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SAMUEL OSLUND

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DESIGN FOR ASSEMBLY : AN EXPLORATION OF EMERGENT GRASSROOTS AGRICULTURAL INNOVATION NETWORKS

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SAMUEL OSLUND

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DEDICATION

To my dear friend Stephanie.
Without your encouragement and support
I would not have taken this challenge on.
Without your dogged belief in me
I certainly would not have finished it.
I am immensely grateful.

PREFACE

As I write this preface, I am reflecting on a story that has been dominating the current news cycle – another technology company has laid off thousands of employees with the click of an email send button. As 2023 kicks off with a continued wave of tech sector cuts, industry leaders have been acknowledging a collective *mea culpa* for projecting continued growth following the COVID 19 pandemic. In addition to the slumping economy, this latest round of cuts has been centered on the emergence of a new technology called Chat GPT, the development of which threatens to further upend the sector. Hailed as a breakthrough in artificial intelligence (AI), Chat GPT has catalysed an 'arms race' between industry players aiming to corner the market on this disruptive technology.

While we may have crossed a new threshold with this advancement in AI, there is something very old about this story of technology – a breakthrough innovation, the disruptive impact it has on the people it touches, the unknowns of what comes next, the race to get there first, and the sense of resignation with which all of this is spoken. Inherent in this story is the belief that technology is deterministic, and that society must rearrange itself around the forward march of technological progress. But is this really an inevitable process? Does technological progress follow a set course, and must we adapt to it? What happens if we begin to question this story of inevitability?

Shifting focus to the margins, this thesis explores the possibility of a different story of technology. It takes place far from Silicon Valley, in a sector that may seem an unlikely place for cutting edge innovation. Set in rural Quebec, this research tracks the evolution of a cooperative network of small-scale farmers. Faced with a lack of affordable and appropriate technology this network has been designing and producing tools to meet their own needs. In an industry where the century-long trend has been a relentless increase in the size of both farms and of agricultural technology, these small-scale farmers stand as something of an anomaly. Rather than adapting to the latest industry innovations, they are choosing to make their own.

This instinct to make is the guiding theme of this research project - it is an instinct to not simply question the status quo but create an alternative to it. In this sense, this thesis is not really about technology, but about the process of bringing something new into being. It is an inquiry into the nebulous terrain otherwise known as 'design' and the possibility of creative action in the face of what seems to be all but inevitable.

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LIST OF ABREVIATIONS AND ACRONYMES

AI	Artificial Intelligence
AG 4.0	Agriculture 4.0
DG-ML	Design Global Manufacture Local
DIY	Do-It-Yourself
CAPÉ	Coopérative pour l'Agriculture de Proximité Écologique
CEGEP	Collège d'enseignement général et professionnel
CETAB+	Centre d'expertise et de transfert en agriculture biologique et de proximité
CSA	Community Supported Agriculture
GOAT	Gathering for open Agricultural Technologists
GPS	Global positioning system
INAB	Institute national d'agriculture biologique
DfS	Design for Sustainability
DfST	Design for Sustainability Transitions
L'AP	L'Atelier Paysan
MAPAQ	Québec Ministère de l'Agriculture, des Pêcheries et de l'Alimentation
MLP	Multi Level Perspective
UN	United Nations
REAB	le Réseau des étudiant.e d'agriculture biologique
RFF	La Réseau des ferme famille
RJME	Réseau des joyeux maraîchère écologique
SSHRC	Social Science and Humanities Research Council
STS	Science and Technology Studies
TD	Transitions Design

RÉSUMÉ

Avec le développement rapide des technologies numériques, de l'intelligence artificielle et des machines autonomes, beaucoup ont suggéré que la quatrième révolution agricole était en marche. En adoptant une perspective critique sur la technologie, ce projet se penche sur les marges pour trouver des alternatives aux récits dominants de l'innovation disruptive et de l'agriculture numérique. S'appuyant sur la théorie et la pratique du design, ce projet explore le travail de la Coopérative pour l'Agriculture de Proximité Écologique (CAPÉ), un réseau d'innovation agricole émergent basé au Québec. Répondant à un manque de technologies appropriées et abordables, ce réseau de petits agriculteurs écologiques conçoit et construit en coopération des outils adaptés à leurs besoins.

