digitalisation may re-enforce existing power structures. ▪ Digitalisation can reduce trust among actors due to increased inequalities. ▪ Not only trust among actors is affected, but that trust in the value chain as an institution might be subject to change. ▪ Existing trust relations may hamper the uptake of digital technologies.	▪ Digitalisation disrupts actor interactions and the organisation of interactions and the wider value chain. ▪ Trust relations are likely to change under the influence of digitalisation, affecting collaboration, information sharing and use, and the further uptake of digital technologies.
Value chain governance and trust	▪ Governance is essential in steering a group of stakeholders towards a collective goal, through guidelines, agreements and decisions making processes. ▪ Governance also takes the institutional setting into account, e.g. what are the formal and informal rules that change and shape the agreements? ▪ Governance may lead to competitive advantages through joint learning, pooling of	▪ Governance arrangements can continue to foster the existing competition, distrust, hierarchy and temporary needs. ▪ Existing perceptions, communication and trust play a crucial role in governance. ▪ Governance arrangements may exacerbate existing power imbalances. ▪ Existing governance arrangements may hamper	▪ This includes agreements about data security, privacy, and ownership, but also storage, maintenance, costs, accountability, etc. ▪ Governance arrangements need to consider flexibility, duration, the relation between involved actors and the type of social contracts (e.g. formal, informal and level of trust).

	resources and new or improved products and services.	actual (data) sharing or collaboration.	
Digitalisation for trust development	▪ Trust in data and technologies is essential for broader (interpersonal) trust development and can develop or increase over time. For example: ▪ Blockchain technology has the potential to overcome interpersonal or even institutional trust issues by being 'trust-free'. ▪ Blockchain can enhance consumer and partner trust. ▪ Blockchain can improve: data security and transactions; communication; predictability of trading partners; benevolence. ▪ Capabilities to undertake big data analytics could overcome (organisational culture related) differences and build trust. ▪ Digital platforms could have the potential to enhance trust building and cooperation through decentralisation of data collection and information delivery.	▪ Trust issues around the data input/source and the digital technology itself. ▪ Lock-in and path dependency are both a cause and a consequence of digital technology use, leaving no space for (dis)trust. For example: ▪ When it comes to more complex social relationships there is still a need for trust development, within and by blockchain technology. ▪ Blockchain may require an intermediary or a trusted third party, which might impact on the technology driven decentralized trust. ▪ Research does not provide clear evidence of trust development between actors when they are 'off-chain'.	▪ Trust in data requires: knowing the data source, data collection method and the meta data. ▪ Trust in technology requires: Perceived usefulness, the ability and ease of use, and understanding the digital technology. ▪ Trust in data and technology is connected to adoption. For example: ▪ Blockchain does not have a lot of added value when there is already existing trust ▪ Limited research on the role of digitalisation in trust development at value chain level.

3.3 Methodology

3.3.1 Data collection and analysis

Initial data was collected as part of the DaVinc3i Community project (2016-2019), which was set up to support digitalisation of the flower sector. To gain better insight into the barriers and opportunities for digitalisation of the Dutch flower sector, 15 exploratory semi-structured interviews were held with a range of interviewees, such as researchers, policy makers and representatives organisations of various value chain actors (e.g. growers, transporters and traders). These interview findings were validated in a workshop, allowing for triangulation of the interview data (see Salvini et al., 2020). Relevant findings will be shared in the case description below.

This chapter builds on and deepens the insights around the digitalisation process of the Dutch flower sector reported earlier (Salvini, Hofstede, Verdouw, Rijswijk, & Klerkx, 2020) by focussing on the role of trust. Therefore, another 18 semi-structured interviews were held in 2019. Some of the interviewees, or their respective organisations, overlapped with the previous set of interviewees, however there was more direct input from transport, grower, and trade actors. The interviewees included growers (5); transport companies (2); auction (1); trade companies and their representative organisation (4); retailer (1); service providers (4); and a researcher (1). All interviewees were selected based on their involvement in the project or through snowball sampling. The main requirement being that they were actively considering or involved in digitalisation.

The second set of interviews was analysed using Atlas.ti (version 8 for Windows). The interview transcripts were coded for the different uncertainties and types of trust discussed by the interviewees. The coding helped to identify key topics and relevant quotes, which are shown in the results section.

3.3.2 Case description

The Dutch flower sector has a long standing tradition and an internationally leading position with an annual export value of €6.2 billion in 2019 (VGB, 2021), not only in growing top quality flowers and plants, but also being the main logistic hub for import and export of flowers and pot plants across the world (de Keizer, Groot, Bloemhof, & van der Vorst, 2013; van der Vorst et al., 2016; Verdouw, Beulens, & van der Vorst, 2013). See Figure 3.1 of a simplified overview of the value chain. The success of this sector is based around

intensive cooperation between the large number of heterogeneous actors, including growers; traders; auction houses; producer organisations; retailers; and a wide variety of (logistic) service providers (Salvini et al., 2020; van der Vorst, Bloemhof, & de Keizer, 2012; Verdouw et al., 2013), which also differ in size, type of ownership, focus (national/international), and particular product (Salvini et al., 2020). This results in a large variety of value chain configurations with products for example being sold via centralized points, such as auction houses, or directly between (multiple) traders, going to a variety of retail outlets (de Keizer et al., 2013).

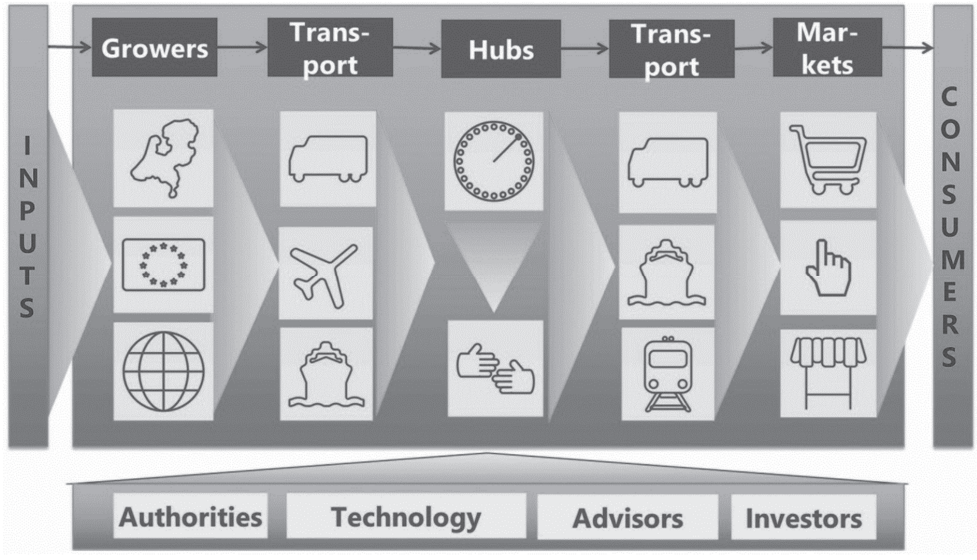

Figure 3.1 Simplified value chain structure of the Dutch flower sector (Salvini et al., 2020, p. 4).

The flower sector, however, also deals with a range of (known) uncertainties that are closely related to the sector's characteristics. There are, for example, a high proportion of small sized and family-owned businesses, be it growers, traders, or transport companies. These businesses value hard work and craftmanship regarding the product or service they deliver, and are typically very supply driven (Salvini et al., 2020). Moreover, these businesses often have employees with a relatively lower level of education, and a relatively high average age of business owners. This combination of factors often results in a focus on daily activities and operational problem solving, rather than a strategic view of their business and the wider sector (Salvini et al., 2020).

Additionally the sector deals with uncertainty around demand and supply of products due to the perishability of products and their dependence on weather conditions (Verdouw, Beulens, Trienekens, & Verwaart, 2010). Moreover, the flower sector is supply-driven, partially due to the relative inflexibility of production process of flower products. This also causes a mismatch between demand and supply, as consumers can only buy what is offered to them (Salvini et al., 2020). These demand and supply uncertainties are exacerbated due to global challenges, such as higher consumer demands regarding the quality of the products, transparency of the production process, and overall sustainability (Hajkowicz & Eady, 2015; Trienekens, Wognum, Beulens, & van der Vorst, 2012; Verdouw et al., 2010).

The above characteristics and existing uncertainties lead to a high degree of competition both horizontally between similar actors and vertically among different supply chains of the same product (Salvini et al., 2020), i.e. there is little differentiation, which puts additional pressures on the profit margins. At the same time the value chain actors have become used to these uncertainties and the related lack of transparency (Salvini et al., 2020), which creates information asymmetries between buyers and sellers and enables actors to gain a competitive advantage (Wever, Wognum, Trienekens, & Omta, 2012). To deal with this competition, business-level interests are given priority over sector-level interests, impacting on the level of collaboration to address sector-level challenges and opportunities (Salvini et al., 2020). This is further exacerbated by the sector representative organisations having a limited understanding of the needs of their members, and the termination of the commodity board for horticulture in 2015, which up to then undertook the role of sector coordination as an independent organisation (Salvini et al., 2020).

At the same time, the Dutch flower sector needs to innovate to maintain its leading position (Verdouw et al., 2013). So far, the Dutch flower sector has progressed through product innovation, i.e. the breeding of flowers and pot plants. Furthermore, there has been process innovation within glasshouses to improve the growing process and enhance efficiency (see for an example of product and process innovation Verdouw et al., 2010). This nowadays also encompasses a range of digital technologies, for example the use of sensors to monitor and control the glasshouse temperature (RBC, 2019), or robotics for flower picking (van Henten, Bac, Hemming, & Edan, 2013). These processes are often referred to as digitisation (rather than digitalisation), whereby analogue information is converted into a digital form (Autio, 2017). These product and process innovations have

contributed to the high quality and the high export numbers of the Dutch flower sector; however, they often occur at the business-level.

Like many other sectors and value chains globally (see for example Fromhold-Eisebith et al., 2021; Kiel et al., 2017; Klerkx et al., 2019; Kolloch & Dellermann; Mas & Gómez, 2021; Verdouw et al., 2016), the Dutch flower sector is also facing digitalisation (Verdouw et al., 2013). Digital technologies can allow for better monitoring and control of the products in the value chain, which enhances the quality, and allows for the development of services that focus on consumer and customer needs (Cenamor, Rönnberg Sjödin, & Parida; Verdouw et al., 2013). For example, through global tracking and tracing of products with RFID tags, to measure temperature and humidity, which impacts on the flower quality and therefore the so-called 'vase life' of these flowers; or the (potential) use of IoT in trucks to identify the product location during transport for a better prediction of ETA; and the use of various types of online platforms to support trade. Digitalisation is however perceived as challenging, or even daunting, as it is not always well understood. Various actors perceive it as complicated and may also find that digitalisation negatively impacts on their competitive advantage (Salvini et al., 2020), while others are aware that you need to collaborate, for example through data sharing (Salvini et al., 2020).

In other words, digitalisation is the next step in maintaining the strong export position and high quality standards. Although, understandably, the combination of the above-mentioned key characteristics, existing uncertainties, and digitalisation is challenging for the actors in the Dutch flower sector.

3.4 Findings

In this section we explore the level of collaboration, interpersonal trust, and trust in the value chain in relation to digitalisation. We do this by describing the trust situation prior to digitalisation, then explore, through two examples, how digitalisation occurs within the flower sector and how this effects/ and is affected by existing trust relations.

3.4.1 Existing trust and collaboration

The Dutch flower sector is characterized by a long-standing tradition of working together with many growers and related businesses in a relatively small geographical area. This has as an effect that within the Dutch flower sector "*everyone knows everyone*". A service provider said: "*You operate in a sector where everyone talks to each other*", and an

interviewee from a representative organisation stated: *"It is a small world. Everyone knows each other, especially in the Aalsmeer region. Behind the scenes more things get discussed and decided than through official ways. That is typically the Dutch flower sector*". As such, the flower sector is also characterized by a high level of informality.

The high degree of informality is partly due to the lack of regulation in the sector. The flower sector of course must adhere to trade and financial rules, and at the level of the grower there is basic regulation regarding phytosanitary standards and crop protection. However, the flower sector has a lot less regulation compared to other agricultural sectors as it is a non-edible product and does not have any further requirements down the value chain. This has consequences for the way of working, or as a trader mentioned: *"Due to the lack of regulation regarding food safety, we do not have good and mandatory structures or supplier obligations to meet certain requirements. […] There is also a lot of cheating between the administration and reality going on, often undeliberate."* This was further confirmed by a service provider: *"If there is no regulation and you don't have to demonstrate anything you get a free-spirited culture. […] And as long as you pay, you can do whatever you want. Then you get individual behaviour"*. In other words, the lack of regulation creates room to be flexible.

The flexibility is therefore another a characteristic of the sector and expected by all types of customers in the value chain, as a transporter explains (Eric): "*With this customer you should do a bit more of this, and with that customer you should do a bit more of that?"*. Among the interviewees it is also felt that this flexibility is needed, to remain competitive. However, the flexibility also creates uncertainties, as the same transporter continues: "*You want to standardise, but at the same time you also want space for exceptions."* These uncertainties and the need to stay competitive have a great impact on the way collaboration is organized in the value chain, and the character of trust relations.

Vertical collaboration

Despite this culture of 'everyone knows everyone', the collaboration among value chain partners is mostly based on the transaction of a flower product or a related service. A key player in this process is the auction house, which is historically, the market enabler between producers and buyers. They have a powerful position as growers are (and must be) members of the auction to sell their products. Furthermore, they hold a monopoly on dealing with transactions and finances between growers and traders. Additionally, they

organise and manage the stacking trolleys used for transport of flowers and plants. Hence, they function as a pivot point within the regional flower market and between the regional flower market and the world. The relation between the auction and the individual growers and buyers is, despite the long-standing history, however, mainly based on business transactions. Or as a service provider shares: "*It is a case of culture, 100 years in which the auction clock has played a central role. And by definition a transaction model in which the relationship whereby the customer is called 'buyer', that is saying something. There not really a relationship, let alone a partnership*." This business-oriented attitude with no openness, created some distrust as the service provider continues to explain: "*And this culture has created some distrust, keeping the cards close to the chest."*

Yet the auction house feels they are under pressure as they see their role as market enabler changing (see also Salvini et al., 2020), because the so called 'clock or Dutch auction', i.e. open-outcry descending-price auction (Wikipedia, 2021), is becoming less relevant with more direct trade taking place between growers and traders. This affected their position and created uncertainty. Therefore, the auction decided to become more directly involved in the buying and selling of flowers. However, this radically changed traditional roles and moved the auction into the territory of traders, which created uncertainties amongst traders. Especially as the auction has a lot of insight into the pricing of products due to their financial role, which traders were lacking. Due to the business-oriented way of operating, both by the auction as well as by other actors, trust was mainly based on calculative arguments and was at some stage particularly low between the auction house and (the representative organisation) of the traders. However, both have reported that this is slowly improving again.

Not only the relationship between the auction house and the traders has changed. Growers and traders have also had a long-standing history of transactional relations and low trust, as a service provider illustrates: "*A history of limited relationships and maybe some distrust, although this mainly stems from growers towards traders [...] based on who did the real investment in the production process.*" However, just as with the auction, this relationship is improving as he continues to say: *"Although this sentiment is slowly decreasing and the vertical connections are improving.*"

Horizontal collaboration

While there is gradual improvement with regards to vertical collaboration, horizontal collaboration among groups of actors seems to be even more challenging. Competition for market share plays a major role in the lack of horizontal collaboration. Among growers there are various ideas about horizontal collaboration. One grower of indoor plants mentions: *"There is no real collaboration. It takes effort to get everyone together and all those growers are very stubborn. Everyone finds his own ideas best and his own process most important."* A trader, who previously worked for a grower, remarked along similar lines: *"I have seen many collaborations between growers over the years, they always end up fighting. [...] because it is about 'what is in it for me'."* The same grower also states that collaboration with other growers is difficult, simply because there are too many growers which creates competition. As such, many relations are based upon calculative transactions. Or as a grower explains about collaborations between bigger and smaller companies: *"[we are] dependent on these small family owned business, while we are a serious business. They are too, but at a different scale. And if they want to collaborate they usually only come to get something, but bring very little. [...] You must collaborate, but that has to be on the basis of equality."* This is striking as most of these businesses have known each other for generations.

Despite the transaction-oriented character of the relationship, collaboration among growers does take place. Examples are study groups, marketing groups, or grower groups linked to the auction. However, opinions about their usefulness and the level of collaboration vary among the growers. The grower mentioned above perceives them as a collection of 'talk groups', as they take too much time and where *"... very little is said. Everyone pays attention to what they are sharing and how they say it. People come to get something and not to give anything."* Another grower (of garden plants) does see the benefits of these different groups as a lot of information gets exchanged about different topics, however *"the competition is steep and with regards to some topics businesses seem to increasingly shut their doors. [...] Such as marketing and product development."* An orchid grower adds to this that there is a necessity to collaborate with other growers because both trade companies and breeding companies are consolidating and continue to grow and *"you do not want to get stuck in the middle."* Hence, they are also collaborating to be an equal partner in the value chain. Financial data, however, is not shared with other growers of the same product, due to competition. A rose grower, on the contrary, explains that he is happy to share both production and financial data, but only with a small group.

He mentions that while they all compete, the total production of this group of growers is still relatively small on an international scale, hence that makes it easier to share commercially sensitive information. Moreover, he says it is about sharing your passion as well. A service provider who supports a grower group that is linked to the auction perceives a lot of collaboration amongst growers, and said that there is *"enormous openness amongst growers, who sometimes also can be rampant, but the cluster [of growers] has become big through open innovation and knowledge sharing, etc."* However, business size matters, e.g. he represents a group of larger growers who have different needs and interests than smaller businesses.

These findings show that the decision to participate in these different groups itself is already calculative, e.g. 'what is in it for me', or 'how can we join forces against some other value chain actor'. And this participation also comes with conditions, people are calculating regarding information exchange and have limited willingness to be open or vulnerable. Another group of actors that has limited horizontal collaboration are the traders. If they collaborate, it is in subgroups, just as with the growers, often linked to the product they are trading or the size of their business. And trade companies are increasingly growing and consolidating. A service provider states: *"Collaboration between trade companies hardly exists and is in fact always a deal. So, it is a business merger or takeover. The collaboration exists to some extent, and also their representative organisation, but it is not the main focus."* The representation organisation of the traders shared that *"bigger companies are increasingly collaborating in certain areas. [....] but you do see a difference between big and small companies. And that difference [in the ability to collaborate and reap the benefits thereof] is increasing."* Interestingly, the areas in which more collaboration takes place are usually non-competitive projects or topics such as sustainability of the products and of the value chain. Similar challenges appear in the horizontal collaboration between transport companies. A transporter remarked in relation to a joint transport network that *"collaboration remains challenging. [...] Some companies thought 'nice, a network to make use of'. If there is a network it is all organized. But then you notice there is no commitment. [...] So eventually we quit last year."*

In summary, horizontal collaboration among groups in the value chain remains challenging; characterized by calculative attitudes of actors and keeping their cards close to their chest. Although many actors acknowledge the importance of collaboration, especially to keep up with developments in the sectors, they are hesitant to engage in open relations.

Consequently, trust relations are limited and characterised by calculative arguments. This has an impact on how the sector deals with new developments, such as digitalisation.

3.4.2 Digitalisation in the Dutch flower sector

As mentioned in section 3.3.2 digitalisation is impacting the Dutch flower sector in many forms. Consequently, value chain actors are faced with uncertainties and challenges. Despite these challenges effort has been put into the digitalisation process over the past decade in the Dutch flower sector. The two examples of digitalisation efforts highlighted in this section, both related to online platforms, were selected based on the type of collaboration in the value chain (horizontal and vertical), and the complexity of the digitalisation process; the first example is less complex compared with the second.

Data sharing through a trader foundation

The first example of digitalisation is a foundation that has been set-up and paid for by Dutch trade companies. This foundation monitors payment behaviour of (mostly foreign) debtors based on data and information automatically supplied by the traders who are members of this foundation. The foundation had a government-based predecessor, through which trade companies had to share their sales information so that the government could monitor the export figures. This predecessor was, however, abolished in 2014. Since then, several trade companies who valued the market and debtor information generated by this body started their own independent foundation. This foundation mainly provides a level of assurance around pending payments (i.e. when a trader receives money, they can subsequently pay the auction, the transporter, the grower, etc.).

Due to the monitoring role between debtors and clients, the foundation has a growing amount of data about actors and related transactions that can potentially be used for a wide range of purposes. However, even though they want to make more use of the digital data, the options for this foundation to make the most of the large amount of data that they receive are limited. First and foremost because the members demand anonymity and privacy. For example, when there is a problem with one of the debtors, who is a customer of multiple members, the foundation is not allowed to mention the member with whom this debtor has a problem, only that this debtor has a problem with one of the members. Moreover, that type information is only shared with the members of the foundation.

The foundation has therefore only recently begun to provide data analytics services, based on the data they collected throughout the past years. This for example involves sharing member data with trusted-third parties. These new services are only possible because it is their own foundation, which does not have a profit motive, as the foundation's manager put it: *"We've already built the trust, they [members] know what they can expect and that we are good at it."* However, before any additional activities (i.e. beyond providing market and debtor information to their members) can be started by the foundation all of the members have to unanimously agree, as they are the ones to pay for it themselves through their annual fees. This shows that the traders are very careful with data sharing, due to the high level of competition. In this case there is enough trust, due to long lasting one-to-one contacts between a single trader and the foundation, to allow data sharing beyond its initial intended use. Most likely, this is also because each individual trader can benefit from the additional services to enhance their own market share, i.e. it intensifies the competition.

Other interviewees also see the benefit of having such a foundation and the way it is organised. A transporter states that some of the debtors across the world repeatedly leave a trail of damage. Through the foundation the Dutch traders are covered. He refers to the limited sharing of data as following: *"[A trader might say:] That customer is coming from someone else, where he apparently was not paying. I do not need to know where exactly he was coming from, but I also do not want him."* A representative of the Dutch traders states in relation to the foundation that: *"I think it is important, that when it comes to confidential information, that you make agreements about it. [...] They do not do anything else as always dealing with confidential data and in the meantime they have the trust."*

Although the foundation is a unique and successful effort in sharing customer and sales data, it also shows that it was born out of necessity, starting with the government body. Hence it was more obligation, followed by habit, and benefits from the traders' competitive position, that led to the existence of the foundation. On the one hand it shows there is a degree of trust between traders, as it was a joint effort between participating traders to continue to share data and invest in the foundation after the government body stopped. Yet, the way it has been set up, as described above, also shows that this trust is very calculative and fitting with the competitive and transactional character of the relationships among the traders. As such the foundation does not necessarily enhance the trust

between traders, only the trust or confidence in the foundation as an institution has increased.

Diverging and consolidating trading platforms

Another example of both horizontal and vertical digital collaboration stems from the sprawl of various web shops and trade platforms that popped-up over the past few years, all aiming to bring demand and supply together. This resulted in many different channels for growers to show their available supply and for traders to access that same supply. As growers advertised the same product on different platforms, growers ran the risk of selling the same product twice to different traders. The auction house took the opportunity and purchased a few of these platforms, solving this issue while at the same time establishing its position by creating its own platform. This platform connects to a broad range of existing web shops and other trade platforms, hence becoming a one-stop shop for growers and traders, and conveniently linking other (digital) service providers, such as transporters. However, according to a trader, this platform is members only, i.e. only the growers associated with the auction house can sell their produce on this platform. It also forces users (both growers and traders) to use the auction's financial infrastructure, while on the other hand it does not impose any requirements regarding sustainability and is unclear about data governance. The latter was also confirmed by a representative of the traders, who pointed out that the auction was running behind with agreements on data governance, especially as they were taking over a platform that was often used by the traders, i.e. trader data would not be safe anymore. This combination of factors made that the traders feel that their way of doing business and freedom of choice was being 'attacked', as the web shops and trade platforms provided a way to bypass the auction. Hence, this created more pressure on the already fragile relationship between traders and the auction.

Two large trade companies therefore decided to build their own platform, but quickly realised that they needed other traders to provide a powerful alternative to the auction's platform. Another 20 traders joined in building a 'traders' platform. A director from a trade company said: *"Two companies started [platform]. Maybe from distrust. [...] Two leaders thought: it is not smart to do it together, let's see if we can involve more. [...] And there is the recognition that two captains on one ship might not work. So let's see if we can create a certain mass, so that our leadership is supported by others."* A representative from the traders stated that *"You cannot make agreements with the auction as an individual [about*

data governance]. […] So you have to do that together. And that trust you are only going to get at the moment you make agreements with each other, this is what now happened in [the traders platform]." The creation of this new trader platform was perceived by other interviewees as a *"smart move"* from the traders, but at the same time they saw the new traders platform especially as a response to increased uncertainty and risks associated with the auction platform and consequently distrust in the auction. One interviewee captured it as: *"most traders are also a bit afraid of the auction"*. Hence the traders' platform created a sense of 'us against the big auction', fostering a drive to work together and stimulating trust development among traders based on shared experiences and a certain group feeling.