En déplaçant l'attention des artefacts technologiques vers les pratiques sociales innovantes du groupe, cette recherche interroge les questions de technologie et de changement social. En utilisant à la fois *l'ethnographie de design* et la *recherche par le design*, le projet explore comment la participation à un réseau de pairs modifie notre capacité à répondre aux défis que nous rencontrons en tant qu'individus, et comment nos choix créatifs peuvent avoir un impact sur les systèmes plus larges dans lesquels nous agissons.

Mots clés : design pour l'innovation sociale, innovation de base, innovation agricole, bricolage, autoconstruction, théorie d'agencement

ABSTRACT

With the rapid development of digital technologies, artificial intelligence, and autonomous machinery many have suggested that the Fourth Agricultural Revolution is well underway. Taking a critical perspective on technology this project looks to the margins for alternatives to dominant narratives of disruptive innovation and digital agriculture. Drawing on both design theory and practice, this project explores the work of *la Coopérative pour l'Agriculture de Proximité Écologique* (CAPÉ), an emerging grassroots agricultural innovation network based in Québec. Responding to a lack of appropriate and affordable technologies, this network of small-scale, ecological farmers is cooperatively designing and building tools suited to their needs.

This research interrogates questions of technology and social change, putting the group's innovative social practices at the center rather than their specific technological innovations. Employing both design ethnography and research-through-design methods, the project explores how participation within a network of peers can dramatically expand our capacity to respond to the challenges we encounter as individuals in unexpected ways, and how our creative choices can impact the broader systems in which we act.

Keywords :

design for social innovation, grassroots innovation, participatory design, transitions design, AG 4.0, DIY, assemblage theory, autonomous design, technological sovereignty.

INTRODUCTION

I stood next to a large welcome tent, scanning workshops and demonstrations taking place amongst neatly divided fields. The rolling hills around us and well-kept infrastructure gave the appearance of a model farm. This farm was the setting for *ExpoChamps BIO 2021*, an annual gathering of farmers that are members of *la Coopérative pour l'Agriculture de Proximité Écologique*, or the CAPÉ. The CAPÉ is a cooperative of more than 300 farms with collective projects ranging from shared marketing and distribution to the design and production of small-scale farm technology. It is this latter project of Do-it-yourself (DIY) farm tools, or *autoconstruction,* that brought me to the event. *ExpoChamp BIO* is an opportunity for members of the *Autoconstruction Group* to share their latest techniques and tools with one another, and to feature technology that the coop has collectively developed. *ExpoChamp BIO is* an important social event for the cooperative which has been a pioneer in developing and sharing innovative approaches to small-scale organic agriculture in Quebec. This year, in addition to these 'grassroots innovations,' there were a number of kiosks featuring companies and start-ups that have are producing tools for this growing segment of the agricultural sector.

Looking between the printed program, I located the presentation I was eager to attend: "3pm Demonstration - Weeding with the OZ market gardening robot." From my own experience working in the small-scale agricultural sector for the last twelve years this kind of technology is somewhat of an anomaly, as automation, artificial intelligence (AI) and drones tend to be geared towards larger, industrial-scale systems. Peering up from the program I spotted the small white machine, perhaps the size of a dog, slowly wending its way up and down through crops that had just emerged. As I made my way toward the demonstration, a crowd was already gathering around a technician who was in full pitch mode.

Huddled on the periphery of the field, the group listened intently as the small robot zig zagged its way through a neat row of beans, following an invisible line with exacting precision. The technician explains, "The beans were seeded around six weeks ago with a tractor mounted with a GPS tracking device. These coordinates were then transmitted to the Oz bot, allowing it to follow in the exact location of the seeders." The robot was at the average walking pace of a human. It was outfitted with tine weeders, which extended off both sides, allowing it to straddle two rows of beans. Behind the machine a small sweep tine was installed and as the Oz moved along it cleared weeds from both the alley and the two rows.

The technician remarked that the occasional stop and recalibration that we were observing was due to the size of the rocks in the field. There were in fact a significant number of stones and debris, some the size of my hand, and every now and then a wheel of the machine would be sent off course after encountering these obstacles. The small robot would stop, reorient itself, and then resume its precise course along the planted rows, unfazed by these brief interruptions.

The technician again: "The Oz is not there to replace humans, but to assist." His words precisely, a *'coup de main'* or a helping hand in English. The robot, he suggests, can be considered another employee on the farm, and its work can be overseen by the regular farm manager. He underscores, “the machine will still need an operator.” The Oz, he tells the growing crowd, is designed to do the work that is the least enjoyable and most strenuous for people. Weeding acres of beans for example. On farms of this scale this work is often done using hand tools or with a small cultivating tractor. But, he suggests, even with a tractor the farmer is forced to crane their head downwards as they attempt to keep a straight line while monitoring the cultivating tools mounted below the tractor. He rubs his neck, mimicking the discomfort of this position, participants nodding likewise in agreement.

The technician has touched upon a timeless argument for technology: to alleviate people from strenuous and unpleasant labour. It is also a refrain that has gained significant traction within automation and robotics across the tech sector. From Tesla CEO Elon Musk who unveiled the Tesla Bot early in the year, to government officials (Gove, 2019), one of the driving narratives behind artificial intelligence (AI) and autonomous robots is their capacity to do the work that humans simply do not want to do (Kirby, 2022). With the afternoon sun glaring down on the spectators, most of whom are certain to have spent countless hours operating a tractor or weeding with hand tools in similar conditions, the technician’s point hits home. Rubbing the beads of sweat from his forehead and gesturing with his thumb at the Oz, the technician doesn’t need to spell it out - the little machine patiently chugs along undeterred.

Having driven home his argument for the utility of the Oz, the technician pivots to a question that is sure to divide the group: how much does this technology cost? The price of the little robot is $50,000 he states matter-of-factly. Without skipping a beat, he breaks down this cost through a comparative analysis of human labour. The robot can operate for around eight hours per day and runs on electric power. He offers a calculation of what this amounts to over the course of a season in comparison to human labour hours. 160 hours per month, times seven months, at around $15 per hour is something like $16,800. He points out that is a low wage so the robot could likely pay for itself within 2-3 years. By these calculations, in addition to doing mundane work that is the least enjoyable for people, he insists that this little robot is sure investment over time.

The numbers hang in the air for a moment before I hear some hesitant and skeptical questioning. This is not the first time these farmers have heard a similar pitch for the latest labour and cost saving innovation. As the crowd begins to disperse, I recognize a participant coming towards me. Henri, one of the farmer-developers behind a community-led open-source greenhouse project, grins and asks: "were you here for the robot demonstration? Pretty interesting. And *only* $50,000!" His sarcasm is warranted. For many of the participants here, the farms they manage or work on are probably grossing between $100,000 - $200,000 per year. In this light, a $50,000 weeding tool represents an enormous investment.

Henri's comments capture a fundamental challenge that many farmers of this scale have faced for decades: over the last century of industrialization, as farms scaled up in size, the commonly available tools and technology have also grown. This has led to a lack of appropriate and affordable tools for small-scale agriculture. But the cost of machinery is not the only thing at play for farmers like Henri that have been drawn to smaller-scale agriculture as a direct response to pressing environmental and social issues. Indeed, there is a growing awareness that industrial agriculture has been caught in a feedback loop, with emerging technological innovations driving concentration, technological intensification, and increasingly unsustainable modes of production (IPES-Food & ETC Group, 2021).

Thus, when it comes to technology for this growing movement of farmers, it is not so much about gaining access to the latest innovations or reducing the costs of these technologies as it is about finding tools that support the kinds of farming that aligns with their values and vision for a sustainable future. As a result, many of these farms have adopted technologies and practices which might seem to fly in face of conventional wisdom around productivity, efficiency, and progress. It is in this sense that the Oz, while seemingly appropriately scaled, touches on a more fundamental tension between farming networks like *la Coopérative pour l'Agriculture de Proximité Écologique* (the CAPÉ) and conventional industrial agriculture. Because industrial farming and technology have been caught in a recursive loop, farmers like Henri are rightfully wary of the latest technologies that, despite friendly names like 'Oz,' appear to be miniaturized versions of machines fueled by the logic of conventional industry.

As I looked on at the scene – a technology rep pitching his newest tech to a group of skeptical farmers – it felt like a throwback to just about any historical moment in agriculture: the trope of the backwards, rural farmer, hesitant about change and wary of the latest gadgets hailing from away. I can imagine what the newspaper caption might read for something like this: "Robots in the fields! Farmers getting a glimpse at the future of agriculture." Indeed, coming out of the last two decades of digitalization and disruption, innovations like the Oz robot are being hailed by industry (Clercq *et al.*, 2018), government (Gove, 2019) and media (Kateman, 2020) as an almost natural and inevitable evolution of farm technology. A speech from the British Secretary of Agriculture in 2018 captures this sentiment:

> "Our world is entering a fourth agricultural revolution... Accelerating technological advances, such as the drive towards artificial intelligence, the more sophisticated than ever analysis of big data, drone development, machine learning and robotics will together allow us to dramatically improve productivity on traditionally farmed land" (Gove, 2019).