After a few years of both platforms existing a consolidation of the two platforms took place. This was somewhat expected by several interviewees, as consolidation is what often happens with innovations such as these digital platforms. As a trader summarised it: *"It [the traders platform] started as a counter reaction […] Then there was a factor from outside saying: 'This is weird what you are doing. Stop it. You think you can win? Hmm, no, then join forces. Join forces 'without losing face'. And then the next phase is to go show it. […] through their behaviour."* In other words, it was more like a forced marriage. As such, it does not mean there is more trust between the auction and the traders since they started to join forces via the platforms. This is illustrated by the way the merge came into being. The auction got a 50% share in the traders platform, as they wouldn't settle for 49% according to the trader. A service provider said: *"The auction bought them up for 50%, but you can't call it that way of course."* About the level of trust the trader adds: *"It needs more time. […] but sometimes things can go pretty fast. […] Initially there is a basic level of trust, full stop, but not more than that."* In this example eventually the feeling of 'if you cannot beat them, join them' prevails.

So, trust has been an issue within the Dutch flower sector well before digitalisation began. Both vertical and horizontal collaboration has been challenging within value chains due to high levels of competition and other key characteristics, such as the heterogeneity of the sector. Despite the long-standing relations in the sector, this resulted in highly developed calculative trust, constantly balancing risks and uncertainties associated with the collaborations. While relational interpersonal trust slowly starts to sprout, and occasionally also institutional trust, it provided insufficient trust to pro-actively and jointly develop different kinds of digitalisation efforts that would support the sector. The two different types of platform examples and related data sharing, thus, have been born out of

convenience and necessity, aiming to facilitate and maintain competitive advantages. In fact, not trust but distrust has likely played a role in both the development and the governance structure of these platforms, focussing on checks and balances. Consequently, digitalisation processes and platforms have not supported further development of trust between the stakeholders in both platform examples. At most a level of calculative trust or confidence in the governance structure ensuring that their data would remain safe and there would be no impact on their competitive advantage or position could be witnessed.

3.5 Discussion

In this chapter we aimed to address the gap in the literature on multifaceted aspects of trust in relation to complex digitalisation processes in value chains by taking a holistic view of the role that trust plays in digitalisation, by asking: *What role does trust play in digitalisation processes in value chains?* To answer this question, we focused on the Dutch flower sector and have shown the complex relationship between trust and digitalisation. We will now offer some wider reflections and theoretical and practical implications.

3.5.1 Limited trust hinders digitalisation in multiple and mutually reinforcing ways

The findings show that digitalisation creates pressure on the existing trust relations necessary for coordination and collaboration in the value chain. In turn these existing trust relationships are insufficient to support digitalisation of the value chain and to overcome its related uncertainties.

On the one hand we see that, in the case of the Dutch flower sector, digitalisation affects existing cultures, value chain relations, and ways of working, which create new uncertainties and risks. The sector characteristics and related uncertainties create a high level of interpersonal trust based on calculative arguments, but limited trust based on relational arguments at an institutional level, as the relationships among organisations, and their representatives are highly competitive and transactional. Not only these traditional arrangements based on calculative institutional trust are affected by digitalisation, but also the relational and informal aspects at an interpersonal level in the sector change. Especially as the increased transparency and predictably creates uncertainties about data use and sharing, putting pressure on mutual trust relations. This was also found by Legun and Burch (2021), who showed that the highly valued flexibility and informality within organisations and across value chains comes increasingly under

pressure as digitalisation creates standardisation of processes. Our findings are thus contrary to what the literature indicates about digitalisation leading to increased predictability of trade among partners (Kowalski et al., 2021), which is seen as an enabling factor for collaboration. The challenge of digitalisation being hampered by a sector's culture, characteristics and competition echoes findings by Fromhold-Eisebith et al. (2021). Furthermore Kolloch and Dellermann (2018) also found that the attitude and relations of the actors as well as the design, variety and type of technology involved highly impacted the outcomes of a digitalisation process; similar to the Dutch flower sector.

To overcome such trust issues governance arrangements can be implemented to foster more sustainable relations (van den Broek & van Veenstra, 2018). The Dutch flower sector, for example, already seems to have a so called 'market governance arrangement', which is short-term oriented, allows for autonomy of the involved actors, and suits the competitive nature of the sector (van den Broek & van Veenstra, 2018). However, it does not yet allow for longer term and more collaborative governance arrangements, which functions as an enabling factor for digitalisation (Jakku et al., 2019; van den Broek & van Veenstra, 2018; Wolfert, Bogaardt, et al., 2017), and which usually depends on, and fosters, strong trust relations (Nooteboom, Berger, & Noorderhaven, 1997). Therefore it is crucial to move beyond the contracts level, as these contracts do not necessarily stimulate the further development of (relational) trust, but seem to be focused on accountability (van der Burg et al., 2020).

Digitalisation thus comes with the need for more transparency and openness, for which ideally there is true collaboration - rather than competition or cooperation - (Jakku et al., 2016; Snow et al., 2017), based on trust. However, in the case of the Dutch flower sector the opposite seems to be true. Organisations are apprehensive about sharing data, and when they do it is under very strict conditions whereby the actual sharing is limited; often only with one other organisation. While this is understandable as it often involves sensitive business data, it also creates an even more competitive atmosphere, causing people to become even more cautious about data sharing, thus creating a vicious cycle. Instead of digitalisation functioning as an enabling factor for trust development through data sharing, for example through blockchain technology (Centobelli et al., 2021; Hawlitschek et al., 2020; Kowalski et al., 2021), here it functions as a constraining factor.

The existing trust relationships in the Dutch flower sector thus hamper the uptake of digital technologies, a constraining factor also found by others (Balasubramanian et al., 2021; Kopyto et al., 2020; Misaki, Apiola, Gaiani, & Tedre, 2018b). The sector sits in between what Yang et al. (2021) describe as digital technology adoption level A or B: a relatively low technological intelligence and low to high supply chain collaboration. This has implications for future digitalisation pathways and efforts of the Dutch flower sector. When more complex digital technologies, such as Artificial Intelligence, Internet of Things and Blockchain are used by various sector actors, trust is still necessary and may even require active trust management by all parties involved (Kopyto et al., 2020; Myskja & Steinsbekk, 2020). Adoption of these kinds of technologies requires (upfront) trust building around the data and the technology, as well as ensuring that only trusted parties can access (sensitive) data (Balasubramanian et al., 2021; van der Burg et al., 2019a). In the Dutch flower sector issues with trust in data and the technologies itself are present as well (Salvini et al., 2020), and while these issues are likely to hamper interpersonal and institutional trust development, they were not explicit in our examples.

On the other hand, while digitalisation in the Dutch flower sector to some degree enabled multi-stakeholder platforms and communication we have also shown that these digitalisation efforts have not resulted (yet) in an increased level of trust amongst the involved actors. Digitalisation mostly seems to reinforce existing power structures within the Dutch flower sector, a constraining factor also identified in the literature (Beckeman, Bourlakis, & Olsson, 2013a; Bronson, 2018; Bronson & Knezevic, 2016; Carolan, 2017a). Additionally, these efforts may potentially (negatively) affect trust in non-digitalisation collaboration efforts. The above shows that trust is a pre-requisite for the success of digitalisation, however the opposite, i.e. digitalisation facilitating trust development, has not been evidenced thus far. More importantly, digitalisation processes might negatively affect existing non-digital collaboration efforts.

Both horizontal and vertical collaboration, especially for digitalisation, thus remains challenging, despite some progress being made across the value chain. At most, the organisations work together at the level of 'co-opetition' (e.g. cooperation with competitors to maintain or increase the so-called 'pie', while competing with each other for a share of that same 'pie') (Bengtsson & Kock, 2000; Bouncken, Fredrich, Ritala, & Kraus, 2018). The co-opetition element was also found in other studies, where it was described as a commonly found mechanism around platforms functioning as

intermediaries between competing organisations (Andersson & Mattsson, 2016; Cozzolino, Corbo, & Aversa, 2021). This also relates to the level of data sharing, which in our examples is more a transfer of data to a single entity, with the benefits still mainly belonging to the owner of the data, instead of sharing (Giesbers et al., 2021). Despite these sub-optimal conditions for digitalisation, we do see that digitalisation also takes place, albeit likely at a slower pace than in more optimal conditions.

In terms of theoretical implications, deepening earlier work on the role of trust in relation to digitalisation (Agyekumhene et al., 2018; Bronson & Knezevic, 2016; Fielke et al., 2020; Fromhold-Eisebith et al., 2021; Jakku et al., 2019) by specifying the sorts of trust involved, the case of the Dutch flower sector thus showed that while there are successful examples of digitalisation, this process was based on limited calculative trust, or even distrust, rather than relational and institutional trust. Hence, this may lead to suboptimal levels of trust or even induce a negative dynamic of accumulative distrust, which does not lead to true collaboration but is always to some extent negatively affected by co-opetition. This indicates that different sorts of trust at different levels in the value chain (i.e. related to relationships) and in the digitalisation process (i.e. related to technologies and how they impact relationships), needs to be tackled in tandem and that future studies need to better contemplate this diversity of 'trust arrangements'.

In the next section we reflect on what these findings imply for how organisations in value chains overall deal with digitalisation.

3.5.2 The need for digi-grasping to enhance ambidexterity of the value chain

Our findings show that trust in digitalisation, or lack of it, as discussed in the previous section is very much connected to the issue of uncertainty. In line with previous work (Falkenreck & Wagner, 2017; Fromhold-Eisebith et al., 2021; Kobos et al., 2018; Millar et al., 2018; Schneider & Kokshagina, 2021) we have seen uncertainty about the relationships with other actors in the value chain; the technologies involved; how to organise digitalisation processes; and what to expect from the outcomes, which in turn impact again on the market positions, business models, and hence the relationships and trust between the actors of the value chain.

In other words, the uncertainty related to digitalisation and related dynamics of distrust may cause a vicious cycle, which is difficult to break. These uncertainties described with digitalisation are not unique, but similar to other innovation processes, where we have seen

that the relationships with other actors in the value chain play a crucial role, as well as the technology, availability of resources etc. and the governance around it (Meijer & Hekkert, 2007). What our research adds to previous work on trust and digitalisation in agri-food and other value chains (Bronson & Knezevic, 2016; Eastwood & Renwick, 2020; Fromhold-Eisebith et al., 2021; Jakku et al., 2019; Klerkx et al., 2019; Newton, Nettle, & Pryce, 2020; van der Burg et al., 2020; Wiseman et al., 2019), as well as previous work regarding (digital) innovation, disruption and uncertainties (Falkenreck & Wagner, 2017; Kobos et al., 2018; Meijer & Hekkert, 2007; Millar et al., 2018; Schneider & Kokshagina, 2021) is that it shows the intermingled nature of process and outcome in relation to trust and digitalisation. Our research also indicates that organisations and the value chains they operate in are often 'locked-in' to older technological trajectories. These path dependencies are even more difficult to overcome when there is a limited basis of trust, or even distrust, that supports a collaborative approach towards digitalisation and its possibilities. In a sense organisations or even entire value chains become 'locked-out' or excluded from new (digitalisation) opportunities, due to the level of (dis)trust (Newton et al., 2020).

To break out of the vicious cycle whereby existing distrust or limited trust causes limited digitalisation, which in turn causes more distrust due to uncertainties around the digitalisation process, further increased by existing (technological) path dependencies, there needs to be sufficient space for exploration to 'grasp' digitalisation, i.e. to see what the possibilities and challenges are in both the short and longer term and to move from being ignorant to a transformer regarding digitalisation (Dufva & Dufva, 2019). This is to understand what digitalisation means for an organisation in terms of their identity (Rijswijk et al., 2019) and innovation process (Haefner et al., 2021). This can already be complicated at the level of a single organisation, and it may even be more complicated grasping what digitalisation means for an entire value chain or network, in which different actors in a value chain or network can be at different stages of 'digi-grasping' (Fielke et al., 2021; Rijswijk et al., 2019). Even more so given the high levels of uncertainty and low levels of trust. The case of the Dutch flower sector confirms observations in the literature (Fromhold-Eisebith et al., 2021), showing that it is difficult to grasp digitalisation, i.e. to see what the possibilities and challenges are in both the short and longer term and to move from being ignorant to a transformer regarding digitalisation (Dufva & Dufva, 2019). Hence, joint digi-grasping at value chain level therefore seems to be necessary, and here approaches such as serious games could be useful (Salvini et al., 2020).

There is perhaps also a role for so-called 'disruptors'. For example in the Dutch flower sector, these disruptors need to come from outside the value chain given the strong lock-in. However, this is not without risks as disruptors may threaten the status quo and enhance distrust. Disruptors thus need to create a sense of urgency and a common purpose, or function as an intermediary. This points to the important role of what has been called ambidexterity, e.g. striking a balance between exploiting the certain old or current while having sufficient space to explore the uncertain new and future possibilities (Lawrence, Tworoger, Ruppel, & Yurova, 2021; Turner et al., 2017), which could allow actors to step out of their regular patterns of competition or co-opetition and to explore new levels of collaboration for digitalisation. Ambidexterity may thus lead to development of trust around digitalisation in several ways. It could support trust development in the data and the technology; among value chain actors and between them and potential disruptors; and allows for experimenting with suitable governance structures, also considering the accommodation of potential 'losers' which disruption inevitably evokes (Barrett et al., 2020; Herrero et al., 2021; Klerkx & Rose, 2020).

However, joint digi-grasping could also lead to further lock-in in old trajectories when done in current configurations of the value chains, whereby differences between actors are not always well understood and the digi-grasping process is not supported through joint exploration (i.e. letting go of competitive relations). Additionally new digital technologies increasingly have their own agency – such as AI, making these technologies an extra (f)actor to take into consideration (Kolloch & Dellermann, 2018; Legun & Burch, 2021). These two aspects combined (e.g. old value chain configurations leading to further path dependency and agency of technologies) could indicate that the concept of a value chain with clear linear relationships and a clear division of subsequent tasks may no longer be sufficient. Tentatively, it may indicate that it is time to move to an ecosystem approach whereby these human and non-human actors operate in a 'value network' (Kolloch & Dellermann, 2018) in which reciprocity (and therefore trust) is an underpinning success factor (Pachoud, Delay, Da Re, Ramanzin, & Sturaro, 2020).

3.5.3 Methodological reflections and limitations

It is important to note that the results in the chapter are based on interviews from 2019. Due to the rapid innovation around digital technologies and the related digitalisation process it is likely that the Dutch flower sector now finds itself in a different position regarding trust and digitalisation. For example, more complex technologies might be

implemented, both horizontal and vertical collaboration may have increased due to improved governance structures and hence more institutional trust may exist. Furthermore, due to the competitive nature of the sector, interviewees may understandably not have been open about what new ideas, efforts and collaborations they were developing with regards to digitalisation in the Dutch flower sector.

3.6 Conclusion

With this research we aimed to show the connections between trust and digitalisation in a holistic way, focussing on the multifaceted aspects of trust and digitalisation in value chains. Based on a case study of the Dutch flower sector, we showed that there is limited (institutional) trust in this sector to support digitalisation. This indicates that the different manifestations of trust (e.g. interpersonal trust, institutional trust, and trust in data and technologies) all play a crucial role in digitalisation and need to (positively) coincide to achieve successful digitalisation, both in terms of the process and the outcomes. Additionally, we have seen that the existing trust relationships and competitive incumbent context do not sufficiently allow for exploration to support digitalisation, even when this space is being created through dedicated projects (such as DaVinc3i Community), hence the process and the outcomes of digitalisation end up in a vicious cycle. Future research could look into ways to break out of this cycle, and differences in the pace of digitalisation in competitive, co-opetitive, cooperative and collaborative contexts.

These findings underscore the importance of understanding trust in relation to its specific context, e.g. value chain and sector characteristics, and to see trust as a reciprocal concept, i.e. to understand how trust and digitalisation in value chains develop in relation to each other. A main theoretical implication is that a better awareness of mutually reinforcing (dis)trust dynamics and vicious (or virtuous) cycles in relation to digitalisation are needed. Such an approach adds an interesting and novel perspective to existing studies on trust and digitalisation, that often hold an instrumental focus and provide limited insights into the factors and dynamics underlying the interrelation between trust and digitalisation. Such a perspective is highly valuable for future studies aiming to understand how and why digitalisation impacts trust, and broader social relations, especially in the early stages of digi-grasping in which we, to some degree, seem to constantly remain due to the ongoing development of new digital technologies.

Chapter 4

Digital transformation of agriculture and rural areas: A Socio-Cyber-Physical System framework to support responsibilisation

Abstract

Digital technologies are often seen as an opportunity to enable sustainable futures in agriculture and rural areas. However, this digital transformation process is not inherently good as it impacts on many aspects (e.g. economic, environmental, social, technological, institutional) and their relations. The Responsible Research and Innovation approach calls for a better understanding and anticipation of the often unknown impacts. To meet this aim we have developed a framework that allows to gain insight on the relations between the social, the cyber and the physical, i.e. a Socio-Cyber-Physical System and have described conditions for a successful digital transformation of such a system. These are design of, and creating access to digital technologies, and navigating system complexity. This framework allows for a better problematisation of digital transformation and has been illustrated through an example of digital dairy farming. It supports an enhanced understanding of moral responsibilities regarding digital transformation, fitting within the Responsible Research and Innovation approach, as well as the succinct step of understanding who is responsible or accountable for the identified (positive or negative) impacts, i.e. responsibilisation.

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4.1 Introduction

Digital transformation in agriculture and rural areas is a policy priority at global level (Trendov et al., 2019; World Bank, 2017, 2019). In Europe, the European Commission set out as one of its objectives "fully connecting farmers and the countryside to the digital economy" in order to achieve a smarter, modern and sustainable future of food and farming (European Commission, 2017, p. 7). This was followed by the Green Deal in which digital technologies are considered "a critical enabler for attaining the sustainability goals of the Green deal in many different sectors"(European Commission, 2019b, p. 7), and in 2020 the Farm to Fork strategy indicates that "the CAP [Common Agricultural Policy] must also increasingly facilitate investment support to improve the resilience and accelerate the green and digital transformation of farms" (European Commission, 2020a, p. 16).

Digital transformation comprises a spectrum of activities, encompassing both digitisation and digitalisation. *Digitisation* can be described as the "technical conversion of analogue information into digital form" (Autio, 2017, p. 1), while *digitalisation* is the term often used to describe the socio-technical processes surrounding the use of (a large variety of) digital technologies that have an impact on social and institutional contexts (Tilson et al., 2010). Digitalisation goes beyond the level of a single business or entity, linking on- and off farm data and managements tasks, which are enhanced by context- and situation awareness and triggered by real-time events (Rose & Chilvers, 2018a; Wolfert et al., 2014). Digital transformation is thus a process whereby over time the options of digital technology use, the associated complexity (i.e. interactions between the various aspects of a system, such as (digital) technologies; institutions; organisations; people; and the environment) and their related impacts on society, either positive or negative, increase.

Many consider digital transformation as the solution to the challenges that agriculture and rural areas face (Trendov et al., 2019; World Bank, 2019). However, lessons learned from past technological revolutions suggest caution (Bronson, 2019b; Eastwood, Ayre, et al., 2019), as (agricultural and rural) innovation is not an inherently good and value free process, but normatively laden and driven by different worldviews and visions. Correspondingly, different development directions exist, each with its own winners and losers (Brooks & Loevinsohn, 2011; Klerkx, van Mierlo, & Leeuwis, 2012; Thompson & Scoones, 2009; Vanloqueren & Baret, 2009), also in relation to digital transformation (Cowie et al., 2020; Klerkx & Rose, 2020; Lajoie-O'Malley et al., 2020). Current digital technologies may have several undesirable, unseen and unknown impacts, e.g. emergent

effects that only become clear once these technologies are brought into practice (Klerkx & Rose, 2020; Pansera, Ehlers, & Kerschner, 2019; Scholz et al., 2018). It has for example been argued that instead of transforming agriculture and rural areas, digital technologies reinforce current systems which are deemed unsustainable economically, socially and ecologically and favour incumbent large players (Clapp & Ruder, 2020; Cowie et al., 2020; Miles, 2019; Prause, Hackfort, & Lindgren, 2020). Given the game-changing potential of digital technologies, strategies for digital transformation of agriculture and rural areas will therefore need to take the socio-economic conditions, that influence and are influenced by processes of digitisation and digitalisation, into account (Klerkx & Rose, 2020). Bearing in mind that different technological configurations, referred to as socio-technical 'bundles' (Barrett et al., 2020), may lead to a different distribution of impacts on stakeholders (Klerkx & Rose, 2020; Rotz, Duncan, et al., 2019).

Hence, digital transformation in agriculture and rural areas comes with a range of (ethical) concerns, and therefore a growing number of authors has argued for a Responsible Research and Innovation approach to digital transformation in agriculture (Barrett & Rose, 2020; Bronson, 2018, 2019b; Eastwood, Klerkx, et al., 2019; Klerkx & Begemann, 2020; Lajoie-O'Malley et al., 2020; Rose & Chilvers, 2018a; Rose et al., 2021; van der Burg, Bogaardt, & Wolfert, 2019b) and rural areas, where Cowie et al. (2020) propose "Responsible Rural Research and Innovation" (RRRI) as a sub-field of RRI. RRI anticipates the impacts of innovation, reflects on and is responsive to its unintended, consequences (Bronson, 2018; Klerkx & Rose, 2020; Owen et al., 2012). Stilgoe et al. (2013) capture the RRI approach in four main principles: anticipation, inclusion, responsiveness and reflexivity.

While the RRI approach has often been suggested, application has however been limited, and is at best patchy. For example, Eastwood, Ayre, et al. (2019) found that innovations around smart farming have focused on technological development and on-farm use without taking socio-ethical implications into account. Several other authors indicated that the RRI approach also fails to engage certain food system actors (e.g. citizens, consumers, other rights holders) in the innovation process (Bronson, 2015, 2018, 2019b; Eastwood, Ayre, et al., 2019). It has also been argued that digital transformation processes are sometimes hard to 'grasp' for stakeholders (Dufva & Dufva, 2019; Rijswijk et al., 2019), which may lead to a limited 'readiness' to innovate responsibly (Eastwood, Ayre, et al., 2019). Blok and Lemmens (2015) indicate that practical applicability of RRI is problematic

and requires a more thorough examination of RRI, because of a mismatch between the ideal of responsibility and the realities of existing innovation processes. To deal with these issues that affect satisfactory enactment of RRI, a comprehensive framework is needed that guides the (upfront) assessment of the impact of digital transformation processes in agriculture and rural areas, thus supporting the ability to undertake digital transformation in a responsible manner. Rose and Chilvers (2018a) therefore call for: 1) a more systemic approach to map innovations associated with digitalisation of agriculture; 2) broadening of notions of inclusion in RRI in order to include a diversity of participants; and 3) testing responsible innovation frameworks in practice to estimate if innovation processes can be made more socially responsible, in order to make RRI more relevant and robust for upcoming agri-technology. In this chapter, we focus mainly on the first element of Rose and Chilvers' (2018a) proposal, informing a more systemic approach to map innovations associated with the digital transformation of agriculture and rural areas, in connection with the second element, informing who is responsible for what and should be included in RRI.

We aim to support an RRI approach in building strategies for digital transformation in agriculture and rural areas, by instilling what Maye, Kirwan, and Brunori (2019) have dubbed as responsibilisation, a concept which has close links with the notion of responsibility which is central in RRI. *Responsibility* has a double meaning, on one hand there is ex-ante, or normative, responsibility, which is about behavioural standards that on the basis of current knowledge allow for minimization of risks. This has mainly to do with moral duties and moral sanctions. On the other hand there is ex-post responsibility, i.e. the duty of actors to respond to undesired or unintended consequences of technologies or behaviour. This second meaning is much nearer to the concept of accountability, and can even be subject to sanctions. This also implies a cognitive link between information, decisions, practices, and their outcomes. However, if it is impossible to know, even with uncertainty, what the effects of one's choices are, it is impossible to allocate responsibilities. *Responsibilisation* (see Figure 4.1) then is a process whereby, in relation to the improvement of shared knowledge on the links between action and its consequences, behavioural standards for involved actors are developed and enforced through accounting mechanisms and sanctions. The process of responsibilisation is fed by problematisation, through which the community reflects on the ethical (or even the legal) standards related to a given innovation in relation to new or disclosed information and improved knowledge. Problematisation calls into question actors' behaviour and

provides the grounds for the community to distribute ex-ante and, when a greater degree of information is available, ex-post responsibilities. In complex systems, responsibilities are distributed (Barnett, Cloke, Clarke, & Malpass, 2010), hence everybody bears a fraction of responsibility for the outcomes of the system. I.e. the greater the information one can get about the link between action and its consequences, the greater the possibility to distribute responsibilities and to move from ex-ante to ex-post responsibility. In other words, responsibility is inherently linked to knowledge production, use and communication, but this requires a through and holistic understanding of the issues at hand. We therefore link responsibilisation is to the problematisation of effects of digital transformation of agriculture and more broadly rural areas.