While this rather optimistic view of technology seems to bode well for tech and agribusiness industries, what does it mean for farmers? As with industrialization, should we expect a dramatic reimagining of agriculture tuned to the technological trends of the time? Are farmers like Henri, who have increasingly embraced alternative modes of farming, doomed to be absorbed or left behind by "progress" and this fourth agricultural revolution? The words of the Secretary seem to suggest that technology is on a set trajectory that will shape society and determine the future. So, should farmers simply embrace this next revolution as a foregone conclusion?

To question technological determinacy is to suggest that alternative futures might exist or, at the very least, coexist. In other words, where we end up is a matter of contention. But what are these contested futures? If such alternative trajectories indeed exist, what do they look like and how might we understand their potential? These are the questions at the heart of this research. This project, however, evolved out of a series of much simpler questions - questions which I was confronted with while managing a small-scale farm in Montreal in 2013. Unable to find an affordable root washer on the market, I began designing my own. This problem led to a series of relationships and events that were a catalyst for a deeper inquiry into what kinds of futures might lay ahead for the farming communities of which I am a part.

During the process of developing that tool, now seven years ago, I encountered peers who faced similar challenges and soon discovered parallel networks of farmers who, by addressing a lack of affordable and appropriate tools, were developing a unique approach to innovation. Grounded in contemporary open-source ethos and traditional cooperative models, these novel practices seemed to challenge conventional understanding of how innovation happens. These observations led me to wonder how technologies designed and produced at the margins differed from that of industry. In essence, the scope of this project moved from the scale of the individual solving everyday challenges on farms, to a deeper inquiry about the implications of networks tackling broader challenges collectively. This project tracks the origins and approaches of one of those networks, the CAPÉ, a farmer cooperative whose early roots can be traced to the back-to-the-land movements and through contemporary internet and communication technologies (ICT).

While this thesis touches on themes of technology and innovation, it is important to state from the outset the focus here is not so much on technological artifacts as it is about the process of imagining and bringing things (both the tangible and intangible) in being. In other words, this research is about the act of *designing*. "Design," say Nelson and Stolterman, "is the ability to imagine that-which-does-not-yet-exist, to make it appear in concrete form as a new, purposeful addition to the real world" (2012, pg. 12). This conception of design is a helpful point of entry for how I have approached the innovative social practices emerging in networks like the CAPÉ - it also serves as a point of departure, as this research explores how we both shape and are shaped by the worlds we inhabit. As we will see in the following chapters, design theory and practice are powerful tools for which we can address questions around technological innovation, and perhaps more fundamentally, tools for which we might imagine technologies. Thus, while this thesis might be seen as a proverbial wrench in the works of common-sense views of progress and innovation, my hope here is to offer more than a critique of technology. By exploring these issues as both a farmer and designer I demonstrate that alternative pathways for technology are not only possible, but indeed exist. Tracking through fields, online forums, back country workshops and digital archives, this research project attempts to draw together the parts of an emergent system of grassroots innovation as it assembles.

CHAPTER 1

Critique - Ecosystems or Echo chambers?

1.1 Agriculture 4.0: Technological innovation and the (possible) future of agriculture

By now the pitch is familiar, almost formulaic: The CEO presenter on stage; an opening statement that summarizes the state of agriculture today - rapidly growing population, migration from rural regions to cities, the environmental crisis; a leading question: what if we could solve all these problems? The pitch: the company's disruptive technological innovation and the role it will play in ushering in the future of farming. From lettuce grown in urban warehouses, to autonomous drones surveying endless acres of land, this vision of the future of farming anticipates the explosion of digital technologies and the role they will play in what has been called the fourth agricultural revolution, or AG 4.0 (Klerkx et Rose, 2020). The domestication of animals and stabilization of crop varieties, the introduction of the plow and animal power, synthetic fertilizer and pesticides, steam power, oil and the tractor, the rise of bioengineering and the green revolution - these are all deemed to be pivotal periods of innovation, known as agricultural revolutions, that underly modern industrial agriculture.