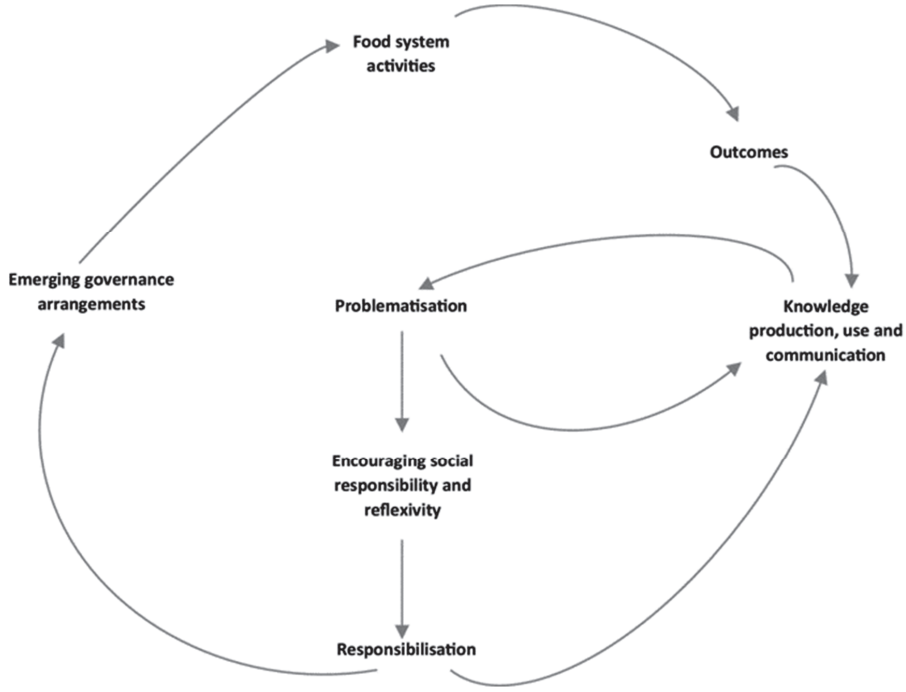

Figure 4.1 The process of responsibilisation and its implications (Maye et al., 2019)

In this chapter, we articulate a framework that supports the processes of problematisation and eventually responsibilisation, enhancing an understanding of systemic change linked to digital transformation, unravelling the multiple interactions created and affected by digital transformation in the context of agriculture and rural areas. Through the concept of 'cyber-physical' systems, which has been forwarded as a way to

understand the relationships between digital technologies and the environments they are embedded in (Klerkx et al., 2019; Lioutas et al., 2019; Wolfert, Ge, et al., 2017), we aim to offer a way to sharper define problems and reflect on potential consequences of digitalisation. Processes of problematisation, as a part of RRI principles such as anticipation and reflexivity, can open new areas of responsibility and inform governance activities to shape future agriculture and food systems and other activities in rural areas.

The framework, developed within a project that aims to support the assessment and planning of digitalisation processes of agriculture and rural areas[2], aims at building a base for supporting participatory assessment, planning and design of digital transformation processes by offering a number of concepts to sharpen reflection on digital transformation and its potential impacts. This chapter proceeds as follows: In the next section we will sketch a systems approach to digital transformation, introducing the concept of 'Socio-Cyber-Physical System', also highlighting the conditions that create opportunities and threats to actors when exposed to digital transformation processes. Section 4.3 will illustrate the framework in the context of digital dairy farming, also showing the implications for responsibilsation and section 4.4 will discuss research and policy issues and draw conclusions.

4.2 Unravelling Socio-Cyber-Physical Systems

Digital transformation can be considered systemic change, as it affects the way people, things and institutions coordinate themselves in order to perform their activities (Cowie et al., 2020; Klerkx & Rose, 2020; Nambisan et al., 2019). Digital transformation entangles digital, physical and social worlds through a multiplicity of technologies. We propose to study these entanglements using a systems approach. The nature of the systems referred to are hybrid, that is, relations among entities belong to both social and technical domains also encompassing biological and physical entities (and in this sense also connecting to concepts such as socio-ecological systems), which connects to recent discussions in rural sociology regarding a move to a 'more-than-human' approach (Legun & Henry, 2017) and a 'relational approach' (Darnhofer, 2020; Kok, Loeber, & Grin, 2021; West, Haider, Stålhammar, & Woroniecki, 2020) to transformative processes, and similar calls in agricultural innovation studies to better take into account materiality and biology (Berthet, Hickey, & Klerkx, 2018; Pigford, Hickey, & Klerkx, 2018).

[2] For more information see www.desira2020.eu

As illustrated in Figure 4.2, there is a range of concepts building on the idea of a system. Social scientists have developed the concept of *socio-technical system* to highlight that technology is embedded in social relations (Bijker, 1995; Hughes, 1987), and that there is a co-evolution between these domains. Scholars in technological disciplines have developed the concept of *cyber-physical system* to highlight the links between digital and physical entities in systems (such as agricultural systems, rural areas) wherein physical objects and processes are replaced, or complemented, by digital ones (Griffor, Greer, Wollman, & Burns, 2017). In this section we will briefly review the socio-technical system concepts that already connect social systems to technical systems (which may comprise physical and biological systems in our case), and will then propose the concept of *Socio-Cyber-Physical System* as a heuristic tool to study the processes of digital transformation.

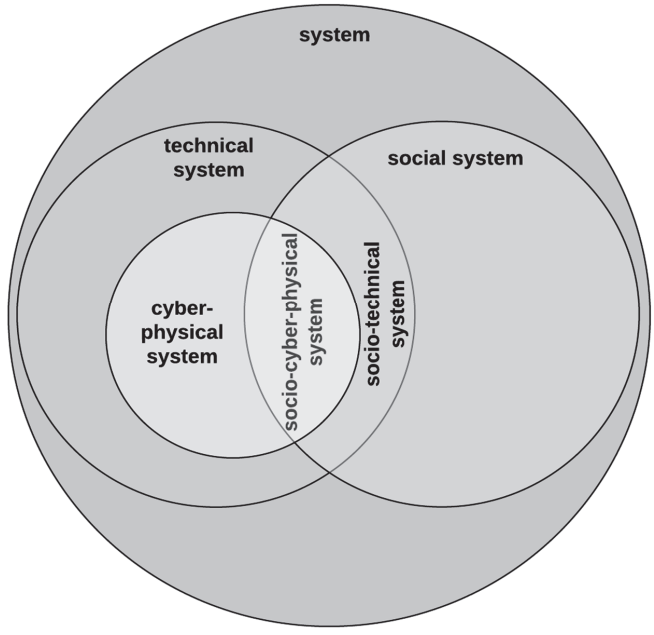

Figure 4.2 Hierarchy of system concepts

4.2.1 Socio-technical systems

A socio-technical system (Bijker, 1995; Hughes, 1987) refers both to the interrelatedness of social and technical aspects of an organisation or the society as a whole (Ropohl, 1999), whereby technology, besides material things, also includes organisational structures and processes (Botla & Kondur, 2018). Social actors that are part of the socio-technical system

have different aims and interests among them, and are also endowed with varying levels of resources (knowledge, social capital, etc.). Furthermore, they hold different positions in society or in a specific organisation, and act according to varying routines, norms and social values. Additionally, some actors may hold a power position over others in which they, for example, can control the system's performance, influence other actors' activities, and restrict access to technology. At the same time, the use of new technologies or new regulations can also reset existing social asymmetries, depending on how socio-technical relations change the connections among technologies and social actors. Verbeek (2012), considers technologies as mediators between entities of a system, which play a constituting role on shaping the identities of the entities involved in the relation: they "help to constitute what means to be a human being" (Verbeek, 2012, p. 393).

4.2.2 Socio-Cyber-Physical Systems

Digitalisation of socio-technical systems opens a new field of enquiry, given the nature and the characteristics of informational entities (Lioutas et al., 2019; Wolfert, Ge, et al., 2017). In information science, *Cyber-Physical Systems* (CPS) describe the mutual interaction between a *cyber domain* and the *physical domain* (Griffor et al., 2017). This implies the understanding of how digital information interacts with and transforms the physical world (which comprises both natural and manmade materialities). Digital technologies expand the world of artefacts as they disconnect reality from materiality (many of the practices we carry out have only informational content), location from presence (we can meet at distance, activate devices remotely, monitor behaviour at a distance), multiply the possible realities we can experience, and expand the time experience, expanding the multitasking possibilities (Floridi, 2014). Through for example digital twins, virtual replications of physical systems continuously updated by their twins' data (El Saddik, 2018; Verdouw, Kruize, Wolfert, & Chatzikostas, 2017), it is possible to predict harmful events in a physical system and intervene before the events occur. Furthermore, there is a continuous exchange and integration of physical and informational objects (Floridi, 2014). Each time a digitisation event occurs, for example taking a photo with a digital camera, a part of the physical reality is replicated into the digital sphere. When a robot, a cyber-physical entity, acts upon the physical world, for example, a drone spraying a pesticide, it does it on the basis of the digital representation of the world it has. The efficacy of new generation robots, depends on the accuracy of the digital representation of the system upon which it acts. Given their storability, reproducibility and transmittability, data can be pooled with other data and used for very different purposes

than the original one. This makes the digital component of CPS extremely dynamic, as it is only partially constrained by physical entities. This has important sociological implications that the concept of CPS cannot capture, as CPS do not consider social agency hence there is a need to introduce a *social domain* to the concept of cyber-physical systems.

In the social sciences field, Haraway (1990), with the concept of 'cyborg' that overcomes the human/machine dualism, opened the way to the development of the concept of *Socio-Cyber-Physical Systems* (SCPS)(Lioutas et al., 2019) (Frazzon, Hartmann, Makuschewitz, & Scholz-Reiter, 2013; Sheth, Anantharam, & Henson, 2013; Zavyalova, Korzun, Meigal, & Borodin, 2017) as "systems constituted by the social world (people), the digital world (data), and the physical world (things)" (Rijswijk et al., 2020). If we consider that socio-technical systems are composed of actors, rules, and artefacts (Bijker, 1995; Geels, 2004), SCPS can be seen as socio-technical systems in which digital artefacts are an additional key factor in the system's existence and functioning (see Figure 4.3). The cyber domain of SCPS therefore has the power to change radically social practices: as they replace or augment material objects, they reshape the meanings of both material and immaterial entities, generate new skills and make others obsolete. Thus, with the concept of SCPS, digital transformation is framed as a socially constructed process, allowing for the identification of key entities and their interactions across the three domains of which SCPS are composed.

These three domains each consist of a variety of entities (see Table 4.1 for definitions). Intradomain relations and interactions (Figure 4.3) are often governed by a particular type of entity within that domain, which is a set of rules. The domains also interact with each other leading to certain (wanted and unwanted, known and unknown) outcomes and adaptations to the system which they form together. In the process of digital transformation, special emphasis is put on the cyber domain, as the physical and social entities become encoded into digital entities and expand the possibilities for action in the other domains.

Table 4.1 The configuration of domains of the SCPS

Domain	Entities	Interactions
Social	Social actors, groups and communities, and institutions	Relations between entities in the social domain are regulated by *social rules*, such as routines, social norms, ethical norms, informal behaviour, policy, laws
Cyber	Cyber entities are composed of a) digital reproductions of the physical sphere created by digitisation processes, e.g. from a paper-based map to a digital model of a farm which can be used by a drone, as well as b) original digital constructs, such as software, big data, cloud computing, Internet of Things, etc.	The relations between entities in the cyber domain are regulated by *cyber-rules*. For example, communication between devices is regulated by specific protocols (such as WiFi, Bluetooth, 5G); another example is the data format (PDF, DOC, …), a specific arrangement of data so that they can be stored, exchanged, and correctly interpreted. Digital technologies can communicate with other technologies, digital entities interact with other digital entities, performing operations and making choices potentially independently of humans, while initially being designed by humans.
Physical	These entities can be natural or artificial, according to the degree of manipulation they have undergone as a result of human activities. This includes living organisms and natural resources (plants, animals, etc.) and physical things to support living and working in the (natural) environment (e.g. analogue technology, infrastructure, finances)	Relations between entities in the physical domain are regulated by *natural rules* and by *technical rules*. For example, wild animals select in the environment the entities – plants or animals – that suit their nutrition, avoiding harmful entities. Water cycles are regulated by natural processes, such as evaporation and precipitation, but also by technical processes, such as water extraction from wells or circulation into pipes.

As can be read in Table 4.1 and alluded to in section 4.2.1, in the context of agriculture and rural areas, the physical world can also be understood to comprise the ecological world, so a socio-cyber-physical system may even be seen as a socio-cyber-physical-ecological system as has been tentatively argued (Klerkx et al., 2019). This already shows that it is difficult, in the real world, to isolate interactions between entities belonging to a single domain. Our social interaction is profoundly influenced by our physical world, and even when machines interact only amongst themselves, they have been designed by actors that can switch them off at any time. However, for analytical purposes, it is useful to make

distinctions. Firstly, the interactions between cyber and physical domains occur through automation, data collection, management, monitoring and controlling, e.g. Internet of Things. This also includes feedback loops from cyber to physical, e.g. milking robots causing the cows to adjust their milking patterns (Bear & Holloway, 2019b; Driessen & Heutinck, 2014), and connections between digitalisation and genome editing (Clapp & Ruder, 2020). Secondly, there is the interaction between the social and physical domains, which could include the governance of natural resources, e.g. irrigation systems or the legal requirements for buildings in a natural environment (Fischer, Petersen, Feldkoetter, & Huppert, 2007; Lund, 2015). Other examples are ecotourism, the connection between farmers and their livestock, or the links between the quality of road infrastructure and rural entrepreneurship (Cowie et al., 2020). Finally, there are interactions between the cyber and social domains that for example influences jobs (see Rotz, Gravely, et al., 2019), enhances sensing capabilities of people which may impact for example advisory systems and advisor-farmer interactions (Eastwood, Ayre, et al., 2019; Ingram & Maye, 2020), creates new "proximities" affecting rural-urban and spatial inequalities (Haefner & Sternberg, 2020), and develops social media networks – i.e. the cyber entities function as a multiplier of the social entities (see Klerkx et al., 2019 for an overview of multiple additional examples of effects). The social entities, such as values, in turn create the basis for, for example, programming and algorithm development.

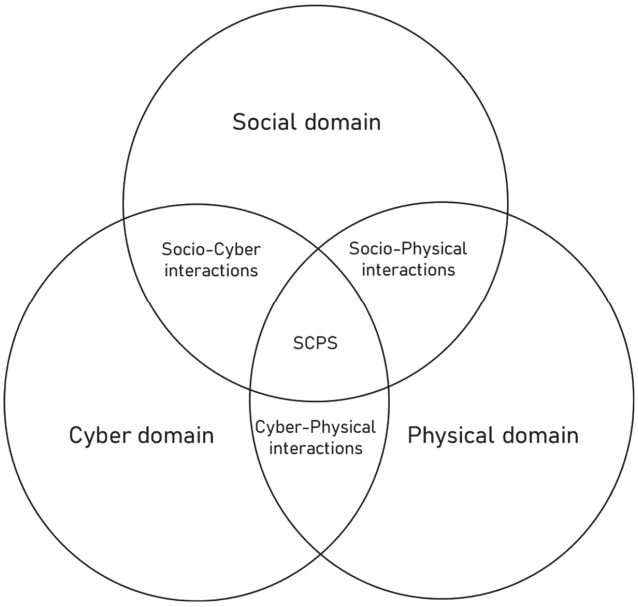

Figure 4.3 The socio-cyber-physical system with related interactions based on the three domains (social, cyber and physical).

4.2.3 Conditions for impact of digital transformation

As argued in section 4.1, having a better understanding of the SCPS undergoing digital transformation, can enhance problematisation which in turn informs RRI. However, we argue that in order to enhance social responsibility and reflexivity it also should be made clearer how SCPS relate to three conditions for successful digital transformation which can have (positive or negative) impacts (Rijswijk et al., 2020): the *design* of digital technologies (Cooper, 2005; Whiteley, 1993), creating *access* to digital technologies (Klerkx et al., 2019; Shepherd et al., 2020), and navigating *system complexity* (Mocker, Weill, & Woerner, 2014). They co-determine different interactions between social, cyber and physical domains (see Table 4.1 and Figure 4.2), or emerge from them, and hence are related to *impact of digital transformation.* Table 4.2 provides a non-exhaustive overview of known (negative) issues of digital transformation linked to these conditions for each of the domains.

With regards to *design*, digital technologies are designed to realise a given (desired) outcome and impact, such as improved productivity, profitability and sustainability (Global e-Sustainability Initiative & Deloitte, 2019), i.e. to have intended consequences. However, digital technologies often also come with (known and unknown) unintended

consequences, which can either be positive or negative (Klerkx & Rose, 2020; Scholz et al., 2018) In some cases, outcomes can be harmful to people, animals or to the environment. Design-related impacts can induce modifications of existing dynamics, both in the social and in the business context, causing a redistribution of risks, benefits, and burdens among actors (Yeung, 2018). The design of technologies may be value laden, e.g. programmers views of the world are (unknowingly) reflected in the software they design which may exclude certain (groups of) people, hence raising ethical concerns (Johnson, 2019; Leavy, 2018). At the same time technologies may also be vulnerable to environmental conditions, such as heat, wind, and humidity, or to espionage or cyber-attacks (Nikander, Manninen, & Laajalahti, 2020). Furthermore, conditions not considered during design, e.g. temporary lack of Internet connectivity, may cause serious issues, not in the least the inability to use services when needed (Shepherd et al., 2020; Steinke et al., 2020). Taking into account indirect and long-term effects leads to design approaches that anticipate problems, such as 'user centred design' (Steinke et al., 2020) 'secure by design', 'safe by design' or 'sustainable by design' (Patrignani & Whitehouse, 2013; van de Poel & Robaey, 2017). More in general, responsible design involves users and stakeholders in the design process, aiming to reduce the above mentioned risks, by putting users' need at the center through a human-centered design approach (stepping into users' shoes) to address the large and diverse community of stakeholders. Novel strategies, such as design thinking, advocate for a deeper, more personalized, understanding of users, instead of identifying aspects equally common to most users. (Carell, Lauenroth, & Platz, 2018).

Impact is also related to *access* to technologies, i.e. the distribution of physical, social, human and legal resources necessary to get access to digital opportunities. A well-known problem is that as a result of lack of economic, physical, or educational access to the internet, (groups of) people suffer from social and economic marginalisation and uneven socio-economic development. I.e. different levels of access to information or capacity to operate will create inequalities in the distribution of the costs and benefits of digital technology use. This is known as the (rural) digital divide, and addressing the problem goes much beyond the coverage of broadband infrastructures, because the availability of digital resources in an area also involves the possibility to readily buy, configure, and use digital devices that can easily operate jointly with existing digital devices (interoperability) (Rotz, Gravely, et al., 2019; Salemink, Strijker, & Bosworth, 2017; Wolfert, Ge, et al., 2017). Assessment of access conditions should consider potential users of the technology and consider the costs and the benefits that could be created. A recent document of the

European Network for Rural Development (2020) suggests assessing rural areas in relation to their readiness for digital transformation, as different readiness levels may imply different priorities. Consideration of access conditions would also frame digital transformation strategies as socio-technical strategies, addressing both the technical and the social conditions for generating value and implementing integrated policy mixes.

A third condition for (positive or negative) impact of digital transformation is *system complexity*. The more digitisation and digitalisation proceeds, the stronger the need to connect system entities to each other, and the greater the influence of the cyber domain. Increasing connectivity adds to complexity because of the multiplicity of ways in which each entity interacts with others (see section 4.2.2). A too fast technological pace, enabled by the malleability of digital technologies (Nylén & Holmström, 2015), may be challenging for final users, who perceive technology as a black box on which they may depend for e.g. business operations. This causes a dependence on (technical) experts, adding to the economic costs. Assessment of system complexity should consider changes to entities and activities of a system in relation to the connections with other entities and other domains. According to Perrow (1984) complexity of a system combined with too tight coupling (strong cause/effect links between entities) leads to vulnerability of systems and to domino effects.

A combined consideration of all 3 conditions is often required in order to have a successfully operating SCPS which creates positive impacts and counteracts negative effects of digital transformation. E.g. social exclusion related to digitalisation can be caused by lack of access to the Internet and the cost of an application (*access* conditions), or the design of technologies with bias or intrusive forms of conditionality (Kaye, 2018) (*design* conditions), or to the difficulty to make all parts of a system work (*complexity* conditions). For example, social networks and lack of connectivity can amplify the stigma of farmers not complying with environmental regulation, extending the stigma to the whole category.

Table 4.2 Non-exhaustive overview of known issues of digital transformation

	Design	**Access**	**System complexity**
Social	Poor usability leading to use-related difficulties (Human Machine Interaction)(Aleixo,	Partial or total exclusion because of lack of digital skills or	Too fast technological pace sometimes challenging for final

	Nunes, & Isaias, 2012; Haapala, Pesonen, & Nurkka, 2006) Biased technology (Johnson, 2019; Leavy, 2018)	education (van Deursen & van Dijk, 2014) High costs (Higgins et al., 2017) Lack of skills to reconfigure systems after upgrades / changes (dependence) (Nylén & Holmström, 2015)	users (Nylen and Holmstrom, 2015) Unintended consequences of algorithmic regulation (Lodge & Mennicken, 2017) Redistribution of risks, benefits, and burdens among actors (Mönnig, Maier, & Zika, 2019; Piasna & Drahokoupil, 2017; Shepherd et al., 2020; Yeung, 2018) Difficult policy context not easing digital transformation (Hinings, Gegenhuber, & Greenwood, 2018)
Cyber	Loss of data due to improper use or external causes (e.g. attacks) (Duc & Chirumamilla, 2019) Inability to work in some conditions, e.g. temporary absence of Internet connectivity (Shepherd et al., 2020; Steinke et al., 2020) Personalization and profiling (Zuboff, 2019) Bias in algorithms causing e.g. exclusions or difficulties to access services (Kaye, 2018) Technological lock-in (Kaye, 2018)	Poor access to Internet connectivity (Townsend, Sathiaseelan, Fairhurst, & Wallace, 2013) Lack of digital infrastructure and resources readily available (Townsend et al., 2013) Lack of interoperability features in hardware and software components (Fulton & Port, 2018) Dependence on previous innovation; exclusion due to technological lag (Fulton & Port, 2018)	Opacity (black box) (Meske & Bunde, 2020) Operational complexity – dependence on experts (Tantalaki, Souravlas, & Roumeliotis, 2019; Zhang & Kovacs, 2012) Difficulty in developing diversified development trajectories (Clapp & Ruder, 2020)
Physical	Digital solutions not resistant to e.g. atmospheric conditions, work in the field, etc. (Von Känel & Vecchiola, 2013) E-waste and disposal (Pickren, 2014)	Availability of digital devices (computer, smartphone, etc.) and adoption rate (Andriole, Cox, & Khin, 2017) Location dependence (Cowie et al., 2020;	Need for up-to-date hardware (computer, smartphone, …) (Andriole et al., 2017)

		Salemink et al., 2017; Townsend et al., 2013)	

4.3 Illustration of the framework: A dairy system as Socio-Cyber-Physical System

As indicated in the introduction, the process of digital transformation encompasses both digitisation and digitalisation, whereby digitisation is more often seen at the early stages of the digital transformation process, and tends to focus on the micro level, e.g. a single business or organisation. Digitalisation often encompasses more actors in for example a value chain (e.g. meso or macro level) and implies a more mature level of digital technology use (Eastwood, Klerkx, & Nettle, 2017; Fielke et al., 2019b; Higgins & Bryant, 2020). The concept of SCPS, however, suits both stages of digital transformation. In order to illustrate the SCPS concept, we apply it to the context of dairy farming and how it has engaged with digitisation feeding into more comprehensive digitalisation. We do not aim to display a full analysis of all SCP relationships across the three conditions (design, access, system complexity), as this would fall outside the scope of this chapter, but zoom in on some elements (see also Table 4.3). This illustration is based on insights coming from several articles on digitalisation in dairy farming. Dairy farming, the second biggest agricultural sector in the EU, is dealing with ongoing intensification resulting in increased farms size, mainly in terms of herd size (Clay, Garnett, & Lorimer, 2020; Thorsøe et al., 2020; Vellinga, Bannink, Smits, Van den Pol-Van Dasselaar, & Pinxterhuis, 2011). Therefore farm management, considering aspects such as animal health and welfare; milk production and quality; and feed production and quality, is increasingly undertaken with the support of various digital technologies.

4.3.1 Digitisation at the farm level

To describe the application of the SCPS concept at the farm level we focus on one aspect of farm management, namely milk production and quality. A large number of dairy farms in the EU make use of automatic milking systems (Jacobs & Siegford, 2012), of which the next step is robotic milking, as milking robotics can perform the whole milking process in an accurate manner, with minimal human intervention (Kiselev, Kamalov, Borisov, Fedoseeva, & Sanova, 2019). Thus, it creates more flexibility for a farmer, reduces physical labour (e.g. effort) and may also cause a decrease in (external) labour costs on farm (Rodenburg & House, 2007). The increased flexibility in labour requirement affects farmers' wellbeing through a better job satisfaction, mental health and family-work balance (Hansen et al., 2020). In Figure 4.4 the process of digitisation of the milking

process is illustrated. It shows the replacement of the social-physical activity of milking done by the farmer and an automatic milking system, with a cyber-physical activity of a robotic milking system.

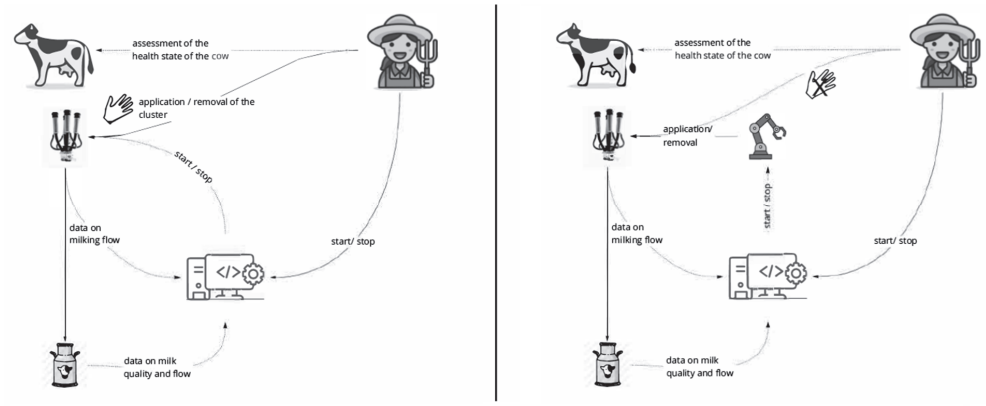

Figure 4.4 Digitisation of a milking system

While at first glance the replacement of the farmer's involvement in the milking process seems simple, it entails numerous social, cyber and physical changes (Hansen et al., 2020). In the basis, the robotic arm replaces the task of the human in applying the cluster to the udder of the cow (socio-physical becomes cyber-physical). In the *cyber domain* this implies however, a) digitisation of the information necessary to apply the cluster (position of the udder, state of health of the udder) and Artificial Intelligence (AI) to command the robot (Simões Filho et al., 2020); b) digitisation of the information necessary for AI to check if the robotic arm has performed its task correctly or to adapt tasks due to changes in external or internal conditions such as heatwaves or abnormal milk production (Fuentes et al., 2020); c) control tasks (start/stop) taken over by the control unit (Kulatunga, Shalloo, Donnelly, Robson, & Ivanov, 2017); d) storage of the data in the control unit or in the cloud (Kulatunga et al., 2017).

Within the *physical domain* additional entities have been placed, namely the old milking system is being replaced by the robot, requiring reconfiguration of the milking shed, additional space for the computer system, but also the cows need to adjust to this new milking method (Wildridge, Thomson, Garcia, Jongman, & Kerrisk, 2020). The cows, for example, can now get milked whenever they want, instead of 2 or 3 times a day at fixed

hours (Hogeveen, Ouweltjes, De Koning, & Stelwagen, 2001; Jacobs & Siegford, 2012). Moreover, walking into a robotic milking system and not having a recognizable process is something that needs to be taught to the cows and may take up to several weeks (Jacobs & Siegford, 2012). Some cows will never adjust to this new system and have to be taken off farm.

This combination has a big impact on the *social domain*. The initial intended outcomes, or the needs of the farmer that initiated the digitisation process, namely increased flexibility, less physical effort and a reduction of labour costs (Rodenburg & House, 2007), will also have secondary effects on organisational rules of the farming household, the allocation of labour time of the farmer, a change of the skill portfolio of the farm, up to an evolution of social values of the farmer and the farming community (Floridi et al., 2013; Hansen, 2015; Oudshoorn, Kristensen, Van der Zijpp, & De Boer, 2012; Rodenburg, 2017; Was et al., 2011). It also has inclusion and exclusion effects, because the initial investment of implementing milking robots is high and therefore often these robots are only within reach for medium to large farms, requiring the development of robust financial plans (Shortall, Shalloo, Foley, Sleator, & O'Brien, 2016).

Describing the changes in the SCPS with the introduction of robotic milking on a farm starts with considering the necessary conditions to be in place in order to avoid negative unintended (albeit often unknown or unseen) impacts. One of the *design* conditions could for example be that the robotic arm needs to be designed in such a way that it does not negatively impact on animal health and welfare, despite the cow having to adjust to this new way of milking. For all intents and purposes, the robotic arm may actually increase animal health and welfare, due to a more secure disinfection of the udder or the ability of the cow to be milked whenever is needed, hence possibly reducing the risk of mastitis (de Mol & Ouweltjes, 2001; Krömker et al., 2010). An *access* condition related to the design of the robotic arm and its software is that the farmer must be able to understand and interpret the data gathered throughout this milking process. In terms of *system complexity*, all the different elements as discussed before become connected, and this requires adjustments in the ways farms are structured and new organisational arrangements as regards the way data are stored and exchanged (Eastwood, Klerkx, & Nettle, 2017).

4.3.2 Digitalisation of the dairy value chain

Besides an automatic milking system, there are often numerous other digital technologies on a dairy farm, such as neck collars or feed sensors, which all generate data and are increasingly connected through means of IoT (Wolfert, Ge, et al., 2017). This data can be combined to gain new insights, supporting farmers with additional farm management information and tools, thus aiming to provide added value to farmers. This exponential on-farm data generation also provides new opportunities for agribusinesses. Integration of data at all steps of the production chain (pasture/crop data, animal feed, weather, animal health, milk production and quality) multiplies the potential of the use of data at all levels of the chain (Pesce et al., 2019), and opens new markets for digital services and equipment. This in turn also impacts the farm-level digitisation as technologies need to be designed in such a way that they can communicate with each other or that data can be shared and combined. Digitisation of dairy farms thus implies a restructuring of the dairy value chain (Eastwood & Renwick, 2020). I.e. a digitalisation process, whereby for example advisors need to be able to support farmers in understanding and using the digital technologies, or technology providers provide tools that are interoperable with other digital technologies of other providers (Eastwood, Klerkx, & Nettle, 2017).

The above shows that changes in the *cyber domain* (e.g. combining different data sets) affects the *social domain*, such as the relations between actors on- and off farm, in this case between farmers and (digital) technology and service providers. This can include many other actors as well, such as suppliers, processors, regulators, the community, and many others. In the example mentioned above advisors and technology providers need to define a new role and adjust their relation with farmers to some degree (Rijswijk et al., 2019). Moreover, digital technologies may positively affect farmers' social status, making the profession more attractive for young people. On the other hand, automation may bring to deskilling of workers, marginalisation and unemployment (Sparrow & Howard, 2020).

In the *physical domain,* several effects can also be seen. For example, dairy systems, and livestock systems in general are among the most critical for their impact on the environment as they contribute to Green House Gas emissions, to pollution of water, soil and air, and have a low efficiency of conversion into nutrients in comparison with other food sources (Duru & Therond, 2015; FAO, 2018; Smith et al., 2014). ICTs are increasingly considered in relation to dealing with these challenges (Tullo, Finzi, & Guarino, 2019), e.g. sensors can detect odours (Pan, Liu, Peng, Yang, & Gregori, 2007), polluters, GHGs

(Banhazi et al., 2012). These sensors can also detect behaviour, indicating whether the animal is undergoing stress (Tullo et al., 2019). Through means of blockchain, a technology based on distributed databases of encrypted data, this data can turn into non-modifiable information that accompanies the product and allows for tracing back to the farm that has generated a given outcome (Kamilaris et al., 2019). While aiming to enhance sustainability and animal welfare this can, however, also have negative consequences on both farmer, worker, and animal autonomy who could become to some extent 'servants' of automated dairying systems (Bear & Holloway, 2019a; Holloway, Bear, & Wilkinson, 2014a, 2014b; Rotz, Gravely, et al., 2019; Vik, Stræte, Hansen, & Nærland, 2019).

Regarding the conditions, when moving from digitisation to digitalisation the different conditions become even more interlinked encompassing a multitude of entities in each domain of the SCPS, thereby in itself showing the increasing *system complexity*. Referring to the example above of data generation and combination on- and off farm *design* conditions can include the interoperability between different technologies, as mentioned above, and preferably the data generated on- and off farm is FAIR (findable, accessible, interoperable and reusable) (Jouanjean, Casalini, Wiseman, & Gray, 2020; Mons, 2018) to those who need it, while as well as considering ethical, legal and social implications (ELSI) (van der Burg et al., 2020). For example, *access* concerns the right of farmers to repair their machines or own their own data, which sometimes is restricted due to intellectual property rights of the manufacturer (Bronson, 2018; Carolan, 2018).

Future developments in value chain transparency, compliance, digital policy enactment can further increase system complexity. For example, retailers could be interested in data about milk quality, including its environmental footprint, as this information may add value to the product if communicated to consumers (Ridoutt & Hodges, 2017). Health authorities could be interested in data about state of health of the herd, so they can build epidemiological models, and environmental authorities can check if the farm complies with emission limits (OECD, 2019). Policy support could be conditioned to the respect of minimum standards. Hence, the technologies have broader structural systemic implications (Vik et al., 2019).

4.3.3 Implications for responsibilisation

The illustration highlights that an analysis of the SCPS along with analysis of the conditions of design, access and system complexity supports the identification of the

different (potential) positive and negative impacts of the digital transformation process in agriculture and rural areas (see a summary in Table 4.3 of some issues identified in the illustration). Hence, it enables a sharper problematisation, which in turn helps to elucidate who may be responsible for understanding and dealing with these impacts. It shows that for some issues actors have a direct responsibility to attend for example animal welfare issues during the operation of the technologies, but also ex-post responsibility, i.e. a duty to respond to undesired or unintended consequences.

Table 4.3 Application of the SCPS framework to identify issues around digital dairy farming

	Design	**Access**	**System complexity**
Social	▪ Increased flexibility of the farmer. ▪ Reduced labour costs on farm. ▪ Less physical effort required. ▪ Farmers need the right to repair and to own their own data (FAIR and ELSI principles).	▪ (Re- and De-)Skilling of farmers and workers to operate AMS. ▪ Financial in- or exclusion due to investment costs. ▪ Marginalisation or unemployment of farm workers. ▪ Advisors need to take new roles. ▪ Reduced autonomy of farmers and workers. ▪ Farming becomes more attractive to young people.	▪ Changing organisation rules of the farming household. ▪ Different allocation of labour time. ▪ Evolution of social values of the farmer and the farming community. ▪ Tracking & tracing for retail purposes and compliance through data sharing for policy purpose can cause biases towards farmers. ▪ New power dynamics between all actors (e.g. farmer and advisor).
Cyber	▪ 'Datafication' of all components of the dairy farm to allow for the technology to communicate. ▪ Added value for farmers of through farm management tools.	▪ New markets for service providers, e.g. online data platforms	▪ Data gathered by automated milking systems is linked to manufacturers databases and to regulatory systems.
Physical	▪ Breeding needs to be attuned to AMS.	▪ Cows need to be trained to adjust to AMS.	▪ Restructuring of milking sheds and farm lay-out to

	▪ Increased animal welfare due to tracking of animal behaviour.	▪ Discharging cows which do not fit AMS. ▪ Reduced animal autonomy.	accommodate AMS with possible effects on landscapes and biodiversity.

In our dairy farming example the on-farm data generation and the subsequent disclosure would increase responsibilisation of farmers, as they would be accountable for product and environmental quality and animal welfare. Additionally, those requiring the data disclosure, and those that set the standards for product and environmental quality as well as animal welfare have an even bigger responsibility of supporting farmers in meeting these requirements, as trade-offs and ethical dilemmas may also arise. As digital technologies require an investment small farmers may not be able to finance this, causing an additional problem of being unable to demonstrate their performance regarding the quality of their product and environmental compliance. Land prices could also be affected; retailers may decide to exclude underperforming farmers from their supply chains. Disclosure of data about farm pollution may generate stigma of the community over polluting farmers (OECD, 2019), and misuse of data may cause reputation damage to compliant farmers. These aspects show that the impact of technologies – and their game-changing potential - would depend on the broader SCPS in which they are embodied, and should thus be considered in early stages of technology design and including the governance and regulatory implications and requirements. Designing different socio-cyber-technical solutions may change the distribution of costs and benefits of information flows, as it shapes the way data are made available, accessed and owned. Depending on the availability, access, ownership of data the relations of power between actors of the system could be strongly affected, as shown by the debate about data sharing arrangements (van der Burg, Wiseman, & Krkeljas, 2020). Furthermore, and this is perhaps different from SCPS in other settings where this may be a more indirect or remote environmental effect (Berkhout & Hertin, 2004), in an agricultural and rural setting, there may also be a direct impact on the ecological system (Klerkx et al., 2019), as shown by the example in Table 4.3 'restructuring of milking sheds and farm lay-out to accommodate AMS with possible effects on landscapes and biodiversity'.

These aspects also show that a range of actors are involved, such as farmers, advisors, animal welfare NGOs, regulators, equipment manufacturers connected in different ways to different issues, and that issues may play out at different scales (on-farm, near farm,

regional, national, global) (Eastwood, Klerkx, & Nettle, 2017) Also, in view of the sometimes unintended consequences which perhaps not be fully captured in design, ex-post responsibility should be a continuous concern to adapt and adjust where and when necessary during further diffusion and scaling of technologies, also addressing institutional and power dynamics that affect inclusion and exclusion of actors (Klerkx & Rose, 2020; Kok et al., 2021; Rose et al., 2021; Wigboldus et al., 2016).

4.4 Discussion and conclusion: Unravelling Socio-Cyber-Physical Systems to support 'responsibilisation'

In this chapter a framework was developed connecting three domains of SCPS and their relationships to conditions for successful digital transformation (design, access and system complexity). Digital transformation changes the distribution of costs, benefits and responsibilities in system, requiring involved actors to act upon possible negative effects of costs and benefits. This is in line with claims that digital transformation of agriculture and rural areas should not be technology driven, but problem-driven and be open to different transition pathways (Klerkx & Rose, 2020; Lajoie-O'Malley et al., 2020; Rose & Chilvers, 2018a). Past experiences of agricultural and rural modernisation have demonstrated that 'technology push' without addressing the underlying socio-economic (and ecological) dimensions risk to generate unpleasant or unwanted outcomes (Horlings & Marsden, 2011; Pingali, 2012), and calls have been made for 'just transitions' (Lamine, Darnhofer, & Marsden, 2019). For this reason, the issue of digital transformation cannot be only a matter of catching up with the digital divide, rather, digital transformation of agriculture and rural areas should be linked to a broader transformation of the socio-economic patterns of development and linked to coherent strategies.

Following calls in the literature to further elaborate RRI for application to digital transformation in agriculture and rural areas (Bronson, 2018, 2019a; Cowie et al., 2020; Eastwood, Klerkx, et al., 2019; Rose & Chilvers, 2018a; Rose et al., 2021), this chapter offers a framework to support articulation of the digitisation and digitalisation situation at hand. The lens of SCPS can assist in highlighting consequences of altered relations between the social, cyber and physical domain, and thus how the structure and power dynamics within the system may change. The framework aids in problematisation of the potential digitisation and digitalisation impacts (i.e. anticipation), informs the process of defining

social responsibility (i.e. moral responsibilities and accountabilities), and supports reflexivity.

Anticipation of consequences could improve the design capacity, for example through transdisciplinary involvement of relevant stakeholders. By gaining deeper awareness of the systemic impact of digital technologies, researchers and technology developers learn to associate their work to its impact, so to better appraise the pros and the cons and to anticipate any unintended consequences in terms of access and systemic complexity. This enables them in their capabilities to grasp 'the digital' and its effects (Dufva & Dufva, 2019; Fielke et al., 2021; Rijswijk et al., 2019), and turns this into 'responsibilisation capability'. It also enables highlighting a wider range of relevant actors and the (ir)responsibilities they have, and what this implies for designing the arenas in which RRI can be enacted, e.g., Living Labs, Transformation Labs , Innovation Platforms (see Pereira et al., 2020; Turner et al., 2020). Beyond an initial RRI exercise, given the relational nature of and complex interactions in SCPS which affect transformation dynamics (Kok et al., 2021), and beyond initial phases of design, technology development and implementation, this could also be a continuous reflection in the process of what has been dubbed 'responsible scaling' (Wigboldus et al., 2016).

In terms of policies, the SCPS framework can support performance-based policies around research an innovation or digitalisation strategies, as it has the potential to connect science-policy-society interfaces, for example through improving technology foresight, giving methodological strength to multi-actor projects and providing facilitation tools for innovation platforms. Furthermore, the framework could help to identify needs for support to rural actors to address access and complexity issues related to digitalisation, as it can be applied to the regional contexts. Embodied into criteria for funding and for policy assessment, frameworks like the SCPS can form the missing link between technology development and sustainable development of agriculture and rural areas.

This framework, however, only sets out the broader contours for supporting participatory assessment, planning and design of digital transformation processes. Hence further work is needed to operationalize criteria for assessing both the SCPS and the conditions for impact. This can be part of future RRI efforts connected to specific digital transformation processes in agriculture and rural areas.

Chapter 5

A problematization of inclusion and exclusion in digitalisation: A reflection on trade-offs and nuances

Abstract

The use of digital technologies with the aim to improve agriculture is a trend today, and expectations of the benefits and transformative capacity of these technologies are high. In practice, digitalisation comes with trade-offs, and potential benefits and harm are not equally distributed. This chapter unravels how processes of digitalisation in agriculture may lead to inclusion and exclusion of people in the present or future, illustrated with examples from an European Union context. A broad variety of inclusion and exclusion factors are discussed across three levels: specific digital technologies; digital innovation packages; and the digital innovation system. This shows how the interplay between access conditions, design choices, and system complexity determine if and how inclusion and exclusion take place, at what level, for whom, and with what impact. In doing so, this chapter breaks with the normative assumption that inclusion is always positive and exclusion always negative. Instead, when it comes to the use of digital technologies in agriculture, inclusion and exclusion are more than a binary distinction between 'who is in' and 'who is out,' or what is 'good' and what is 'bad'.

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The adaptation includes a change in the order of authors to: Rijswijk, K., McCampbell, M., Wilson, H., & Klerkx, L.

5.1 Introduction

The use of digital technologies to enhance efficiency of production, processing, and trade, aiming to improve the profitability and sustainability of organizations and industries, has become a global trend in a wide range of industries including agriculture (see also Klerkx et al., 2019; Trendov et al., 2019). The digitalisation process concerns the use of digital technologies and infrastructures in businesses, economy, and society as a whole, thereby restructuring social, professional, and institutional contexts (Autio, 2017; Nambisan et al., 2019; Tilson et al., 2010) through, for example, digital communication and social media (Brennen & Kreiss, 2014; Chowdhury & Odame, 2014; Hansen et al., 2014; Rijswijk et al., 2020).

As several authors (Gras & Cáceres, 2020; Klerkx et al., 2019; Klerkx & Rose, 2020) note, it is a popular assumption in a lot of technically oriented studies on digital agriculture (see for example Trendov et al., 2019; Verdouw et al., 2021) that digitalisation is ultimately beneficial for everyone, and truly transforms agriculture. In practice, the true socio-economic impact of digitalisation processes in agricultural is yet to be seen, and recent critical analyses of digitalisation in agriculture point to unequal distribution of benefits and harm (Bronson, 2019b; Rose et al., 2021; Rotz, Duncan, et al., 2019; van der Burg et al., 2019a). This unequal distribution relates to mechanisms of social inclusion and exclusion, terms that are generally used to organize people (or groups) according to criteria that define who is 'in' and who is 'out' (Graham & Sweller, 2011). For example, when assessing access of farmers to real-time weather information via a smartphone, one could take geography, gender, age, wealth, etc. into account; but in practice, processes of inclusion and exclusion are more complex. In digital agriculture (i.e. digitalisation both on- and off-farm, e.g. in the broader value chain), in- and exclusion have recently gained traction through the Responsible Research and Innovation approach (Bronson, 2018; Eastwood, Klerkx, Ayre, & Rue, 2017; Rose & Chilvers, 2018a). These studies have, however, remained relatively limited, focussing on the necessity to include relevant actors through participatory processes, but not necessarily looking at the obstacles for these relevant actors to be included.

This chapter has the objective to unravel the complexity of inclusion and exclusion in digitalisation processes in agriculture at three levels: 1) access conditions in relation to a specific digital technology; 2) design choices in relation to a digital innovation package; and 3) system complexity in relation to the digital agricultural system. To date these

potential causes and impacts of inclusion and exclusion are underexplored in an agricultural context, especially when looking beyond access conditions. There is a knowledge gap about the understanding of inclusion and exclusion surrounding digitalisation of agriculture. This chapter provides a broad overview of factors causing inclusion and exclusion and establishes a more nuanced discourse around inclusion and exclusion related to digital agriculture and its impact on people's lives. These inclusion and exclusion factors are further illustrated and nuanced with examples from an European Union (EU) context, where several research and innovation projects (e.g., those funded by the EU Horizon 2020 programme) focus on the access conditions, but also pay increasing attention to the design of technologies and the related system complexity on which we will further elaborate in this chapter.

5.1.1 Methods

Underpinning this chapter is a non-systematic, narrative review (Ferrari, 2015) of the literature on digital agriculture was conducted[3]. Purposeful sampling was used to select articles for the review, with the authors each suggesting a number of publications which were then reviewed for relevance (see Figure 5.1) according to analytical framework (Appendix 1). Selected publications were reviewed for 105 variables in total falling in three broad categories and sub-categories: (1) access conditions (availability, affordability, agency and awareness, ability), (2) design choices (design related risks), (3) system complexity (technology-social organization and integration).

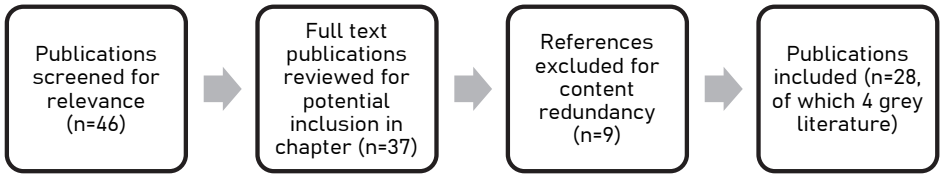

Figure 5.1 Scheme for selecting literature for review.

5.2 Conceptual framing of social inclusion and exclusion

Notions of inclusion and exclusion in sociology address structural inequalities faced by different groups; traditionally mostly women, and also disabled, illiterate, indigenous, or

[3] In the original version of this chapter (McCampbell, Rijswijk, Wilson, & Klerkx, 2021) the literature review had an additional focus on studies from Africa. This has been replaced and further extended with studies relevant to an EU context to illustrate the analysis, in view of the overall empirical focus of the thesis.

(rural) poor people. Inclusiveness has long been promoted as a strategy to alleviate poverty, increase economic growth, generate employment, progress horizontal and vertical (gender) equality, and improve well-being (McKinley, 2010).

Inclusion and exclusion are often used as binary distinctions that are defined by people either falling inside or outside specific social categories, and above or below specified limits (Mascareño & Carvajal, 2015). Within this context the *good*, *expectable*, and *normal* are attributed to inclusion, while exclusion being the negative opposite (Parsons, 1965). However, modern societies allow for a people and groups to be simultaneously included and excluded, hence inclusion and exclusion are not an 'either-or' matter, since no person is ever fully included or excluded (Mascareño & Carvajal, 2015). The distinction between inclusion and exclusion is thus more complex than a static observation of who is 'in' versus 'out' (Fitoussi & Rosanvallon, 1997) and should be approached as a process taking place within a particular social context, instead of a dichotomy between insiders and outsiders.

The thinking about inclusion and exclusion should therefore move beyond binary terms and pay particular attention to the formation and maintenance of various kinds of power (Du Toit, 2004). Stichweh and Windolf (2009), for example, distinguish between *including exclusion* and *excluding inclusion*, i.e. how inclusion in one group can result in (indirect) exclusion from another and vice versa. In this regard, Sen (2000) identified *unfavourable forms of inclusion*, for example, as pointed out by Joseph (2014), a subordinated type in which inclusion benefits are not evenly distributed. E.g. agricultural value chains in which the profits are unevenly distributed between farmers, processors and retailers. Digital responses to address subordinated inclusion comprise applications that connect producers and buyers, thus bypassing the middlemen (Aker et al., 2016) and e-auctions (Joseph, 2020). Unfavourable inclusion can also be illusive, so that the outcome of being included is then the same as being excluded (Joseph, 2014). An example of *illusive inclusion* is when a farmer is selected to participate in a survey of project, with the expectation to benefit from this. In practice, however, the farmer often never hears from this project again, nor witnesses results.

Sen's (2000) framework, besides unfavourable inclusion, furthermore recognizes constitutive, instrumental, active, and passive exclusion. *Constitutive exclusion* has direct impact on the person excluded, such as female farmers not being invited for agronomic training and therefore not developing the same knowledge as male farmers. *Instrumental*

exclusion leads to exclusion through causal linkages, for instance, when a farmer cannot access credit to buy inputs and equipment to increase farm production, resulting in a negative business results, e.g. entering a vicious cycle. *Active exclusion* is deliberate, as in purposely not inviting women for agronomic training, while *passive exclusion* is non-deliberate and the result of social processes. In the latter case, exclusion is an unintended consequence of some decision or action, such as early-warning messages about the outbreak of a crop disease not reaching poorer farmers because they cannot afford the smartphone needed to receive the message. Nevile (2007) argues that when active forms of exclusion (or unfavourable inclusion) act as causal factors, focus should be on reasons and possible justifications for the deliberate decision to exclude. For passive forms of exclusion (or unfavourable inclusion), the focus should be on ways to mitigate unintended consequences.

5.2.1 Observing mechanisms of inclusion and exclusion linked to digitalisation

Existing (data) inequalities are characterised as "a basic problem of inclusion/exclusion, based on the notion that inequality in diffusion of, access to, and use of data can widen development gaps between individuals, groups, and nations" (Cinnamon, 2019, p. 215). This framing has been criticised for being insufficient in explaining or addressing causes, forms, and consequences of inequalities, as it is known that digital engagements and digital capital can play a key role in a range of outcomes for individuals. Those individuals who are more digitally included enjoy more advantages than those who are not; and as time progresses forms of digital exclusion change (Robinson et al., 2015). Hence, digital and data inclusion and exclusion always occur in a specific context (see for example Kilpeläinen & Seppänen, 2014). Figure 5.2 presents the relation between three levels of digitalisation at which inclusion and exclusion takes place: 1. the level of a (single) digital technology; 2. a digital innovation package (i.e. a design of digital hardware and/or software, and the institutional arrangements to use it); and 3. a digital agricultural system (i.e. the configuration of various rival and/or adherent and/or synergetic innovation packages and the socio-cultural context in which they need to operate).