There is no consensus about just what technologies and innovations should be included under this nascent fourth agricultural revolution (Barrett et Rose, 2020). While some have linked it to precision-ag, the use of AI, and smart farming (Rose et Chilvers, 2018), it is also associated with the rise of cultured meat, indoor vertical farming, and the potential of blockchain technologies to disrupt conventional food supply chains (Clercq *et al.*, 2018). Despite the lack of a clear definition, the concept of AG 4.0 has become a popular catch-all term to describe emerging agriculture technology today (Klerkx et Rose, 2020). It is perhaps this flexibility that allows AG 4.0 to be instrumentalized in the present discourses surrounding innovation in agriculture. Thus, while the technologies themselves vary across segments of the farming industry what is striking is the consistency of an emerging narrative of urgency and inevitably.

Like the previous agricultural revolutions, AG 4.0 has been predicated on familiar stories of progress: the rise in productive capabilities, the constantly expanding role of technology, and the reduction in the amount of human labour engaged in food production. These familiar themes build on the notion that technology has a telos, moving along a set path, disrupting, and rearranging society as it evolves (Goldsmith, 1981). According to this line of reasoning, anticipating, and harnessing these emergent technologies enables us to combat intersecting contemporary crises. While the issues underscored by proponents of AG.4.0 are perhaps accurate in their assessment of the dire issues with the present conventional food systems, are the proposed solutions, and the imagined futures on which they are predicated, inevitable? This chapter sets out to examine this 'common sense' perspective of technological innovation.

Rather than focusing on academic research, I turn instead to narratives emerging within industry, media, governments, and institutions and how these groups position the various technologies that fall under the heading of AG 4.0. Drawing on these primary sources for discourse analysis, I show how recurrent themes and perspectives are used to normalize deterministic views of technological innovation. I then turn to the Science and Technology Studies (STS) research to examine how a critical perspective of technological innovation might trouble the future envisioned by proponents of AG 4.0.

1.2 Emerging discourses and the future of farming

"Can crop pollination technology save the bee... from itself" asks the headline of a recent article from the Food and Farming Technology magazine (Peskett, 2021). The article begins by highlighting the concern about dependence of world food systems on pollinated crops which account for around 30% of our food sources. The authors note that bees are not only facing issues of pests and diseases causing colony collapse, but the growing demand for managed honeybees for pollination could be contributing to a decline in native pollinator species. In response, the article highlights a handful of start-ups and research initiatives that are aiming to address these problems through the development of what they call "augmented pollination technology." One such company, DropCopter, has developed a technology that 'surgically' applies pollen to crops using drones. In a post explaining the landscape of emerging agricultural technology, DropCopter states:

> Everything in our world is now being affected by technology in one way or another, and farming is no exception. From IoT to drones, technology is changing the way farmers and consumers interact with the food they grow and eat... Digital farming is using precision location methods and decision quality agronomic information to correct cultivation issues on a farm. Digital farming provides operational systems which can scale to millions of acres, deploy across multiple crops, and provides an end-to-end solution to small growers and large growers alike. (*What is Digital Farming?*, 2020)

The company goes on to state that: “with these new technologies and new digital farming practices DropCopter and companies like DropCopter are able to combat what many scientists say are looming threats to our planet and our food supply chain“ (Ibid). The company premises the expansion of digital technology into agriculture as essential for addressing the issue of the decline of pollinators. The technology not only solves the problem of pollination, but also allows the farm to scale up in size. This movement of technology into agriculture is described as, if not exactly natural, then an obvious evolution as farming is ‘no exception’ to being ‘affected by technology.’ The statement evokes the sentiment that *everybody already knows this*. Having established the context, DropCopter goes on to describe in general terms what digital agriculture is. The technology uses “precision location methods'' and “decision quality agronomic information to correct cultivation issues.” Here, while the language is both technical and vague, the objectives and purpose of these technologies is taken as obvious. Thus, on the one hand technology is simply evolving in this direction, yet on the other hand these technologies are vital tools, allowing farming to scale to meet the demands of the future. The two discourses reinforce each other, but the final section of text is perhaps the most important in shaping a narrative of urgency for this innovation: the planet is facing an existential threat and it is imperative that we develop these technologies in order to combat it. This normative position encouraging active efforts to create AG 4.0 technologies stands in contrast to the implication that AG 4.0 is an inevitable side effect of technological advancement.