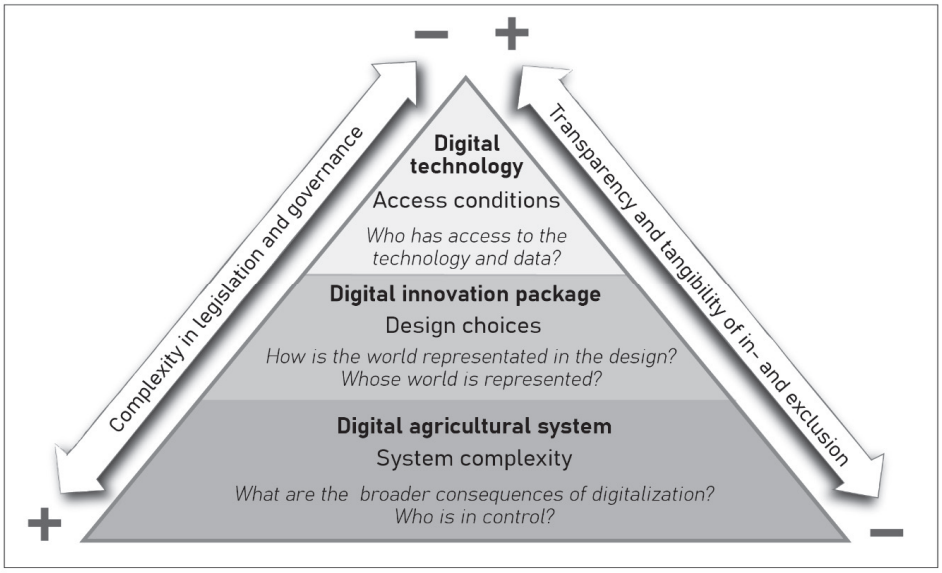

Figure 5.2 Relationship between the three levels at which digital and data inclusion and exclusion may appear, with increasing or decreasing complexity in the vertical axis governing the digital systems, and marking how tangible and transparent inclusion and/or exclusion are.

5.3 Digital technologies and access conditions: Looking at digital divides

In the following sections, we further unravel the three levels introduced in the conceptual framework, using existing literature and illustrating them with examples from an EU context. Starting with the level of digital technologies, we discuss different forms of inclusion and exclusion that together present a variety of (potential) areas of concern in relation to digital agriculture as identified in Table 5.1.

Focusing on a specific (single) digital technology, and the access to it, has as advantage that inclusion and exclusion are relatively tangible and transparent. Several studies on digital agriculture have therefore concentrated on this level, studying who can and who cannot access a digital technology, and the conditions required for access (see for example Rotz, Gravely, et al., 2019; Salemink et al., 2017). In these studies, negative socio-economic impacts of digitalisation have often been summarized under the umbrella of the so-called 'digital divide'. Digital divides are born from inequalities in access, literacy, cost, or service relevance, and continue to exist despite being a key challenge for achieving

social and economic goals, regardless of the wealth of a country or if nation-wide access has increased (USAID, 2020). This leads to social and economic marginalisation and uneven socio-economic development (Brooks, 2021; Clapp & Ruder, 2020; Gardezi & Stock, 2021; Gras & Cáceres, 2020; Rijswijk et al., 2020; Rotz, Duncan, et al., 2019; Salemink et al., 2017; Stock & Gardezi, 2021). Thus known factors like location; age; gender; ethnicity; wealth status; and education level, determine access to and use of digital technologies by individuals, and they foster individuals' inclusion or exclusion to potential or assumed benefits of digitalisation.

Digital divides relevant in the context of digital agriculture are the *rural digital divide*, *gender digital divide* and the more recent *data divide*. The *rural digital divide* has often been associated with rural broadband and connectivity (Townsend et al., 2013). For example, rural areas across Europe are lagging behind when it comes to digital connectivity and accessibility whereby 87.4% of rural EU households were passed by at least one fixed broadband technology and just over half of them (52.3%) had access to high-speed next generation services, compared to an average of 96.7% of EU households having access to fixed broadband services (European Commission, 2019a). This divide differs from country to country whereby there is only a 2% gap in the Netherlands compared to a 25% gap in Bulgaria (Trendov et al., 2019). Besides limited connectivity, rural areas also deal with lower internet speeds and less reliable connections (Skerratt, 2010). Rural areas are further disadvantaged because there is limited or no market competition between broadband providers for example, as there are unattractive investment conditions, such as physical distance and lower population density (Cowie et al., 2020; Malecki, 2003; Salemink et al., 2017). This also contributes to the rural digital divide as urban areas tend to have growing markets and increasing business investments (Townsend et al., 2013).

The *gender digital divide* is often defined as gender differences in access to resources and digital technology, and research tends to focus on the consequences of such a divide (Robinson et al., 2015). (Digital) Technology is a gendered space, whereby women tend to have less access to digital technologies in terms of use, learning abilities or opportunities, and ultimately job, education and income perspectives (Cooper, 2006; Hilbert, 2011; Mushtaq & Riyaz, 2020; Robinson et al., 2015). This is also linked to the offline roles of technology users, as their online behaviour online is an extension of their offline roles (Colley & Maltby, 2008), whereby women tend to spend more time on care and household

duties, hence they have less time, as well as less money control, and they give priority to others' needs such as education of their children, business, and social relations (Ghadially, 2007). Women, furthermore, tend to underestimate their digital literacy in comparison to men (Hargittai & Shaw, 2015). Although the gender digital divide tends to be even more problematic in developing countries (Antonio & Tuffley, 2014; Mumporeze & Prieler, 2017; OECD, 2018), in Europe this divide is also present. In 2017 women across Europe had a rate of basic ICT skills (55%) lower than males (60%) (Eurostat, 2017). In other words, the gender digital divide is an outcome of the broader gender gap, also in part due to inherent gender biases and socio-cultural norms (OECD, 2018). Vice versa, the gender digital divide also further widen the gender gap, as for example digitalisation will cause job losses, which are likely to amplify the current gender gap World Economic Forum (2016).

Additionally datafication, defined as the transformation through which objects, relationships, events, and processes become data points that are machine-readable and analysable by digital technologies using data analytics, machine learning, and complex algorithms (Williamson, 2018), has become increasingly important. This has led to the emergence of a specific new type of divide: the *data divide*. The data divide refers to asymmetries between the 'data haves' and 'have-nots' (Scholz et al., 2018). According to Cinnamon (2019, p. 228), data divides matter because "access to data production and analytics in some cases actually has the reverse effect, the instantiation of new harms and the widening of inequalities."

5.3.1 Challenges arising from digital divides

To better understand the (negative) socio-economic impact of access, we further this into five sub-categories: availability, affordability, awareness, abilities, and agency, following Roberts and Hernandez (2019). Availability here implies various forms of access: material (digital hardware, software, and data; infrastructure (required to access and use those hardware, software and data); institutional (rules and regulations); market (demand and supply); and suitability (is the digital technology a good and fair fit for the context?).

This lack of availability of infrastructure, such as broadband, and therefore connectivity puts pressure on social and economic development of rural areas. This has as a consequence that there is less or no access to services in rural areas such as e-Health (Hage, Roo, van Offenbeek, & Boonstra, 2013), e-Government (Quinn, 2010; Trendov et al., 2019), (public) transportation services (Velaga, Beecroft, Nelson, Corsar, & Edwards,

2012), educational services (Trendov et al., 2019) and entertainment and leisure (Townsend et al., 2013). Thus due to infrastructural unavailability and absence of the market, as described in the previous section, rural areas are essentially excluded from participating and benefiting fully of the temporary society (Salemink et al., 2017; Trendov et al., 2019). This exclusion often is passive and constitutive, although active exclusion can also occur. While at the same time there is great potential to realise socio-economic benefits in rural areas through the use of digital technologies and mobile services, especially related to health, agriculture and financial sectors (Boekestijn, 2017). Broadband connections are thus crucial in reducing inequalities for rural communities (Roberts, Beel, Philip, & Townsend, 2017; Townsend et al., 2013). The European Commission had the aim of connecting 100% of Europeans to broadband by 2020 (Dröge, 2018). This aim was not met, in 2020 still 36% of Europeans were not covered or connected to broadband internet (Sarpong, 2021). The European Commission already developed an 'Action plan for Rural Broadband' (Dröge, 2018), and in 2021 the Commission proposed a vision for 2030 as part of their Path to a Digital Decade, in which they aim for gigabit internet for everyone and 5G connectivity everywhere, including rural and remotes areas (European Commission, 2021b).

Affordability relates to economic capacity: capital required to access digital technologies; one off or recurring material investments; and whether the technology delivers profit. Inclusion and exclusion here result from economic inequalities between farmers and farmers and other actors, thus resulting in passive and constitutive exclusion. Affordability challenges may exacerbate with extremely high initial investments, or recurring expenses. Continuous investments become more problematic in case of technological lock-in and path-dependency, tying a farmer to one particular company or organization due to proprietary software, inability to access farm data without a subscription plan, or inoperability with competitive offers (Bronson, 2018). Considering that in particular small family farms, which we still see a lot around Europe (Lowder, Skoet, & Raney, 2016; Poczta-Wajda, 2020), often have a limited income due to increasing costs of resources and/or decreasing prices for their products (Glover & Reay, 2015), practically any investment may be considered 'extremely high' in this context. In addition, social needs and values influence perceptions about affordability. For example, the common conception that 'time is money' in high-income countries legitimates investments in labour and time saving technologies. Most farmers (in Europe), however, charge too little or no labour costs for their own work and time, especially women's time, resulting in

a totally different cost-benefit calculation (Grassi, Landberg, & Huyer, 2015; Schröder, 2014). Additionally, whether investments guarantee profit return or not matters, especially in volatile markets with fluctuating agriculture produce prices (Rotz, Duncan, et al., 2019). These affordability issues may all result in exclusion of farmers' access to digital technologies, by definition (e.g. unable to buy a phone) or by choice (e.g. unwilling to invest in a phone).

Moreover, limited access does not only relate to the availability and affordability of technologies, but also to the ability to adopt and use these technologies (Salemink et al., 2017; Townsend et al., 2013). These capabilities encompass the ease of learning and using a digital technology, and whether farmers can afford investment in additional training and resources (e.g. time, effort, physical strength). This relates to user ability in terms of general and digital literacy, and physical ability. Digital literacy is a relatively new issue relating to skills and knowledge required to use digital technologies, such as using hardware and software, and making sense of data produced or received to ultimately benefit from it (Newton et al., 2020). In the EU in general digital skills development receives increasing attention in various policy instruments, such as the European Skills Agenda[4], which focusses on the overall development and use of skills of individuals and business by strengthening sustainable competitiveness, ensuring social fairness and building resilience, for which digital skills are key, and the Digital Europe Programme[5], which aims to bring digital technology to businesses, citizens and public administrations. In an agricultural context digital literacy also receives attention and is described as having "basic competences for managing digital devices (smartphone, computer), simple applications (e-mail, WhatsApp, Facebook, YouTube, web search, simple agri-apps, etc.) and basic equipment interfaces. A basic understanding of digital fundamentals would later allow farmers to manage more sophisticated software and equipment."(EIP-AGRI, 2020). In the report the role of service providers, such as farm advisors, in supporting digital skills development was also acknowledged (EIP-AGRI, 2020). This however requires that digital technologies for the level of tech savviness of both farmers and their service providers as to prevent passive and constitutive exclusion (Ayre et al., 2019; Eastwood et al., 2018; Higgins & Bryant, 2020; Rijswijk et al., 2019).

[4] European Skills Agenda: https://ec.europa.eu/social/main.jsp?catId=1223&langId=en
[5] Digital Europe Programme: https://digital-strategy.ec.europa.eu/en/activities/digital-programme

The rural digital divide may thus reinforce existing power differences, for example between farmers and suppliers, as well as social and economic differences in relation to labour and skills (Bronson & Knezevic, 2016; Townsend et al., 2013; van der Burg et al., 2019a). This also evokes the question of who is allowed to have access to, and related to that, ownership of for example the actual digital technologies and the data generated by it? Several authors (Bronson & Knezevic, 2016; van der Burg et al., 2019a; Wiseman et al., 2019) have looked at these topics from the perspective of an individual or organisation, or have studied how this also affects the broader governance of agri-food systems and innovation processes in terms of the politics of economy, ecology and knowledge, as well as technological lock-in and collaboration (Carolan, 2017a, 2018, 2020b; Jouanjean et al., 2020; Miles, 2019; van den Broek & van Veenstra, 2018). This includes for example concerns regarding universal access and the increasing power of data in economic governance, together with the lobby of big tech companies for strategically advantageous regulation, puts for example low-income countries at risk of data extraction that benefits foreign rather than domestic economies (Fraser, 2019; Mann, 2018; Mann & Iazzolino, 2019). In the latter case there is a risk of unfavourable inclusion, specifically, of subordinated inclusion. Although there are initiatives to support the governance of digital agricultural systems, such as the development of an EU code of conduct for agricultural data sharing (van der Burg et al., 2020), as well as an array of large scale EU funded projects aiming to, amongst other things, these initiatives tackle data ownership and privacy issues often from a more technology driven point of view (e.g. Internet of Food and Farm 2020, SmartAgriHubs, Demeter, and ATLAS[6]). Challenges, for example around trust and trust development (Gardezi & Stock, 2021; Jakku et al., 2019; van der Burg et al., 2020), however remain.

These challenges related to access and digital divides call for agency and awareness of all relevant actors about the socio-cultural context in which digitalisation takes place. Agency and awareness are, however, less tangible issues related to individual actors' knowledge and power, or part of the socio-cultural make up of agricultural communities they belong to, e.g. more wealthy or higher-educated communities are likely to be more aware and have more agency regarding access to digital technologies. Agency and awareness are thus critical factors that influence constitutive and passive exclusion, for example based on the type of community you live in). These factors also influence the actual adoption decisions, especially in cases of non-adoption or de-adoption, regardless

[6] For an overview of these projects: https://digital-strategy.ec.europa.eu/en/policies/large-scale-pilots-digitisation-agriculture

of good availability, affordability, and ability of users. Reasons for inequalities in access to digital technologies and data thus are not just limited to observable, tangible, or seemingly individual factors (like age, gender, and wealth). As seen in Figure 5.2, this only makes the tip of the iceberg visible. Inequalities also extend to more unobservable, intangible, and aggregated issues. These relate to the other levels of Figure 5.2, viz. the digital innovation package, and the digital agricultural system, which we will see in the next sections.

Table 5.1 Overview linking the three levels (digital technology; digital innovation package; digital agricultural system), forms of inclusion and exclusion that can arise, and existing or future areas of concern that were identified.

	Specific digital technology	**Digital innovation package**	**Digital agricultural system**
Overarching reason for inclusion and exclusion at this level	Access conditions.	Design choices.	System complexity.
Related data inequality	Access to data.	Representation of the world as data.	Control over data flow.
Likely forms of exclusion and unfavourable inclusion	Active, passive, constitutive, inclusion; subordinated inclusion.	Active, passive, constitutive, instrumental exclusion; subordinated, illusive inclusion.	Passive, instrumental exclusion; subordinated, illusive inclusion.
Opportunities	Increased equal access to digital technologies.	Decisions and solutions that anticipate unintended consequences (e.g. based on fair and responsible data principles).	Establishing synergies between digital technologies and innovation packages.
Threats	Digital divides; data divides.	Design related risks.	Digital traps: data originators or users become stuck in/with a particular system or digital technology.
Factors influencing existence of	(Mostly) tangible aspects determining	Risks and prospects related to design decisions.	Socio-technical organization and integration with the

inclusion and exclusion	a person's access to a technology.		digital innovation package(s).
Current or future areas of concern for unintended consequences and inclusion and exclusion	*Availability* of: hardware, software, data, infrastructure, rules/regulations, demand/supply. *Affordability*: income/wealth, cost of material, value proposition, ease of use and learning. *Agency*: autonomy, norms/values/beliefs, identity as a farmer. *Ability*: digital literacy, general literacy, human physical ability, type of farm/geography.	Obsolescence of skills, individual and group privacy, (data) security, concentrated/private data ownership, user profiling, data processing location, data aggregation, regulations for digital development, choice vs. obligation to participate/be included, distribution of technological benefits, associated economic/social arrangements/ contracts, product/service sustainability, technological bias (e.g. algorithmic).	Information overload, information quality issues, loss of human control and oversight over technology, human/animal-machine interaction, addictions, cybercrime, blurring of roles of organizations, ethical dilemmas.

5.4 Digital Innovation Packages and Design Choices: Deciding about the design and anticipating design consequences

Digital technologies and interventions are designed with a specific objective and desired outcomes in mind. Decisions about the design determine, for example the physical, front-end design (e.g. the hardware and software interface) and system or back-end design (e.g. programming languages used, location of databases, interoperability with other systems). These design choices around digital technologies and innovation packages are always accompanied by risks, as it requires decision making about the world that the technology and the collected data collected represent, i.e. whose world is represented, and how is this done. These decisions alter our physical world and how we operate in it, potentially causing unequal opportunities (Cinnamon, 2019). Design related impacts are, however, not always intended. Unintended consequences are likely, which in turn can lead to all forms of exclusion and unfavourable inclusion. Design choices are ultimately accompanied by trade-offs: saying 'yes' to one design feature usually equals saying 'no' to other features.

Those trade-offs make exclusion almost inevitable as design-for-all or one-size-fits-all solutions are highly complex and oftentimes simply impossible. An example trade-off is the anticipation that progressing digitalisation in agriculture will reduce demand for farm labourers (Herrero et al., 2021), in particular seasonal labour (Legun & Burch, 2021), resulting in a de-skilling or replacement of current farm labourers (Rotz, Gravely, et al., 2019). At the same time digitalisation could be a net job-creator too, offering opportunities for those with the right skills (Rotz, Gravely, et al., 2019). This non-deliberate loss of particular jobs is in turn an example of unequal distribution of benefits as well as instrumental and passive exclusion. Design choices should therefore ideally anticipate these unintended consequences, which could become design related risks (Rijswijk et al., 2020). In this, transparency and accountability are desirable.

Designing digital innovation packages is also about (re-)distributing power among actors, with some becoming more influential than others (Clapp & Ruder, 2020; Gardezi & Stock, 2021; Klerkx & Rose, 2020). This raises questions about the distribution of the benefits from digital technologies among different actors, such as technology developers, users, data originators, and data owners (Brooks, 2021; Jakku et al., 2019). Do design choices reduce exclusion and support the equal distribution of benefits, or do they create marginalization of individuals or groups? This relates to subordinated inclusion, e.g. one actor will benefit more from an innovation design than another. Digital agriculture is often associated with high-tech, smart technologies and large-scale, input-intensive farms. Scholars have observed that wealthier, large-scale, commercial farmers benefit more from digitalisation in agriculture (Bronson, 2018). In the absence of large numbers of corporate farms to date, however, current digitalisation initiatives in Europe focus mostly on reaching family farms, which are and will increasingly diversify in terms of their orientation towards digital technologies amongst other things (Bock, Krzysztofowicz, Rudkin, & Winthagen, 2020). The diversification and profiling of different farming styles already creates instrumental and passive exclusion, as in the particular report, commissioned by the European Commission (Bock et al., 2020), some farm(er) profiles were (indirectly) labelled as 'good' or 'bad' in terms of their readiness for the future and the underlying issues that may cause a particular farm(er)profile to occur were individualised (van der Ploeg et al., 2021). Hence digitalisation may support a limited number of specific agricultural production systems at the expense of others (Bronson & Knezevic, 2016; Klerkx et al., 2019). Others argue that visions for the role of digital technologies support perpetuation of a status quo that prioritizes maximization of global

agricultural production (Lajoie-O'Malley et al., 2020). Thus while there is, for example, widespread use of (smartphone-based) applications and platforms (Phillips, Relf-Eckstein, Jobe, & Wixted, 2019a; Prause et al., 2020), in practice, however, wealthier or more tech savvy farmers are more likely benefit more from what digital technologies have to offer, due to the advantage of an overall larger capacity to access and invest in digital technologies in general (Fleming et al., 2018). This as an example of illusive inclusion; the design of a digital technology may be inclusive for all.

Additionally there is increasing attention for the combination of digitalisation and agroecology, which has a farmer centric focus (Ajena, 2018; Gkisakis & Damianakis, 2020; Maurel & Huyghe, 2017; Wittman et al., 2020), and together with diversification of family farms' orientation to digitalisation (van der Ploeg et al., 2021) this could also lead to more inclusiveness in terms of decision-making power over the design of digital innovation packages and ultimately a better distribution of benefits. At an EU level there are various initiatives, such as Pixelfarming, #DigitAG and Technology for Ecology[7], active in this space of combining various agriculture related transformations, farm styles and more inclusive design.

5.5 Digital agricultural systems and system complexity: Emerging mechanisms of inclusion and exclusion in digital agriculture

In this section we cover the third level, system complexity, or the composition of elements that together make up the digital agricultural system and the socio-technical organization within it. The digital agricultural system is complex in multiple ways: variations in crop production systems and value chains; national and international jurisdictions; the multitude of actors involved; and the ever-growing diversity of digital technologies and technological packages which may or may not be interconnected or interoperable. The complexity and motions of digital systems make prediction and visibility of different forms of inclusion and exclusion challenging.

System complexity also increases uncertainty about issues such as the quality of data and information as input and output of digital systems. A possible response is more

[7] Pixelfarming: https://pixelfarming.eu/
#DigitAg: https://www.hdigitag.fr/en/
Technology for Ecology: https://technology4ecology.org/

technological integration. Integration offers opportunities for synergies and reduced complexity, yet a lack of integration can become a digital trap (Rijswijk et al., 2020). For example, a user may become stuck with a particular piece of hardware or software that is not interoperable with other items, or cannot be updated, hence becomes obsolete. Interoperability and coupling of systems is therefore critical (Fulton & Port, 2018). In contrast, too tight coupling of systems leads to vulnerability and potential domino effects, i.e. if one system fails, all fail. How do digital traps and domino effects relate to inclusion and exclusion? The first can result in perpetuating inclusion or exclusion: those included remain included, those excluded remain excluded. Instrumental exclusion may be the outcome of the latter because of the causal linkages between systems.

Furthermore digital systems rely on data input to operate. However, data inconsistency is a known problem, especially with large datasets from heterogenous sources, needing investment in rigorous efforts to reduce data noise and correct inconsistencies (Philip Chen & Zhang, 2014). Another challenge with data aggregation is the need to consider variances in how data is interpreted. Although mainstreaming interpretations enhances interoperability, it also raises the question of whether 'hybrid' interpretations are trustworthy or provide a new form of interpretative doubt (Mansour, Sahandi, Cooper, & Warman, 2016), and whether they support or undermine equality. For example, the outcome of interpretational mistakes may be that people are passively included or excluded, which is hard to control for and may have unforeseen consequences. Globally and in Europe there are several initiatives, e.g. GO-FAIR and GODAN[8], that aim make data FAIR (findable, accessible, interoperable and reusable) and support the development of open access to all kinds of data, which also requires the designing and building of data and technology standards, yet these initiatives do not always consider ethical, legal and social implications (ELSI).

Additionally, the presence of digital technologies and data-based decision-making inherently affects real-life interactions, such as between people or between people and animals (Rijswijk et al., 2021). Traditional human-to-human interactions become moderated or replaced by machines, changing relationships between humans and their natural, technical, and social environments and allowing for less empathy, trust building, and judgement of intentions and preferences (Scholz et al., 2018). According to Scholz et

[8] GO-FAIR: https://www.go-fair.org/
GODAN: https://www.godan.info/

al. (2018), data can be a disturbing variable and distractor for sharing experiences and knowledge, taking away agency from the human individual.

This raises the question of who is responsible for these kinds of consequences? Governing digital agricultural systems is inherently difficult (van den Broek & van Veenstra, 2018), especially when they are coupled or operating across-borders. Yet this also influences control over digital technologies and, more importantly, control over who uses data, where, when, and for what purposes (Cinnamon, 2019), as well as who can be held accountable (Rijswijk et al., 2021). In combination with uncertainty about emerging effects of digitalisation, accountability leads to various concerns about misuse of data and blurring roles and responsibilities in the digital agriculture system. Currently, roles and responsibilities of involved actors (e.g. data-owners) are often not clearly defined (see for example Salvini et al., 2020), neither are governance models establishing who is accountable for what (Rijswijk et al., 2021). On top of that actors in the agricultural sector need to redevelop their identity and build new capacity and expertise (Rijswijk et al., 2019), moving for example from being classical agricultural organizations working on crop improvement with face-to-face extension services, to designers and operators of digital platforms and systems, requiring different skillsets and expertise.

Within this complex and opaque environment, it is easy for all kinds of inclusion and exclusion to emerge, at the same time being difficult to anticipate. Additionally, taking action against exclusion or unfavourable inclusion may not be in the interest of the actors who are in control, yet institutional arrangements fall short in effectively controlling this. The latest report of the EU Standing Committee on Agricultural Research on the future of Agricultural Knowledge and Innovation Systems (AKIS) advocates for attention to, and funding for digital innovation, via for example Digital Innovation Hubs, that together with country based strategic approaches to digital transformation would lead to the "fast deployment of digital solutions for a sustainable agriculture, fair and accessible for all." (EU SCAR AKIS, 2019, p. 24). Yet this report does not specifically state how these hubs or strategic approaches can organise the governance of digital transformation in order to deal with the above mentioned system level challenges of inclusion and exclusion. Other reports (see for example Wolfert et al., 2021) and projects build on this aiming to understand the system complexity by zooming in on the AKIS-level (e.g., DESIRA and

I2Connect[9]) that aim to understand the social and economic impacts of digital agriculture, or look to support agricultural advisors in this process. Other projects focus on the Digital Innovation Hubs, with the SmartAgriHubs[10] project giving this more substance through building an interconnected eco-system in which a broad range of actors, including and mainly end-users, can share knowledge about digital technologies in agri-food. While these projects consider the inclusion of a range of actors and technologies and the multitude of connections between them, it yet remains difficult to foresee the impacts of this complexity on inclusion and exclusion.

5.6 Rethinking inclusion and exclusion for digital agriculture

The previous sections showed that as opportunities to capture unique properties about individuals, their farm, and their behaviour (habits, norms and values, likes and dislikes, recurring decisions) expand, it more and more matters who you are and what you do within the broader system, both as an individual and as a company or organization. We have seen that digital technologies may lead to various mechanisms of inclusion and/or exclusion of actors and that increasingly these mechanisms may be intangible in nature (e.g. algorithmic bias, or user profiling). Intangible factors, resulting from design choices and system complexity, become powerful determinants of who is included or excluded and whether inclusion and exclusion is beneficial or harmful, due to e.g. expanding access to data, aggregation of data, and capacity for data computation and manipulation. We previously noted that in relation to agriculture the focus has been biased towards access conditions, while attention for design choices and system complexity lags behind. The latter two are rarely considered, or only in form of critique—such as exclusion of actors in the design process and of actors from the benefits of data generated outputs—without offering solutions to the emerging challenges. Digital technologies meanwhile present themselves as a double-edged sword: being included may be both beneficial and harmful. Similarly, included individuals may gain agency at one level, but lose it at another level.

In this chapter we unravelled the known and future impacts of digitalisation processes on inclusion and exclusion in agriculture and showed the difficulty to identify 'right' from 'wrong.' Ultimately, digitalisation comes with trade-offs, such as job loss (see section 5.4), as people generally lack control over being included somewhere and excluded elsewhere,

[9] Examples of EU projects that look at system complexity: https://desira2020.eu/ and https://i2connect-h2020.eu/

[10] Digital Innovation Hubs project linked to agriculture: https://www.smartagrihubs.eu/

and vice versa. At an European level there are many examples, of which we have mentioned several in this chapter, that aim to anticipate, prevent or overcome the different types of digital technology related trade-offs, consequences and impacts. Most of these projects, policies and reports are aware of the (various) digital divides, but not all go beyond the access level of digital technologies and connectivity. Those that do, for example, include fair data sharing or ethics, while others focus on a particular set of actors that need technological, socio-economic and institutional support in this digitalisation process, and yet others take a participatory approach towards technology design. However, projects and policies that look at all three levels of digital technologies, the innovation package and the innovation system remain limited and their actual success thus far unknown. Thus there seems to be a lack of policy coherence and fragmentation of efforts at an European level.

On the other hand, although designers and implementers of digital technologies may anticipate many unintended consequences, some fall into the category of unknown consequences and simply cannot be predicted beforehand. Additionally, it is not always possible to control for all unintended consequences, especially when they require transformations beyond the technological design, such as the institutional or socio-cultural environment. It is therefore important to regularly reflect and remain responsive towards these unintended and (initially) unknown consequences (Rose & Chilvers, 2018a) and to allow for diversity and alternative pathways (Bock et al., 2020; Klerkx & Rose, 2020; Stringer et al., 2020). Hence, in light of both the process and the outcomes of digital transformation, the dichotomy of inclusion and exclusion and the inherent normative assumption that inclusion is always good and exclusion always bad demands revisiting (see also van Mierlo, Beers, & Hoes, 2020). Therefore the perception that technology and technological progress are inherently good and needed for growth should also be reconsidered. Instead, the trade-offs and unintended consequences that come with digitalisation at the three levels that were discussed in this chapter should receive more recognition and consideration through bottom-up initiatives or concepts such as Responsible Research and Innovation (Bronson, 2019b; Eastwood, Klerkx, et al., 2019; Rose & Chilvers, 2018a; van der Burg et al., 2019a) and emancipatory smart farming (Fraser, 2021), to avoid further misconfigured innovations at a global scale, as for example different types agri-food systems are economically connected and will have mutual impacts when digitally transformed (Fraser, 2021).

Chapter 6

General discussion and conclusion

6.1 Introduction

This thesis set out to develop insights and understanding of the challenges encountered by organisations, value chains and the agricultural knowledge and innovation system (AKIS) in their ability to make sense of digital transformation of agri-food systems. As mentioned in Chapter 1, this thesis is embedded in societal and academic debates which point to the need to increase the understanding of digital technologies and their impact on people, organisations, and society. The digital transformation of the agri-food sector comes with a variety of challenges and uncertainties that contribute to the disruption experienced by various actors. This necessitates an ability of these actors to grasp the current and future situation regarding the use and impact of digital technologies, but there is a lack of knowledge on how this 'digi-grasping' takes place and can be enabled. Hence the overall research question this thesis seeks to answer: *How do actors within agri-food systems make sense of digital transformation?*

The sub-research questions that support answering this overall research question are:

1. *How do actors within agri-food systems perceive digital transformation?*
2. *What are key elements for actors within agri-food systems to make sense of and respond to digital transformation responsibly?*

In this thesis I have looked at various system levels to answer these questions. As these different system levels are nested in, or overlapping with each other (see Figure 6.1), they are not mutually exclusive and therefore influence each other.

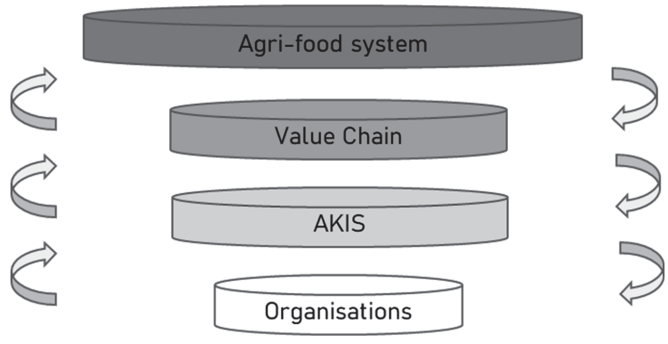

Figure 6.1 Overlap and influence of different system levels

Using these system levels and following the structure of this thesis as indicated in Figure 1.2 in Chapter 1, this conclusion chapter is organised as follows: In sections 6.2 and 6.3 I

connect the findings of the empirical Chapters 2 and 3 to the above sub-research questions, whereby I identify cross cutting themes and discuss and reflect these against the scientific debates this thesis is positioned in (see also Chapter 1). Section 6.2 mainly looks at the organisation level, whereas section 6.3 will discuss the AKIS, value chain and the wider agri-food system.

These two sections are then followed by a discussion of the main concepts used in this thesis, which is more closely aligned with the conceptual Chapters 4 and 5 of this theses. This section also includes theoretical contributions and recommendations for future research. Additionally, there is a reflection in section 6.5 on the research done in this thesis, e.g. a reflection on the methodology and limitations. This thesis, furthermore, has been an interdisciplinary effort and I've drawn on different fields. Section 6.6. provides a final reflection, as well as an overview of the conclusions, practice and policy implications, theoretical contributions and future research, by means of Table 6.1.

6.2 Ignorance is bliss? (Dis)engaging with perceptions of digitalisation

The first sub-question, *How do actors within agri-food systems perceive digital transformation?*, has mainly been addressed in the empirical Chapters 2 and 3, which respectively looked at the AKIS of New Zealand knowledge providers and the Dutch flower value chain.

Chapter 2 described, using the concept of *organisational identity*, that digital agriculture was perceived as a farm-centric development, despite being considered disruptive both on- and off-farm. This understanding of digital agriculture (rather than digitalisation) also influenced the digitalisation responses within the organisations of knowledge providers. Their responses were often ad-hoc, starting with adapting organisational capabilities, practices, and services when their clients and partners required it, rather than a strategic approach allowing for more flexibility of roles and processes, and changing business models. These ad-hoc responses indicate that the New Zealand knowledge providers had limited awareness of the potential opportunities and challenges related to digitalisation, i.e. their general ability to fully digi-grasp (e.g. the ability of actors to make sense of the digital transformation at different systemic levels) was low. These knowledge providers are crucial for supporting other actors (e.g. farmers) in their digitalisation process. The AKIS in which they operate should therefore also better support the digi-grasping abilities of these knowledge providers themselves.

In Chapter 3, which used different kinds of *trust* relationships as the main concept, it became evident that there is a reciprocal connection between the level of collaboration in digitalisation, and therefore trust, and (the uncertainties related to) digitalisation. The level of existing calculative and relational trust is shaping the digitalisation process and vice versa: digitalisation will likely shape different kinds of trust relations (i.e. trust development of interpersonal trust and institutional trust). Using the Dutch flower sector as a case study, the findings show that the sector has a high level of interpersonal trust, but limited institutional trust as the relationships between organisations are highly competitive and transactional. A vicious cycle occurs due to limited trust hindering digitalisation, resulting in limited digitalisation, which in turn causes more distrust (see also Figure 6.2). This is exacerbated by (technological) path dependencies, such as the unavoidable reliance on third parties to access farm data (Bronson & Knezevic, 2016; Carolan, 2020a). Trust dynamics are thus crucial in understanding how actors navigate digitalisation processes, which necessitate collaboration.

Both chapters show that the range of analysed organisations all **perceive** and experience digitalisation as challenging and uncertain for their own organisation and for their (trust) relationships with other organisations. While it is often believed that digitalisation disrupts power structures (which it also sometimes does, e.g. in the case of platform technologies (Bronson, 2019b; Carolan, 2020a), this thesis shows that contrasting dynamics take place, as I will argue in more detail below. Digitalisation seems to (initially) reinforce the existing power structures within a system, as also argued by some other authors (see for example Beckeman et al., 2013b; Bronson, 2018; Bronson & Knezevic, 2016; Carolan, 2017a). Chapter 3 further contributes that these perceptions in combination with existing power structures increase the existing competitive behaviour within a system, for example through the lack of willingness to share data or to invest in digitalisation activities that potentially also supports competitors, which is related to the fear of free riders (see also Salvini et al., 2020). This contrasts with the often-held belief that digitalisation is a democratising force which frees actors up from certain market structures (Jouanjean, 2019; Kamilaris et al., 2017; McKinsey Global Institute, 2016), for example, through blockchain technology (Zhao et al., 2019). Hence, a key contribution of this thesis is to nuance the disruptive and democratizing force of digitalisation, in the particular context of agri-food related systems, on which I will further elaborate in section 6.4.

Both Chapters 2 and 3 also convey that preconceived notions about certain tasks belonging to a particular actor are challenged by digitalisation, resulting in the blurring of roles, responsibilities and boundaries between (public and private) organisations (see also Eastwood, Klerkx, & Nettle, 2017; Nettle et al., 2018; Turner et al., 2020). This is further exacerbated by new actors, such as technology providers and start-ups, entering the AKIS or value chain and the changing roles and influence of incumbent organisations (Ingram & Maye, 2020; Salvini et al., 2020). Chapter 2 adds that, as new entrants tend to be perceived as 'disruptors', they create additional uncertainties for incumbent organisations, and challenge them even more in their digitalisation process in terms of the pace, nature, source or context of system and organisational change. In that sense new entrants can actually affirm the vicious cycle (see Figure 6.2) that these incumbents may often find themselves in.

This thesis hence shows, by means of the digi-grasping concept, that there is a certain level of *ignorance* towards digitalisation at an intra-organisational level, which induces counterintuitive or paradoxical responses of organisations towards digitalisation that go against its transformative and disruptive promise, e.g. by reacting even more competitively with regards to digital technology use and investments. This (intra-organisational) level of ignorance has also been documented by others (Ayre et al., 2019; Eastwood, Ayre, et al., 2019; Fielke et al., 2021), and are further nuanced by the results of Chapter 3 indicating that the ignorance mode of digi-grasping even seems to translate into *resistance* towards digitalisation when it comes to inter-organisational collaboration.

In other words, this thesis shows that the perceptions of digitalisation, uncertainties about roles and responsibilities (among others), and related existing power structures actually delay (the (potentially) disruptive effects of) digitalisation. These findings thus challenge the common understanding that digitalisation stimulates the inter-organisational or system level collaboration required for digitalisation (e.g. Berghaus & Back, 2017; Jakku et al., 2019; Parida et al., 2016; Snow et al., 2017; Tate et al., 2018; van den Broek & van Veenstra, 2018), which in turn would contribute to trust development and digitalisation's promise of transparency and openness. While collaboration would likely allow for the digitalisation process to gain momentum, increase pace and the involved actors to jointly ride the wave of (perceived and/or potential) disruption, the contrary seems to occur, resulting in the earlier mentioned vicious cycle (Figure 6.2).

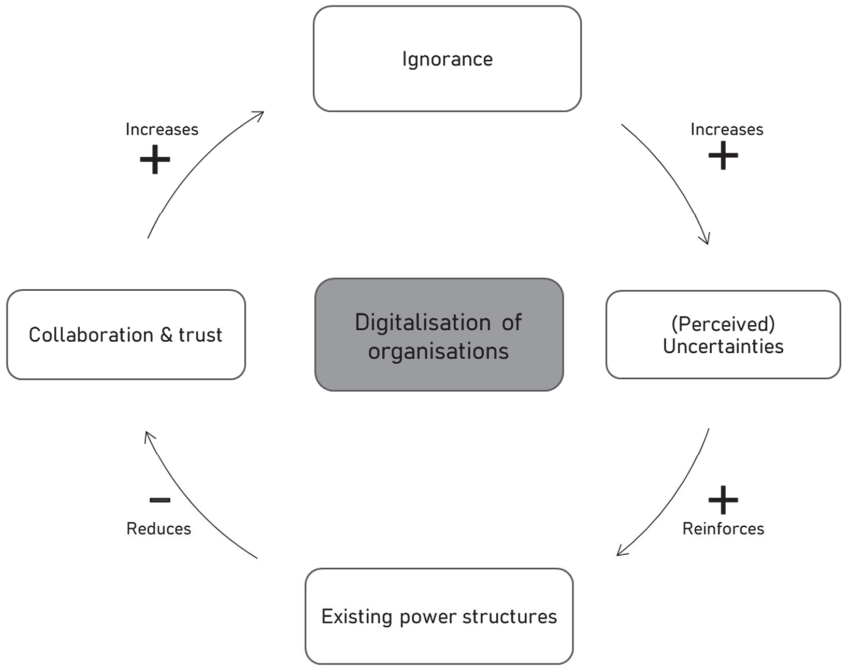

Figure 6.2 Vicious cycle of ignorance causing uncertainty and negatively impacting on the digitalisation of organisations

At the same time, however, some of the interviewed organisations in both chapters did show a gradual move towards the *awareness* mode of digi-grasping. This awareness helped the organisations to cope with the uncertainties of digitalisation, such as the blurring roles and the impact of disruptors. Different organisations might thus be at different modes of digi-grasping, as also indicated by Fielke et al. (2021), creating heterogeneity among actors. To move to an awareness mode requires *flexibility* at an intra-organisational level in terms of (initially) adapting their tangible daily tasks and activities. Earlier studies on the impact of digitalisation on AKIS actors show that digitalisation requires a change in capabilities and roles of, in particular, farm advisory services (Ayre et al., 2019; Eastwood, Ayre, et al., 2019; Fielke et al., 2021). As shown in Chapter 2, and indicated by other authors (Nettle et al., 2018; Obwegeser & Bauer, 2016; Utesheva, Simpson, & Cecez-Kecmanovic, 2017), is it that digitalisation not only requires a change in capabilities and roles of AKIS actors, but ultimately also a change in the

intangible aspects of their organisational identity (such as their purpose and values). This thesis adds to these previous insights that being aware of the opportunities of digitalisation could lead to a virtuous cycle as shown in Figure 6.3.

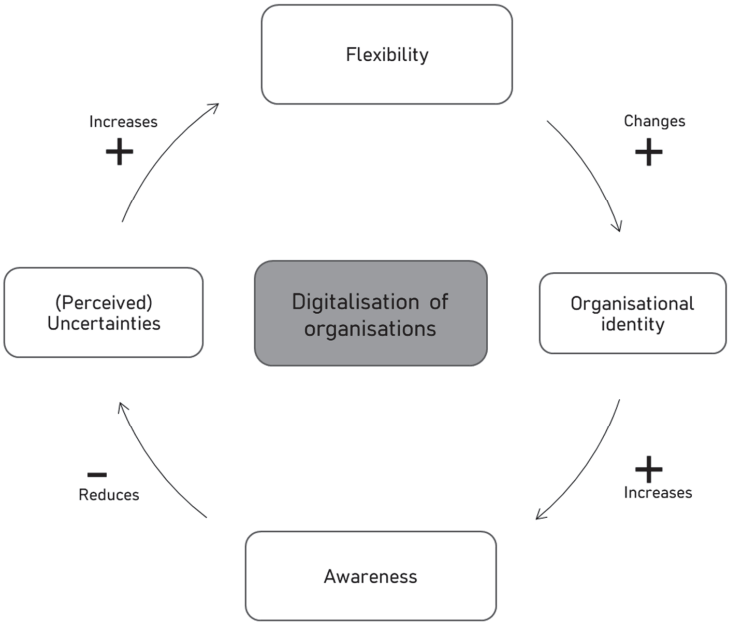

Figure 6.3 Virtuous cycle of awareness reducing uncertainties and positively impacting on the digitalisation of organisations

6.3 Towards responsible sense-making?

Together with Chapters 2 and 3, Chapters 4 and 5 are connected to the second sub-question: *What are key elements for actors within agri-food systems to make sense of and respond to digital transformation responsibly?*, which I will answer in the sub-sections below.

6.3.1 Key elements for systemic change

Building on Chapters 2 and 3 and section 6.2, the *ignorance* seen at an intra- organisational level also impacts on the support that can be given at an aggregated system level (e.g. AKIS or value chain) to grasp digital transformation. As argued in these chapters, to support digital transformation at a system level the involved actors will initially need to develop *awareness* of the possibilities of how digitalisation could help to overcome

commonly known challenges and uncertainties, for example related to data ownership and sharing. As shown in section 6.2 to overcome perceived uncertainties and increase the digi-grasping opportunities, it does, however, require effort of an organisation to invest in *flexibility* to allow for capability building and (intra)organisational roles, and reconsideration of their *organisational identity*.

To further deal with the uncertainties of digitalisation at an inter-organisational or system level, both chapters argue for an increase of and a need for *collaboration*, which has also been highlighted in the literature on digitalisation of AKIS (Ayre et al., 2019; Eastwood, Klerkx, & Nettle, 2017; Ingram & Maye, 2020; Jakku et al., 2019). This thesis nuances this call for collaboration, albeit agreeing with its necessity to underpin the potentially democratising opportunities of digital transformation, but in the sense that collaboration is easier said than done and rather is a challenging space of conflict, contestation and competition that occurs when different actors (jointly) explore and negotiate new roles, responsibilities and organisational identities in light of digitalisation. Chapter 3 thus showed that collaboration mainly manifested itself as *co-opetition* between competing incumbent organisations. The ignorance and resistance of some organisations results in a behaviour that initially sparks a competitive reaction after which it seems that these organisations are 'resorting' to co-opetition. Following the argument of Cozzolino et al. (2021) co-opetition might indeed be the ultimate stage of collaboration for digitalisation among competing organisations, which will take the form of 'collaboration' at a component level (e.g., data sharing), while the organisations remain competitive at the product level. Building on the findings of Chapters 2 and 3 and the previous section I have, however, also shown that less competitive and more *aware* organisations are also more likely and quickly able to anticipate uncertainties, challenges, and opportunities of digital transformation, as they realise that digitalisation indeed requires collaboration rather co-opetition. The likelihood of these organisations wanting to jointly grow and share the 'pie' is higher and therefore they are more likely to reap digitalisation benefits earlier on.

In this thesis I have further built on this aspect of collaboration by making use of theories on trust. This thesis adds that *reciprocity* between organisations (see also Pachoud et al., 2020), when it comes to trust development and the (joint) implementation of digital technologies, plays a key role. Cherbib, Chebbi, Yahiaoui, Thrassou, and Sakka (2021) also stipulate that the level of trust and reciprocity is one of the key factors for collaboration among actors and their willingness to invest in digitalisation, alongside factors such as

organisational culture, organisational commitment, and the absorptive capacity of the involved organisations (i.e. their ability to digi-grasp). The latter factor is also supported by the findings of Chapters 2 and 3, which as mentioned above, show that organisations which operate in a highly competitive environment (initially try to) tackle digitalisation single-handedly and in a more ad-hoc manner, potentially as an attempt to control the uncertainties of digitalisation, but ultimately resulting in less collaboration, lower investments, and therefore less transformative potential of digitalisation.

The presence of different digi-grasping modes among actors thus challenges the status quo of actors that are less advanced in digi-grasping even further, as the digitalisation gap between them and similar (competing) organisations is widening, thereby putting more pressure on the competitive nature of organisations. One way of closing this gap is to leave sufficient space for ambidexterity, both at an intra and inter-organisational level. Ambidexterity allows for the existing heterogeneity of digi-grasping modes, leaving space for actors and systems to consider the balance between exploiting the old situation while exploring the potential of digitalisation, including new roles and responsibilities (see also Turner et al., 2017). Ambidexterity thus provides another way of responding to the uncertainties of digitalisation. That is, experimenting with and learning from new roles, responsibilities and collaborations rather than trying to control these uncertainties. Ambidexterity, as also shown in Chapter 3, is a therefore a concept and **key element** that will help to support the required organisational flexibility, as well as the other key elements, collaboration, trust and reciprocity, which are necessary for responding to the uncertainties of digital transformation at a system-level (i.e. AKIS or value chain). This again contests the notion that digitalisation is disruptive and absolute, but positions it more as a gradual and tentative process, in line with ideas on an emergent 'Digital Agricultural Innovation System' (DAIS) (Fielke et al., 2019b) and a search and experimentation process (Ayre et al., 2019). Digital transformation therefore calls for (digital and joint) learning, and for innovation and transformation to also take place in pre-competitive spaces guided by trusted intermediaries as I will argue in the next section.

6.3.2 Intermediaries for digital transformation support

Implementing the key elements for digital transformation at an AKIS- or value chain-level requires, as indicated in Chapter 2, *system-level support*. This support requires capability building, as mentioned above, both at the demand (farmers) and supply (knowledge providers) side, as well as at an organisational and system level. The need for capability

building of supply side or the system level, in particular AKIS, has also been described by many others (e.g. Eastwood, Ayre, et al., 2019; Ingram & Maye, 2020), but these authors often refer to the development of everyday skills to support farmers in operational practices. This thesis shows that besides the development of these operational skills it also requires a deeper understanding of the digital transformation process and what this means at a system level. In other words, digi-grasping is not only a daily practice at an organisational level, but also includes a systemic understanding about the need for changing underlying values that may or may not support digital transformation. These values are related to the perceptions, uncertainties and existing power structures of the various involved actors, which can be overcome by collaboration, trust, reciprocity and ambidexterity. Reaching such a deeper level of comprehension to achieve system change, however, is not an easy endeavour, as also seen in Chapter 2 and 3. In particular because those actors who would provide this kind of support and input for other organisations to be able to digitalise are themselves also in need of support (e.g. agricultural knowledge providers) or are competing with each other. I therefore suggest that combining the need for capability building with the above-mentioned key elements would result in the joint development of a *digital transformation strategy* at AKIS or value chain level. This includes both on- and off-farm and intra- and inter-organisational perspectives and changes, or as Snow et al. (2017, p. 1) similarly indicate: "the strategic and cultural alignment of digital technologies within the organization and externally with stakeholders."

In order to develop a digital transformation strategy at the AKIS or value chain level, the findings of this thesis point at the importance of actors within these systems who could take on the role of an intermediary, which is also suggested by others (Fielke et al., 2020; Klerkx, 2020). To prevent or deal with (technological) lock-in and to stimulate the four key elements of collaboration, trust, reciprocity and ambidexterity, intermediaries could undertake several tasks that would support the digital transformation of a system in which they operate. This thesis thereby provides an answer to the question posed by Fielke et al. (2020) about what the future tasks of intermediaries are, and builds on the public and private research and extension roles for technological innovation and diffusion, described by Eastwood, Klerkx, and Nettle (2017), by showing that the area for potential collaboration between public and private intermediaries is much larger and more fluid then they indicate, and would in particular encompass the four key elements and actors' underlying uncertainties and values required to overcome digital transformation challenges.

Three main tasks of these intermediaries can be devised: A first task would be to create a sense of urgency and facilitate the (re)shaping of a collective identity (Sraml Gonzalez & Gulbrandsen, 2021) of the agri-food system or its sub-systems, which could speed up the process of collaboration and trust development, leading to joint strategizing and therefore an enhanced digi-grasping ability of all system actors. It is however likely that, as time moves on, the speed and urgency of digi-grasping will increase as actors are becoming more aware and familiar with (the uncertainties and impacts of) digital technologies, due to experiences with other technologies or within other organisations, etc. This is also part of the technological lock-in process in which actors (unknowingly) find themselves. This time factor in combination with the perceptions of organisations about digitalisation will further increase the heterogeneity among actors, potentially creating even bigger gaps and challenges for intermediaries and systems to overcome. Transition intermediaries (Kivimaa, Boon, Hyysalo, & Klerkx, 2019), could also help to deal with the change in pace as through a sequence of (different kinds of) intermediaries to support this process across different digital transformation phases and digi-grasping modes, whereby this thesis also adds a temporal dimension to the public and private research and extension roles indicated by Eastwood, Klerkx, and Nettle (2017). Hence intermediaries, other practitioners, policy makers and science need to (jointly) uncover what the 'appropriate level of digital transformation' is for the involved individual actors and the overall system in which they operate.