We see similar themes In the nascent cultured industry which is forecasted to be worth $94.5 billion by 2030 (Cultured Meat Market Report 2020-2021, 2021). In a recent Forbes article, the author applauds plant-based meat companies, like Impossible Foods and Beyond Meat, for having “almost single-handedly worked to lessen the impacts of industrial animal agriculture” (Kateman, 2020). Looking at the market growth in emerging stem cell base meat technology, the author suggests that this ‘deathless meat’ is poised to further disrupt conventional animal agriculture. One of the more prominent companies in this emerging industry is Memphis Meats, who in a 2020 funding round raised $161 million from industry leaders like Cargill and Tyson foods, along with well known technological entrepreneurs Bill Gates and Richard Branson (Rowland, 2020). The company's webpage states: “together we are reimaging how meat is made” (*Memphis Meat*, s. d.). A sample of media stories featuring Memphis Meats technology, provides an overview of how the company is positioning their innovation. From Newsweek, "Lab-Grown Beef Will Save the Planet — and Be a Billion-Dollar Business” (Burningham, 2016); NBC, "Lab-Grown Meat May Save a Lot More than Farm Animals’ Lives” (Gholipour, 2017); Netflix, "Recipes from the future: Bill Nye tries Memphis Meats” (Nye, 2017). In a post from 2020, titled “Tasting the clean meat of the future,” investor and Virgin CEO Richard Branson writes: “In the next few decades I believe that clean and plant-based meat will become the norm and animals will no longer need to be killed en masse for food... Conventional meat production cannot scale to feed the world’s growing population and appetite for meat” (Branson, 2019).

Here the integration of the issues- unsustainability, animal welfare, and population growth - along with the professed potential of the technology - deathless, sustainable, scalable - dovetail neatly into each other, making the case for cultured meat seem not only inevitable but an imperative. Words like ‘clean,’ ‘scientific,’ and ‘lab,’ are juxtaposed with the pressing challenges Memphis Meat is aiming to solve, reinforcing a sleek argument for why conventional agriculture, with its feedlots and slaughterhouses, needs disruption. Although arguments for conventional agriculture have always been about increasing production and efficiency, Branson claims that farming today “cannot scale to meet the world’s growing population,” alleging that, “meat production has not changed in 10, 000 years. It’s time that changed” (Branson, 2019).

1.3 From visionary start-ups to foresighted policy makers

The visions of the future and the declarations of urgency surrounding AG-tech are by no means limited to industry, media, and venture capitalists, as governments and institutions are increasingly adopting a similar stance on Ag 4.0. A joint publication by the World Government Summit and Oliver Wyman consultants states the following: “The future of agriculture will use sophisticated technologies such as robots, temperature and moisture sensors, aerial images, and GPS technology. These advanced devices and precision agriculture and robotic systems will allow farms to be more profitable, efficient, safe, and environmentally friendly”(Clercq *et al.*, 2018, p. 4). The article calls on governments to play an active role in supporting this revolution, again using arguments for the social and environmental imperatives as well as embracing the inevitable digitalization of agriculture. The writer seamlessly shifts from descriptive to normative, side-stepping any causal link between government support for AG 4.0 and the increasing presence of these technologies. Calling for disruption at the system level the reports states: “The good news is that these digital and technological advancements are taking over the industry, enhancing the entire food value chain. Agricultural technology start-ups have grown more than 80 percent per year since 2012” (Ibid, pg. 11). A speech by the British Environment Secretary, presented at the at the 2019 Oxford Farming Conference, takes a similar tone:

> "Our world is entering a fourth agricultural revolution... Accelerating technological advances, such as the drive towards artificial intelligence, the more sophisticated than ever analysis of big data, drone development, machine learning and robotics will together allow us to dramatically improve productivity on traditionally farmed land" (Gove, 2019).

He goes on to state that this revolution will support, "reducing the need for labour, minimising the imprint of vehicles on the soil, applying inputs overall more precisely, adjusting cultivation techniques more sensitively and therefore using far fewer natural resources, whether carbon, nitrogen or water, in order to maximise growth." Here, the benefits are lumped together as though obvious, including reducing the needs for labour. In addressing the potential challenges and social issues surrounding new technologies the Secretary puts it this way: "we cannot wish away these changes... Science is thus both making us aware of why agriculture needs to change and also enabling that change to meet our needs" (Gove, 2019). This fallacy rides on the urgency of the climate crisis, equating the inevitability of climate adaption with the inevitability of Ag 4.0.