A second task would be to stimulate reciprocity. Intermediaries could support system actors in changing their thinking about the existing system configuration, e.g., less top-down, linear, competitive or less dependent on (perceived) fixed roles and responsibilities. As seen in the business and ICT literature (Cozzolino et al., 2021; Elia et al., 2020; Gupta et al., 2019; Schiavone et al., 2021; Sussan & Acs, 2017), reciprocity is often connected to (digital) eco-systems, ecologies of innovation (Rose & Chilvers, 2018a), and value networks as proposed by Kolloch and Dellermann (2018). These types of alternative systems suggest a more equal and less competitive way of working and intermediaries could thus create more and foster existing collaborative and pre-competitive spaces.

Finally, to enhance ambidexterity, which allows system actors to move beyond their regular competitive behaviour and explore a new (joint) modus operandi (i.e. move across the digi-grasping modes), intermediaries could make use of supportive governance models. Governance is seen as essential in digital transformation (Carolan, 2017a; Fielke

et al., 2019b; Fielke et al., 2020; Higgins & Bryant, 2020; Jakku et al., 2019; van den Broek & van Veenstra, 2018), in particular around data ownership. To allow for various perspectives on this particular topic (e.g. farmers vs. tech companies vs. farm advisory services, or between competing businesses) a governance model such as the tentative governance concept, which "typically aims at creating spaces for probing and learning instead of stipulating definitive targets" (Kuhlmann, Stegmaier, & Konrad, 2019, p. 1091) and is based on "provisional, flexible, revisable, dynamic and open approaches to governance that include experimentation, learning, reflexivity and reversibility" (Kuhlmann et al., 2019, p. 1091) could be of value to the intermediaries navigating such an ambidextrous process.

The intermediaries that can undertake these tasks may come in different forms. They could be existing (public and private) intermediaries as mentioned in Chapter 2, such as farms advisors in AKIS and extension or industry organizations (e.g. Eastwood, Klerkx, & Nettle, 2017; Newton et al., 2020). Specialized intermediaries, fitting in particular to a digital context, are for example Digital Innovation Hubs, as introduced by the European Commission to promote digital transformation for Small and Medium Sized Enterprises in all sectors with the aim of remaining competitive as EU on a global scale (European Commission, 2021a). Alternatively, new entrants into the system can also be intermediaries, which was indicated in Chapters 2 and 3 (see also Cozzolino et al., 2021; Ingram & Maye, 2020). This may seem counterintuitive, because new entrants can engender feelings of uncertainty among ignorant incumbent organisation (see section 6.2), they however also have the potential to break the existing technological lock-in. These 'new intermediaries' can be tech companies, start-ups or the organisations that facilitate them, for example incubators, technology events or AgTech facilitators (e.g., AgTech NZ, Wharf 42, Rabo foodbytes. Startlife or Robocrops). This would likely work better in systems where strong competition among incumbents hampers the joint transformation process, as was the case in the Dutch flower sector. Furthermore, digital platforms, often using on Internet of Things or blockchain technologies to enhance sales, exchange data, or create overviews for so-called end-users, can also function as intermediaries (Andersson & Mattsson, 2016; Munthali et al., 2018), which was also shown in Chapter 3.

It will thus depend on the existing system configuration (i.e. which social, cyber and physical entities are present and how are they related: the level of system complexity) to determine if and what kind of intermediary is most suitable for what task outlined above

and in what way this is governed and orchestrated (e.g. voluntary or obligatory, public vs. private, etc.) (Jouanjean et al., 2020; Newton et al., 2020; van den Broek & van Veenstra, 2018). Although, as discussed in Chapter 3 with regards to disruptors, these different kinds of intermediaries may (initially) affect levels of trust, and stimulate further lock-in or competition. Building on the typology of transition intermediaries by Kivimaa et al. (2019), who point out that there are different kinds of intermediaries for different systemic levels and for different phases and tasks of transformation processes, developing a digital transformation strategy will also require different and multiple kinds of intermediaries that operate at different system levels (also echoing Eastwood et al., 2017). These networks of intermediaries can address both the need for operational skills, as well as alter underlying perceptions, existing power structures and values of system actors. Some intermediaries will thus need to work more in a pre-competitive space, whereas others can work on diffusion on proven digital solutions, and yet others can work on particularly addressing equity and social justice issues.

To support these diverse intermediaries in undertaking the above-mentioned activities, as mentioned in section 6.2, there are a few (analytical) tools such as the digiware (Ayre et al., 2019) and DAIS (Fielke et al., 2019b) concepts. These are concepts that support both the structures in which digital transformation can be shaped (DAIS) and symbols that can act as 'boundary objects' that bring different actors together, such as digiware. While these concepts tend to only focus on the AKIS-level and remain quite abstract, this thesis has further elaborated and adds to such concepts to enhance digi-grasping through the development of the *Socio-Cyber-Physical System* (SCPS). The SCPS considers not only the technological, but also the social and physical aspects involved in digital transformation, and can be used at different system levels or at an organisational level, as shown in Chapter 4. In addition, in Chapter 4 conditions for a successful digital transformation are also described, which are *access to and design of digital technologies and navigating the system complexity*, and can further help intermediaries to understand the suitability of digital technologies for digital transformation of actors and systems. Several authors furthermore argue for more participatory and deliberative processes. (Bronson, 2018; Eastwood, Klerkx, & Nettle, 2017; Rose & Chilvers, 2018a), which could be complemented with serious gaming activities (Cieslik et al., 2021; Galarza-Villamar, McCampbell, Galarza-Villamar, et al., 2021; Galarza-Villamar, McCampbell, Leeuwis, & Cecchi, 2021; Salvini et al., 2020). Hence, intermediaries with more in-depth and ex-ante understanding of the SCPS at the particular system level they operate (e.g., DAIS or Digital

AKIS) can therefore create and support digi-grasping opportunities and abilities of various actors within a system with these (analytical) tools.

In short, a joint strategy, developed with support of various intermediaries undertaking several tasks related to the key elements mentioned in section 6.3.1, would thus help to **make sense of and respond** to digital transformation, and could then lead to the *empowerment* and *transformation* modes of digi-grasping.

6.4 Theoretical contributions and future research

From the preceding sections several points have emerged, and I will now bring these together and reflect on what these mean for the different bodies of work this thesis is embedded in. In particular I have drawn on and want to contribute to knowledge management and innovation studies, broader Science and Technology Studies (STS), organisations studies, business literature and to a lesser extent ICT and engineering related literature. In this section I will describe the theoretical contributions and make suggestions for future research.

6.4.1 Disruptive perceptions of digitalisation

This thesis adds a digital perspective to the field of organisation studies in general, but also to literature that deals with organisational changes in agricultural research and advisory service organisations (Albaladejo et al., 2007; Labarthe & Laurent, 2013; Nettle et al., 2018; Prager et al., 2016; Turner et al., 2021), by applying the concept of digi-grasping as a new way of sense-making at an organisational level. In this thesis I have shown that digitalisation impacts the organisational identity and that organisations have different abilities to digi-grasp. With regards to the organisational identity concept, I suggested in Chapter 2 that future research should also include roles/responsibilities as an intangible identity attribute, to further enhance the applicability of the concept of organisational identity. Another avenue for future research could be studying the changes in the organisational identity of (knowledge providing) organisations due to digitalisation over a longer period, including the broader perspective of other actors related to a particular organisation. This would provide valuable insights into organisational change processes in light of digitalisation. Future research could furthermore undertake a more detailed analysis of the reinforcement of existing power structures in the initial phases of digi-grasping and digital transformation, this could potentially support the easier transition between digi-grasping modes and enhance collaboration.

Linking organisational change and digi-grasping to the concept of disruption, which is often used in business and STS literature (Christensen, Raynor, & McDonald, 2015; Feder, 2018; Ho & Chen, 2018; Kilkki et al., 2018; Millar et al., 2018; Schuelke-Leech, 2018), has led me to conclude that digitalisation is not as unequivocally and fully disruptive as often expected or understood. Although organisations in the ignorance mode of digi-grasping may perceive this differently: while it may certainly disturb certain organisational or system elements, it may also reinforce power structures and lock-ins (as per Clapp & Ruder, 2020). Disruption thus only becomes apparent when there are various modes of digi-grasping occurring at the same time. That is, disruption is a concept that only occurs in relation to other actors and is influenced by their perceptions of digitalisation, hence there are 'shades of disruption'. It then becomes evident that 'ignorant' organisations cannot keep up with the pace of digital transformation of other organisations or the system in which they operate. Incumbent organisations are likely to be 'exposed' as they tend to be less flexible and often are disconnected to new entrants, such as digital start-ups (Cozzolino et al., 2021; van den Broek & van Veenstra, 2018; Wolfert, Ge, et al., 2017). At the same time these new entrants will need to connect to incumbent agricultural organisations to better understand the specificities of a value chain, AKIS or the wider agri-food system in order to be successful (Ingram & Maye, 2020; Klerkx et al., 2019). It would therefore also be useful to gain deeper insights into the relationships between incumbents and new entrants over a longer period of time.

The above suggestion for future research would lead to answering questions such as:

- How do incumbent and new entrants explore new relationships for digital transformation?
- What is the relation between digi-grasping modes and identity change?
- What aspects of an organisation's identity are perceived to having changed due to digitalisation over time by other organisations and themselves?
- What are triggers for organisations to move between digi-grasping modes?

6.4.2 Tentative governance to support the complexity of digitally transforming systems

Continuing the line of thought of the previous section, there are not only different digi-grasping modes among actors within a system, but these actors can vary widely themselves as well, i.e. being a new entrant or incumbent, which is can be closely aligned with being a disruptor or a so-called disruptee. This thesis shows there is heterogeneity of actors and therefore fragmentation within a system due to a lack of collaboration and

trust, in part caused by existing power structures and competition, resulting in a lack of openness (see also Brand & Blok, 2019; van Mierlo et al., 2020 for a broader discussion of the paradox of openness). To better understand this heterogeneity of digi-grasping abilities and the fragmentation within systems, in this thesis I have added business literature perspectives on co-opetition and competition, as well as reciprocity and ambidexterity (Bengtsson & Kock, 2000; Bouncken et al., 2018; Cozzolino et al., 2021; Lawrence et al., 2021) to the field of studies on digitalisation and AKIS (e.g., Fielke et al., 2019b; Ingram & Maye, 2020; Klerkx, 2020, 2021), it still requires further research to understand how these concepts contribute to the digital transformation of AKIS and value chains, which I will further specify below and in the next sections.

In terms of fostering the heterogeneity of actors while overcoming the fragmentation, it would be interesting to have a more in-depth understanding of the different types of transition intermediaries described by Kivimaa et al. (2019) and their relevance for a digital transformation context at the level of AKIS, value chains and agri-food systems. I.e. how heterogenous does the network of intermediaries itself need to be to sufficiently support digital transformation of a system? Empirical research on the roles and task these intermediaries could perform would support the development of this understanding. Building on this there is also space to assess the different kinds of (analytical) tools mentioned in section 6.3.2 and further develop these tools.

One such analytical tool that could support grasping the complexity of digital transformation, is the SCPS framework developed in this thesis, which adds a social dimension to ICT and engineering literature which often discusses more linear Cyber Physical Systems (CPS) (Baheti & Gill, 2011; Griffor et al., 2017; Monostori et al., 2016; Rajkumar, Lee, Sha, & Stankovic, 2010). The SCPS supports the development of deeper insights into the relations between the social, the cyber and the physical, additionally describes the conditions for a successful digital transformation of such a system, as mentioned in the section 6.3. Through paying more attention to the creation of better access to technologies, the development of more inclusive technology design, and the navigation of the system complexity, this framework allows for a better problematisation of digital transformation and its uncertainties. These conditions thus go beyond the 'mere' access to technologies, which, if at all, is often the only kind of condition considered by the ICT and engineering literature (e.g. Monostori et al., 2016). Discussing the technological design and system complexity also involves critically assessing the role of designers

(McCampbell, Schumann, & Klerkx, 2021). The SCPS thereby connects innovation studies to this field and applies this to ICT and engineering literature in an often-under-researched area, namely agri-food.

The SCPS has also been discussed be other authors in the field of innovation studies (Klerkx et al., 2019; Lioutas & Charatsari, 2020; Lioutas et al., 2019) and is also describe at a more abstract level in the form of the DAIS (Fielke et al., 2019b) and digiware (Ayre et al., 2019) concepts. As mentioned before (see section 6.3.2), this thesis deepens this previous work, and provides a more detailed and actionable description of the framework, for example by showing its suitability at different system levels, hence making it more suitable for ex-ante analysis of digital transformation processes and the support of what has been called 'tentative governance' (Kuhlmann et al., 2019). Based on the development of this framework, the empirical insights from Chapter 2 and 3, as discussed in the previous sections 6.2 and 6.3, as well as the overall heterogeneity of actors and systems, this thesis shows that the DAIS or Digital AKIS still seems to be in formation and could be considered a form of tentative governance that can be further enhanced and shaped by intermediaries. This leads to the following questions:

- How do various types of intermediaries contribute to the development of a DAIS?
- What is the role of heterogeneity of actors and fragmentation within a system in the development of governance arrangements and regulatory frameworks for digital transformation?
- What forms of tentative governance are suitable in which type of systems and digital transformation phases?
- How could tentative governance contribute to the seeming paradox of openness (see section 6.2) linked to the first digi-grasping modes?
- How is tentative governance shaped by a complementary network of intermediaries focused on supporting digital transformation?

6.4.3 Broadening notions of RRI

In this thesis I applied a *Responsible Research and Innovation* (RRI) approach, as a way to further understand the sense-making and response process of actors involved in the digital transformation. RRI aims to support a better understanding and anticipation of the (often unintended) consequences and unknown impacts, through the four main principles of *anticipation, inclusion, responsiveness and reflexivity*. Besides applying the approach

this thesis, however, sharpens earlier work and critiques of RRI (e.g., Blok & Lemmens, 2015; Brand & Blok, 2019; Burget et al., 2017; Forsberg et al., 2018; Lubberink et al., 2017) in particular in the context of digital transformation of agri-food systems (e.g., Barrett & Rose, 2020; Bronson, 2018, 2019b; Eastwood, Klerkx, et al., 2019; Klerkx & Begemann, 2020; Lajoie-O'Malley et al., 2020; Regan, 2019b; Rose & Chilvers, 2018a; Rose et al., 2021; van der Burg et al., 2019a). According to these authors RRI is not yet fully unpacking the problems that exist around digital transformation of agri-food systems as it is said to not be practical and inclusive enough. This thesis builds on both these critiques. Firstly, the SCPS framework (see also section 6.4.2), developed in Chapter 4, stimulates two of the principles of RRI, namely *anticipation* and *responsiveness*. Thereby it not only supports an enhanced understanding of moral responsibilities regarding digital transformation, which is fitting within the RRI approach, but also helps to better understand who is responsible and/or accountable for the identified (positive or negative) impacts, i.e. *responsibilisation*, thus providing a more practical point of view towards the implementation of RRI.

Secondly, this thesis calls to improve the RRI principle of *inclusion* (Rose & Chilvers, 2018a; van Mierlo et al., 2020), by better unravelling what matters in defining inclusion. Chapter 5, in particular, shows that due to a broad variety of inclusion and exclusion factors, some of which are specific to digital transformation, it becomes even more evident that digital transformation has winners and losers, or, as stated in Chapter 4, the digital transformation process is not inherently good as it impacts on many aspects (e.g., economic, environmental, social, technological, institutional) and their relations. Inclusion and exclusion occur across three levels: specific digital technologies, digital innovation packages, and the digital innovation system. These are linked to the access, design and system complexity conditions described in Chapter 4 and determine if and how inclusion and exclusion takes place, for whom, and with what impact. In doing so, this thesis breaks with the normative assumption that inclusion is always positive and exclusion always negative. Instead, when it comes to the use of digital technologies in agriculture, inclusion and exclusion are more than a binary distinction between 'who is in' and 'who is out,' or what is 'good' and what is 'bad'. Hence it echoes earlier work also in generic studies on RRI (e.g. van Mierlo et al., 2020), that inclusion should be seen in subtle ways, also being much more sensitive to trade-offs. Additionally, it extends the idea of Rose and Chilvers (2018a) who argue for a broader societal engagement through mapping a more diverse range of actors within existing innovation systems activities in order to enhance digital agriculture, by indicating that there should be more awareness of those who are

(deliberately) not included, rather than the current inclusion which is often a form of 'public acceptance'.

By broadening the notion of RRI I show that it may support the earlier mentioned concept of tentative governance, which in combination with the need for shaping reciprocal and ambidextrous practices (see section 6.3), would allow intermediaries and other actors to be even more mindful of (unintended) consequences to further the development of a Digital AKIS, value chain or agri-food system (which so far still is being experimented with in digital transformation and needs to yet reach a level of 'RRI maturity' (Eastwood, Klerkx, et al., 2019; Regan, 2021; Rose & Chilvers, 2018a)). Intermediaries may foster this broadened notion of RRI to become part and parcel of the digital transformation process. That means that RRI is seen as a key set of values to take into account, in essence meaning that considering ethical, legal and social implications (ELSI) are not just an 'add-on', but are an essential component in the digital transformation of agri-food systems.

Topics for future research could for example include the further unpacking of the responsibilisation concept, which then also calls for a further operationalisation of the SCPS concept and the conditions for impact. To avoid an accountability and contract-based digital transformation process (see Chapter 3) at the various system levels the link between responsibilisation and tentative governance also needs to be further explored through questions such as:

- How do more flexible and adaptive notions of RRI shape longer term processes of tentative governance of digital transformation?
- What is the effect of frameworks such as SCPS, on responsible practice beyond the initial phases of research and innovation for digital transformation?

6.4.4 Reconsidering alternative pathways for agri-food systems

While the previous section already discusses a wider perspective on the process of digital transformation, from the discussion a more fundamental question emerges, namely if digital transformation is required and desired for achieving a sustainable agri-food system?

Building on Section 6.3.1. on the heterogeneity of digi-grasping modes and taking the broadened notions of RRI (e.g., responsibilisation and inclusion and exclusion) into

account, it is safe to assume that not all actors want to or need to move at the same speed or take part in the digital transformation at all. There will likely be a group of actors that will remain *ignorant* or simply do not feel capable to make decisions about their digital transformation. Additionally, other actors will at some point be 'digitally transformed' to a level that they deem sufficient or acceptable (for that point in time), which is likely to be different for all actors. And lastly, there will be actors that are actually *aware* or *empowered* enough to decide that they do not want to take part in a digital transformation process, due to privacy concerns for example. Interestingly, while the digi-grasping concept does aim for alternative futures (Dufva & Dufva, 2019), it does not consider non-adoption or opting out of digital transformation to be one of them. The RRI approach similarly aims to anticipate and respond to unintended consequences, and be reflexive of innovation processes, all in an inclusive manner. Yet wanting to be excluded or take a non-response to digital transformation may also be overlooked even in an RRI approach when it becomes myopic and too fixated on digitalisation and digital transformation, but not fundamentally questioning it.

This shows, and as already alluded to in Chapter 1, that there are different views on the digital transformation of agri-food systems ranging from techno-optimists to techno-pragmatists and techno-pessimists. The different chapters of this thesis have largely followed a techno-pragmatist approach, whereby digital technologies are seen as useful, perhaps even necessary, but unavoidable, albeit with a critical note about the actual implementation and the underlying intent and values. This is in line with the current definitions of both core concepts in this thesis: digi-grasping and RRI. Both concepts display a push for innovation and digital technology, even though in a responsible manner, that will lead to digital transformation for a more sustainable future. In that sense both digi-grasping and RRI also take a linear and instrumental approach to digital transformation, similar to the techno-optimist perspective, which is critiqued in particular by the RRI approach. In other words, this thesis shows that techno-pragmatism is a more critical version of techno-optimism, but eventually also aims to achieve digital transformation.

At a wider agri-food system level digital transformation is seen by techno-pessimists as a continuation or even a reinforcement of the current agri-food system, while others (techno-optimists and -pragmatists) perceive it as a more productive, profitable and sustainable future for these systems. Besides having space to non-adopt, opt out or

wanting to be excluded, which are more closely aligned with the process of digital transformation, there could also be a desire of actors to choose alternative (non-technological) pathways with regards to the content of the digital transformation. These pathways could include new combinations with other agri-food system transitions and innovations (Bock et al., 2020; Klerkx & Rose, 2020; Stringer et al., 2020) which are enabled by and co-evolve with digital technologies, e.g., protein (Helliwell and Burton, 2021; Lonkila and Kaljonen, 2021) and energy (Kolloch & Dellermann, 2018; Markard, 2018) transitions or agro-ecology (e.g. Ajena, 2018; Maurel & Huyghe, 2017; Rotz, Duncan, et al., 2019; Wittman et al., 2020).

This thesis therefore responds to and gives substance to the suggestion of Rose and Chilvers (2018a) who argue for a more systemic perspective of RRI, advocating systemic and structural change, which in my view would include alternative pathways. These alternative pathways would, however, need to consider both the *what* of digital transformation, as there is a demand for alternative pathways that may or may not correspond or be combined with (the ambitions of) digital transformation (Chapter 5), as also argued by several others (Klerkx & Rose, 2020; Rose et al., 2021; Schnebelin, Labarthe, & Touzard, 2021), and the *how* of digital transformation, as in Chapter 4 I discuss who is involved in digital transformation and in what way. In other words, this thesis also stipulates the need to rethink innovation processes in the context of digital transformation. Hence, not only focus on the content of the digital transformation, such as merging them with other types of (agriculture related) innovations and transformations, but also by creating the space to (dis)engage with digital technologies in various ways, which is related to the actual process. In that sense it is more in line with what Fraser (2021, p. unknown) who argues for breaking with the current misconfigured innovations that cannot be fixed by a "misplaced insistence that agricultural innovation can successfully reconfigure sociotechnical relations in one domain, without also pursuing systemic or structural change" and thus the digital transformation of agri-food systems needs re-imagining.

As part of this re-imagining of digital transformation I suggest that, rather than focussing on enhancing the readiness of various actors and system levels for digital transformation (see Balasubramanian et al., 2021; Eastwood, Klerkx, et al., 2019; Regan, 2021), considering the appropriate level of digital transformation, if any at all, is more suitable. This thesis thus also supports reflection and a stronger focus on the directionality of the digital

transformation (see also Schnebelin et al., 2021), which could be an avenue for future research, and could potentially bring the divergent views of the techno-optimist and techno-pessimist closer together. Additionally future research could study the impact of digital transformation on those actors who are (wilfully and/or deliberately) excluded, while they still aim to meet similar goals as those who are taking the digital route. This raises the following questions for future research:

- What are alternative system configurations that support alternative pathways and responsibilisation in digital transformation?
- What is the appropriate level of digital transformation, i.e. for whom and in what way?

6.5 Methodological reflections

With digi-grasping and RRI being core to this thesis I should also consider these concepts to reflect on the methodology used in this thesis. This section, in light of the RRI principle of reflexivity and the emphasis of digi-grasping on uncertainties, therefore reflects on the methodological limitations and considers the implications for validity.

The critique of the techno-pragmatist approach made in section 6.4 also applies to this thesis. While using different disciplinary angles, such as organisation studies, knowledge management, innovation studies, etc., and by building on and working with the critique on the RRI approach, this thesis nonetheless leans towards techno-optimism. Chapters 2 and 3 in particular follow a more techno-optimist line, and Chapters 4 and 5 take a more critical, but still technology-oriented perspective. Besides the choice of digi-grasping and RRI concepts as core to this thesis, this is also a consequence of my involvement in several projects, which has led to the content of this thesis. These projects were and are mainly action-oriented and take a techno-pragmatist approach. My role in these projects was often being an involved insider, having to implement activities to meet project aims, rather than being a critical outsider who observes a process or intervention (Bruskin, 2019). For this thesis the latter role was also important, which meant that I had to wear multiple hats in these projects and therefore had to deal with the diverging interests of myself and others, which quite often was a struggle. Additionally, while my project involvement also had advantages, such as of being able to make use of the projects' networks for data collection (Chapter 2 and 3), or building on earlier work that I could extend into my thesis (Chapter 3, 4 and 5), I simultaneously had to deal with project politics and tensions that I

could not influence, but did influence progress of projects and therefore of my PhD trajectory. Thus, as also anticipated in Chapter 1, my *positionality* will have influenced both the process and the contents of this thesis.

Furthermore, there is a time factor involved. When data was collected for Chapter 2, digitalisation and digital transformation were still in its infancy, with critique largely still being under construction (see Chapter 1 for description of this development through time). This leads to another limitation, or at least a challenge, of researching the digital transformation of agri-food systems, namely dealing with a fast moving (technological) environment and therefore on-going change. On the one hand, this consistent movement shows that there will also be a continuous need to digi-grasp at various system levels, showing the relevance of this thesis now and in the future. On the other hand, this pace of innovation means that the empirical results of this thesis cannot be reproduced as the situation at the time of data collection was thoroughly different than it is at the time of writing this concluding chapter, thus affecting its *reliability* (Kumar, 2018).

Given the qualitative nature of this thesis there are, besides reliability, a few other methodological challenges, of which some have already been mentioned in the individual chapters (e.g. number and type of interviewees). With regards to the external *validity* of the empirical chapters, or sometimes called transferability (Green & Thorogood, 2009; Kumar, 2018), in a case study context, such as in this thesis, the methods cannot be transferred to another context and achieve the same results as with case studies the context matters to provide a 'thick' description, rather than being reliant on a limited number of variables (Green & Thorogood, 2009). However, there is validity with regards to the generalizability of the results (Green & Thorogood, 2009). Through the discussions in each chapter, I have shown how the findings relate to other contexts (e.g., groups of people, countries, sectors, systems, etc.) and although generalisations are an interpretation of the findings, they are valid at a conceptual level (Green & Thorogood, 2009).

The internal validity or credibility (Kumar, 2018) of the empirical findings was somewhat compromised as these findings were not validated by the interviewees, as a form of triangulation, due to time and access limitations with respect to the interviewees. However, through the use of snowball sampling of interviewees to reach a saturation point of new information, and the use the thematic coding and deeper analysis through in-case

comparisons between similar groups of interviewees (based on e.g. profession, sector or other relevant comparative factors), data was triangulated in a different way, hence supporting the internal validity (Green & Thorogood, 2009).

A final reflection is about *consistency* regarding terminology use in this thesis. In some chapters, digitalisation and digital agriculture are used (Chapter 2), with the latter being the words of the interviewees used to describe what they were doing, and the former being the overall process I aimed to describe, which these knowledge providing organisations went through. In Chapters 3 and 5 the term digitalisation is used as mainstay, while in Chapter 4 digital transformation is the commonly used term. This is in part due to the writing of a thesis being an iterative process, which, moreover, is based on articles. Furthermore, while I described the relationships between these terms in Chapter 1, in practice digitalisation, digital transformation and, in an agricultural context, digital agriculture, are still intermingled and equated. Therefore even in this final chapter both terms digitalisation and digital transformation are used, although I have made tighter connections between digitalisation and organisational change, and digital transformation and system level change. Altogether it does show that the topic of digital transformation and related concepts are still in motion.

6.6 Final reflection: Responsibly shaping digital transformation of the agri-food sector

At the end of this conclusion chapter it is time to refer back to the overall research question of this thesis: *How do actors within agri-food systems make sense of digital transformation*? In this thesis I have shown there are several aspects that allow actors within agri-food systems to responsibly make sense of digital transformation (see also Table 6.1). These aspects include at an organisational level the identity, digi-grasping mode and the flexibility of an organisation to change, and at a AKIS- or value chain-level the space to collaborate, build trust, create reciprocity among actors, and stimulate their ambidexterity. This allows them to simultaneously grasp and experiment with the new realities of digitalisation while at the same time still using their existing practices and organisational structures in productive ways until more clarity is achieved about the direction of digital transformation. This requires at a wider agri-food system to be mindful of alternative pathways and to consider who is included or excluded, and who is responsible for the (un)intended consequences of such transformation processes. It takes

the effort of policy makers and practitioners to take these kinds of requirements and considerations into account with the support of a broad variety of intermediaries at different system levels and with various tasks. In fact, appointing dedicated 'digital transformation intermediaries' would be a good starting point for policy and practice to jointly and responsibly make sense of the uncertain digital transformation processes they are in.

As a final reflection I would also like to come back to the quote of a Project manager at a cooperative company in New Zealand in 2017, that I started this thesis with. He suggested that agri-food businesses will "*get rid of the old paper*" (for full quote see Chapter 1), i.e., would digitally transform over time. Based on this thesis I would largely agree with this Project manager, and in fact it is likely that a lot of agri-food businesses have indeed already made significant steps in their digital transformation process. I have however also learned that digital transformation is not something that 'happens', but is formed and shaped by different kinds of actors at different system levels that are all part (deliberate or not) of this process. It will therefore be interesting to see what happens in the coming years regarding digital transformation. Will it be as utopian as the techno-optimists think and have solved all sustainability issues across the globe? Or do we find ourselves in the dystopian situation whereby everything is unified into a database? I firmly believe that as long there is space for actors to make deliberate and well-informed decisions about the use and design of digital technologies in relation to their physical environment and their social context, and thus respect these different choices, we may end up with agri-food systems that can contribute to a more sustainable planet.

Table 6.1. Overview of conclusions; implications for practice and policy; theoretical contributions; and avenues for future research

	Conclusions	Policy and practice implications	Theoretical contributions	Future research
Organisation	▪ A broad range of organisations are (still) limitedly able to make sense and to adequately respond to digitalisation. ▪ Perceived and actual uncertainties, caused by ignorance, reinforce existing power structures and reduce collaboration, trust and related or required openness for digitalisation. ▪ Organisational boundaries and related roles and responsibilities increasingly blur under the influence of digitalisation. ▪ The existing collaboration, trust,	▪ Organisations need more flexibility to experiment and gain experience with digital technologies and their changing capabilities, services etc. ▪ This will result in intangible identity changes (values/ aims) of an organisation. ▪ This will allow organisations to move out of an ignorance mode into an awareness mode, hence reducing the (perceived) uncertainties of digitalisation and speed up the digitalisation process.	▪ Organisations have different abilities to digi-grasp. ▪ Digitalisation is not as disruptive as often expected or understood. ▪ Disruption becomes apparent when there are various modes of digi-grasping occurring at the same time. ▪ Ignorant, and often incumbent, organisations cannot keep up with the pace of digital transformation of other organisations or the system in which they operate. ▪ I.e. disruption is a concept that only occurs in relation to	▪ Including roles and responsibilities in the concept of organisational identity as an intangible identity attribute. ▪ Understanding the changes in the organisational identity of (knowledge providing) organisations due to digitalisation over time. ▪ Including the broader perspective of other actors related to a particular organisation. ▪ A more detailed analysis of the reinforcement of existing power structures in the initial phases of digi-

	power structures and roles and responsibilities are challenged by new entrants. ▪ The above factors slow down the digitalisation process (i.e. create a vicious cycle). ▪ For organisations that are in more advanced modes of digi-grasping the (perceived) uncertainties reduce and therefore the level of (perceived) disruption too. ▪ Various digi-grasping modes exist alongside each other.		other actors and is influenced by their perceptions of digitalisation.	grasping and digital transformation. Questions: ▪ How do incumbent and new entrants explore new relationships for digital transformation? ▪ What is the relation between digi-grasping modes and identity change? ▪ What aspects of an organisation's identity are perceived to having changed due to digitalisation over time by other organisations and themselves? ▪ What are triggers for organisations to move between digi-grasping modes?
AKIS	▪ Limited support for digital transformation both on- and off-farm	▪ System level support should include joint strategy building.	▪ There is heterogeneity in terms of digi-grasping modes and abilities, level of	▪ Understanding the role(s) and impacts of, and interactions between, new entrants

▪ Collaboration, trust, reciprocity, and ambidexterity are key to deal with dominant responses to the uncertainties of digital transformation at system level ▪ Thus far it is unclear who should provide system level support in the current system, as the obvious AKIS actors (e.g. farm advisory services) are also in need of support. ▪ System level support goes beyond operational (on-farm) advise about daily practices and would require a deeper systemic understanding of values.	▪ Various kinds of transition intermediaries (including new entrants/disruptors) could support this process. ▪ Intermediaries would have a range of tasks related to collaboration, trust, reciprocity and ambidexterity. ▪ (Analytical) tools could support the intermediaries, this would lead to stronger support and diagnostics to get overview who and what matters in digital transformation and DAIS/Digital AKIS. ▪ This could in turn result in more joint investments, new forms of (tentative) governance and	disruption added to the general variation among actors. ▪ This leads to fragmentation of digital transformation and therefore adds complexity within already complex systems. ▪ Development of the SCPS framework and conditions for impact to deepen insight on complexity ▪ The fragmentation and complexity show that the DAIS/ Digital AKIS are emergent and can be described as a form of tentative governance.	and intermediaries in the digital transformation of AKIS/ value chains. ▪ Development and assessment of the efficacy of (analytical) tools supporting digital transformation of AKIS. ▪ In-depth knowledge of the role of competition, co-opetition and collaboration and the related trust arrangements ▪ Understanding the role of different digi-grasping modes in developing governance arrangements and regulatory frameworks for digital transformation in a value chain context. Questions:

Value chain	▪ Often there is limited trust between competing and dependent organisations. ▪ This hampers the necessary collaboration and openness for digital transformation ▪ At most there is co-opetition with regards to digitalisation (i.e. no data sharing). This results in a further increase of distrust and a paradox of openess.	regulatory frameworks.		▪ How do various types of intermediaries contribute to the development of a DAIS? ▪ What is the role of heterogeneity of actors and fragmentation within a system in the development of governance arrangements and regulatory frameworks for digital transformation? ▪ What forms of tentative governance are suitable in which type of systems and digital transformation phases? ▪ How could tentative governance contribute to the seeming paradox of openness (see section 6.2) linked to the first digi-grasping modes?

				▪ How is tentative governance shaped by a complementary network of intermediaries focused on supporting digital transformation? ▪ How do more flexible and adaptive notions of RRI shape longer term processes of tentative governance of digital transformation? ▪ What is the effect of frameworks such as SCPS, on responsible practice beyond the initial phases of research and innovation for digital transformation?
Agri-food system	▪ Inclusion and exclusion are not inherently good or bad. ▪ There is a need for understanding who is responsible for	▪ To merge diverging views of digital transformation alternative pathways could be considered. ▪ This includes combinations with other agri-food	▪ Broadened notions of RRI with a more nuanced view of inclusion and exclusion, and adding responsibilisation. ▪ RRI and digi-grasping concepts need to	▪ Development of alternative digital transformation pathways (content and process). ▪ Linking the alternative pathways to the

(unintended) consequences ▪ Digi-grasping and RRI leave no space for all alternative pathways. ▪ The appropriate level of digital transformation needs to be considered. ▪ Techno-pragmatism is a more critical version of techno-optimism.	system transitions and innovations. ▪ Regarding the digital transformation process alternatives include non-adoption, opting out or exclusion. ▪ Overcoming blurring of roles and responsibilities by enhancing the understanding who is responsible for what actions and consequences the heterogeneous actors at organisation, AKIS, value chain, and overall agri-food system level through	allow for alternative pathways both in process and in content.	appropriate level of digital transformation. ▪ Insights into the implementation of responsibilisation in practice. ▪ A further operationalisation of the SCPS concept and the conditions for impact. Questions: ▪ What are alternative system configurations that support the alternative pathways and responsibilisation in digital transformation? ▪ What is the appropriate level of digital transformation, i.e. for whom and in what way?

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Appendix 1. Overview of variables per category and sub-category

Category	Sub-category	Indicator	Indicator explanation	Specific indicator
Access conditions	***Availability***			
	Material	Hardware	Is the hardware available for the user, e.g. phone devices, robots, drones, specific sensors, machinery	Hardware + infrastructure package
				Phone sharing
				Gender divide
		Software	Is the software available for the user, e.g. Publicly available in Android or IOS appstore, proprietary software, limited/local release	Proprietary software
				Findability of software
		Data	Is the data collected by tool available for the data originator	Demanded accessibility vs real accessibility
		Infrastructure	E.g. network (phone + internet), sales of airtime, electricity, repair points, training facilities	Infrastructure esp. electricity and network access
	Institutional	Rules/ regulations	Does the institutional environment allow for the hardware/software/ data to be available to a user Is the necessary infrastructure made available for your locality	Universal access vs private markets

	Market	Demand/ supply	Is there demand and supply for the technology and the ag products produced using that technology?	Rural vs urban supply and demand
	Context	Applicability	Is the software useful in the context of the user?	smallscale vs largescale farmer benefits
				Information usefulness and timeliness
				Time availability of user
				Fit with farmer needs
	Affordability			
	Economic	Income/wealth	Poor, rich, etc.	Wealth gap
				Gender gap
		Cost of material	One off or continuous investment required	One off investment
				Long term cost/lock-in
		Value proposition	Can the investment be justified/lead to profit	
	Use	Ease of use and learning	Is the technology easy to use/is het easy enough to learn how to use it	
	Agency/Awareness			
	Socio-cultural	(perceived) Autonomy	Is a user 'allowed' to use the technology, either formally (e.g. rules, laws) or culturally (e.g. husband not allowing a wife to own or use a phone)	
		Norms/values /beliefs	Influence of social constructs on ownership and	

			use. E.g. internet banned due to religion; girls fearing repercusions of sharing things on social media	
		Identity as farmer	Does the use of technology fit with the social identity of 'being a farmer' in a certain location and context?	
	Ability			
	Literacy	Digital literacy	Ability to use digital hardware, software, and make sense of data	Gender based literacy divides
				Expert skills
				Digital jargon/ understanding (data) regulations
				Literacy induced risks
		Gen. literacy	Ability to read, write, count, calculate	Complex language and trust
				Literacy (and gender)
	Physical ability	Human	Physical ability to e.g. read from a screen, use a touch screen, carry machinery, etc.	Tech made for men
		Land/geography/crop	E.g. size of land , terrain (mountains, forests, or intercropped land), or a crop like banana may make some tech	Crop focus
				Geographical barriers
				Data have and have nots = data don't wants

			not usable or not profitable etc.	
Design choices	Design related risks incl. (unequal) power distribution related risks	Obsolescence of skills (job loss)	Does introduction to the tech lead to disappearance of some jobs (e.g. labourers)	Replacing the farmer
				Changing job characteristics
				Female participation in the (formal)labour market
				Creating new jobs
		Individual and group privacy (incl. surveillance, visibility)	Anonymization of PII. Right to privacy. Group privacy: My individual data may be anonimized, yet I can still be affected, made visible, or excluded due to a policy because based on characterisitcs I was identified as part of a group.	Government access to PII data
				PII vs non personal data
				Farmer concerns about data access
				Data protection policies
				Insufficient legislative power of data protection lwas
				(Women's) privacy within the household
		(Data) security	Is data securely collected, processed, stored, shared? Is there potential personal risk if data is shared with e.g. governments?	Fear of unrightful sharing
				Data and cyber security as umpcoming issue
		Concentrated/ private data ownership	Who owns data? What does this do to data reliability and data access? Is data in the	Lack of transparency about commercially 'owned' data

			hands of few parties? If data is privately owned, who can still access it?	Farmers maintaining ownership
				Concerns about centralized ownership
				Influence of ownership and trust on adoption
				Legislative guidelines
		Profiling (possible in/exclusion/discrimination)	Profiling and typology building of users/farmers and (positive/negative) consequences of that for e.g. in-/exclusion of someone or a group	Profiling for marketing purposes
				Profiling for political targeting
				Concerns about behaviour based targeting and possible discrimination
				Legislative protection
				Women exclusion from digital benefits
		Data processing location (nat. vs int.)	Who and where is data processed? Institutional challenges resulting from foreign data processing	Disparities between agricultural research and advisory and farmer targets, needs, and governance
				Limitations of national legislation
		Data aggregation	Related to combining data from different sources. Is it seen as problematic? Consequences for e.g.	Interoperability issues → technological lock in
				Legislationary restrictions
				Opportunities of

			transparanency of data origin, validity, (group) privacy and security, power distribution	two-way communication
		Regulations for digital devt (incl. codes of conduct and digital principles)	Mentioning of (allignment with) GDPR, codes of conduct, Principles for Digital Development (niet-Afrikaanse context), or other (local) equivalents	Free flow of public data
				Self regulation
				Data protection laws and codes of conduct (insufficiency)
				Transparency evaluator
				Universal ethical guidelines
		Choice vs obligation to participate/be included (incl consent and opt-in/out)	Is the user given a choice = is participation fully voluntary? Is it possible to opt in or out at a later time? Are there (negative) consequences of chosing to exclude oneself or opt out?	Adoption to remain competitive
				Opt-out option
				Lock in/dependency
		Distribution of benefits from digital technology	Who benefits from the technology? How are benefits distributed among different users/developers/ data owners etc.? Efforts to achieve inclusion and fairness, or marginalization	Wealthier farmers benefit more
				Vulnerable people becoming more vulnerable
				Rural vs urban divide
				Large farms benefit more
				Women benefit less/ gender divide
				Multinational benefit
				Commercial benefit

		Associated economic/social arrangements /contracts	Additional prescriptions that come as a side-effect of owning/using the digital technology, which a user cannot control	Futher empowerment of big agribusinesses
				Technological lock-in
		Right to repair yes/no	Ability to have the hardware or software repaired or updated (locally)	Adaptations and repair impossible
		Sustainability	Is the tech going to be around long term? Possibilities to update and repair and receive support after the tech was introduced (and a project ended)	Untransparant and siloed software devt
				Limited lifetime of non-cloud data storage equipment
		Gender/racial /... biased technology	Exclusion that is (unintentionally) build into the design of hardware or software. E.g. AI and ML ranking a specific group always low for credit worthiness.	Large farm bias
				Male bias
				Algorithmic bias
				Exclusion of digitally absent voices
				Exclusion of less digitally literate voices
System complexity	Technology -social organization integration --> digital traps or socio-economic consequences	Information overload	Exponential growth of available information making it difficult/impossible for users to process it all	Information overload from DSS
		Information quality issues	Challenges with reliability and validity of data, and the ability of users to judge this	Inconsistency / data noise
				Evaluating a multitude of services →

				decision paralysis
				Interoperability issues
				Trust in data
		Loss of human control and oversight over technology	Can humans control the introduced digital technologies that ? Who has that control? Consequences of reduced control and oversight due to exponential increase in digital tech options and their interlinkedness	
		Human/animal-machine interaction	Interaction between people or animals and digital technologies. And what does the introduction of digital tech do to existing human-human, human-animal, and human-crop interaction?	Face-to-face interaction
				Digital curtain moderating social relationships
				Human-animal interaction
		Addictions	Addictions to and dependencies resulting from introduction of the tech. e.g. addiction to social media, dependency on whatsapp	
		Cyber bullying/crime	Uprise of digital bullying and digital crime	Cyberstalking and haressment
				Cyber attacks (large scale)
				Social norms

				rejecting digital adoption
		Blurring of roles of organisations	Changing identities of organisations as a result of digital tech	Lack of clarity about roles and responsibilities
		Ethical dilemmas	Expressed ethical dilemmas appearing as a result of digital technologies and use of digital in agriculture	Right to equal data benefits
				Ethical behavioral norms and values
				Universal inclusion and oversight

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Furthermore I would like to thank a lot of people at CPT and KTI. Thanks to all colleagues at KTI and COM for the presentations about your work, the fun at lunch time, or the corridor chats. Cees, thank you for initial involvement as promotor in this PhD trajectory which enabled me to get started in the first place, and for your useful input. Then there are all of the ladies of the administration and secretariat at CPT (some of them moved on): Annette, Vera, Mirjam, Inge, Bea, Meta, Jennifer, Cathelijne, Germaine, Nicole. You all directly or indirectly helped me with figuring out all sorts of contract issues, admin difficulties, teaching related stuff, and probably many other things (in)directly influencing my PhD trajectory. Of course I could not forget my fellow PhD candidates, most of you already finished your PhDs, but all of you certainly made this PhD trajectory more enjoyable. In particular Rica, Horacio, Jan, Jean, Chaniga (my roommate for most of the past years), and probably many more. A special thanks goes to the 'Cucumbers with anxiety': Marie, Mirjam, Mariola and Paola. Although we have hardly all been in the same place at the same time, we kept in touch, supported each other and shared our ups and downs (both PhD and non-PhD related), and nevertheless we persisted!

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About the author

Kelly Rijswijk was born in 1987 in Noorden, a small town in the municipality of Nieuwkoop, the Netherlands. In 2009, Kelly obtained her Bachelor degree in Rural Development at the CAH Dronten, an University of Applied Science. During her Bachelor studies Kelly did several internships at municipalities and NGOs in the Netherlands on topics such as agricultural nature conservation and dejuvenation of Dutch rural areas. The latter was also the topic of her thesis. Kelly enjoyed operating on the boundary between technology development and implementation and the social interactions around it and applied her recently gained knowledge in role as project coordinator at a small NGO with a focus on rural development in the province of Friesland, the Netherlands.

Keen to look beyond the Dutch and European orientation of her Bachelor degree, Kelly enrolled in the Master programme Development and Rural Innovation (then still called Management of Agro-Ecological Knowledge and Social Change) at Wageningen University in 2009. The two year Master degree was a challenging but enjoyable learning curve. It involved a six month stay in Cochabamba, Bolivia for an internship with Centro Agua on the perspectives of different actors in the water sector on the recently implemented human right for water in the Bolivian constitution, and thesis research with NGO Asociación YAKU on the social life of a waste water and sanitation project.

After completing her Master degree in November 2011 Kelly worked for several months as an trainee of Accon AVM, an accountancy and advisory office, to provide advice to farmers on their finances, subsidy opportunities and strategic planning.

In 2012 Kelly moved with her partner to New Zealand and started working as a research associate for AgResearch, a Crown Research Institute in Hamilton, New Zealand early 2013. Here she developed research interests in innovation processes, systems thinking, extension and communication in an agricultural context. Additionally she developed project management, facilitation and Monitoring & Evaluation skills.

After leaving AgResearch in 2015 as a social scientist, Kelly moved back to the Netherlands where she started her PhD project at the Knowledge, Technology and Innovation Group of Wageningen University and Research (WUR). For this she received a three year stipend from AgResearch after which she self-funded her PhD. Besides her

work on the PhD project Kelly continued to work as a researcher in several projects (e.g. EU projects about the social impact of digital transformation on agriculture and rural areas, or on achieving gender equality in agricultural science organisations). During her time as a researcher at AgResearch and WUR she (co-)authored several peer-reviewed articles and other publications, both within and beyond the scope of this PhD project. A selection is listed below.

Wolfert, S., van Wassenaer, L., van der Burg, S., Ryan, M., Klerkx, L., Rijswijk, K., . . . Beers, G. (2021). *Navigating the Twilight Zone: Pathways towards digital transformation of food systems*. Wageningen University and Research. Wageningen, the Netherlands. doi: https://doi.org/10.18174/552346.

Salvini, G., Hofstede, G. J., Verdouw, C. N., Rijswijk, K., & Klerkx, L. (2020). Enhancing digital transformation towards virtual supply chains: a simulation game for Dutch floriculture. *Production Planning & Control*, 1-18. doi: https://doi.org/10.1080/09537287.2020.1858361

Beers, P. J., Turner, J. A., Rijswijk, K., Williams, T., Barnard, T., & Beechener, S. (2019). Learning or evaluating? Towards a negotiation-of-meaning approach to learning in transition governance. *Technological Forecasting and Social Change, 145*, 229-239. doi: https://doi.org/10.1016/j.techfore.2018.09.016

Rijswijk, K., Brazendale. R. (2017). *Innovation networks to stimulate public and private sector collaboration for advisory services innovation and coordination: the case of pasture performance issues in the New Zealand dairy industry*. The Journal of Agricultural Education and Extension, Vol. 23 (3), p. 245-263

Turner, J. A., Klerkx, L., Rijswijk, K., Williams, T., Barnard, T. (2016*). Systemic problems affecting co-innovation in the New Zealand Agricultural Innovation System: Identification of blocking mechanisms and underlying institutional logics*. NJAS-Wageningen Journal of Life Sciences, Vol. 76, p. 99-112

Rijswijk, K., Bewsell, D., Small, B., Blackett, P. (2015). *Reflexive monitoring in New Zealand: Evaluation lessons in supporting transformative change.* Evaluation Journal of Australasia, Vol. 15 (4), p. 38-43

For an overview of all publications see https://research.wur.nl/en/persons/kelly-rijswijk/publications/

Kelly Rijswijk

Wageningen School of Social Sciences (WASS)

Completed Training and Supervision Plan

Wageningen School of Social Sciences

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Writing PhD proposal	WASS	2016	6
Systems Thinking in Practice (STiP) in PhD Research: appreciating and effecting transformations with farming systems research	Harper Adams University	2016	4
'Digitalisation of agricultural knowledge providers: The case of New Zealand'	IFSA Conference, Mediterranean Agronomic Institute of Chania	2018	1
B) General research related competences			
WASS Introduction	WASS	2016	1
Research methodology – from topic to proposal	WASS	2016	4
Qualitative Data Analysis with Atlas.ti	WASS	2016	1
Data management planning	Wageningen Library	2016	0.4
Brain Training	WGS	2016	0.3
Information literacy	Wageningen Library	2016	0.6
'Triggering system innovation in agricultural innovation systems: initial insights from a Community for Change in New Zealand'	IFSA Conference, Harper Adams University	2016	1
Qualitative Data Analysis	WASS	2017	2.5
Reviewer of several journal articles	REIS, JAEE, Agricultural Systems	2017 - 2021	3
'Digitalisation projects at KTI'	Presentation for visiting students from Massey University, KTI/WUR	2019	0.5
'Digitalisation of agricultural knowledge providers'	Presentation Digimetis network, WUR	2019	0.5
PhD skills session 'publishing and reviewing'	KTI	2021	0.3
C) Career related competences/personal development			
PhD representative Knowledge Technology and Innovation Group	KTI	2016 - 2018	4
Teaching & supervising of students – several courses	KTI	2017-2019	4
Teaching outside academia	WGS	2017	4
Facilitation Masterclass Collaborative Design	WASS	2017	0.2
Cross pollination: Portable conversation pieces	WUR/Rietveld Academy	2018	1
PhD skills session on 'planning your career after the PhD and networking'	KTI	2021	0.3
Total			**39.6**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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