As with the discourse emerging from the private sector and media, the government response to AG 4.0 is characterized by a mix of optimism, inevitability, and resignation to the impact these changes will have on agricultural regions and communities. Invoking the legacy of the Second Agricultural Revolution, the Secretary notes that the advances made between the 17th and 19th century are what permitted the population growth that would sustain the Industrial Revolution. This narrative embraces a vision of technology that we can describe as both essentialist and deterministic.

1.4 Technological determinism and essentialism in popular culture

Does technology have an essence? Technological essentialism refers to the belief that there is an inherent, evolutionary trajectory hard baked into technology (Feenberg, 2000). In other words, technologies exist outside of human scope having an internal essence. In line with this conception of technology, determinism holds that society evolves and adapts to technological progress. "A deterministic view of technology is commonplace in business and government," says Feenberg, "where it is often assumed that technical progress is an exogenous force influencing society rather than an expression of changes in culture and values" (Feenberg, 2010). Simply put, progress follows a set trajectory. The newest technology shapes society. If not entirely predictable, it is unavoidable and thus society must accept and embrace technology even as it disrupts established systems.

Even though both determinist and essentialist views of technology have been critiqued by Science and Technology Studies (STS), as Feenberg notes (2010), these ideas pervade popular narratives around innovation and the acceleration to technological futures today. Kevin Kelly, the influential technology journalist, and founder of Wired magazine, has argued in favour of this very point, suggesting that technology has an inherent trajectory. In *What Technology Wants* (Kelly, 2014), Kelly notes because the complexity of technology is always increasing, each breakthrough innovation builds on the ever-expanding number of previous innovations. He calls the sum of this expanding system the 'technium.' Likening this ensemble of technology to an ecosystem, Kelly suggests the technium has built in tendencies and proclivities. As it evolves, it shapes society and nature in order to satisfy these imperatives. In other words, the logic of the technium is self-reinforcing. Each innovation is only possible through drawing on the ensemble of all previous technologies, thus driving the system to increasing interdependence, complexity, and, most importantly, along an inherent trajectory.

It is a compelling narrative, one which fits the discourse of the inevitable future that AG 4.0 signals. Indeed, Kelly himself has spoken at length about farm technology and the future of agriculture. In a recent video blog Kelly (*Kevin Kelly - The Future of Agriculture*, 2020) states that:

> "The primary place where this automation is going to be happening is in robots. It is very obvious that we want to have robots doing the farming. We want to have a machine farm. We want machines to weed. We want the machines to do all the hard dirty work that no human really wants to do. Particularly at the scale that we are having to grow food now."

Kelly does not shy away from aligning the technium with the concept of progress, arguing that even if we include the negative consequences of innovation, overall, there is a tendency towards an increase of freedom, choice, and wellbeing. In *What Technology Wants* he puts it simply:

> "If we create only 1 percent or 2 percent (or even one-tenth of 1 percent) more positive stuff than we destroy, then we have progress. This differential could be so small as to be almost imperceptible, and this may be why progress is not universally acknowledged. When measured against the large-scale imperfections of our society, 1 percent better seems trivial. Yet this tiny, slim, shy discrepancy generates progress when compounded by the ratchet of culture. Over time a few percent "not much better" accumulates into civilization" (Kelly, 2014, p. 74).

This view is premised on the notion of technology having a kind of essence, following a predetermined trajectory, and shaping society. Furthermore, it takes the position of the imperative of progress: these technologies are both inevitable and necessary for the evolution of civilization. Kelly's statement about the beneficial arc of progress and the advance of civilization assumes a certain uniformity and a blatant lack of critical awareness of just who benefits from this conception of progress.

1.5 On technological imperatives, progress, and the legacy of disruption

The connection between the idea of progress and the technological imperatives which it necessitates have a long and intertwined history. If every period of major technological innovation has brought about significant social, economic, and cultural opportunities, it has equally led to the destruction of many previously established systems. Often seen as part of the inevitable trajectory, these periods of transition and the impacts they have on the people that live through them are seen as the cost of the slow train of progress. Indeed, we have a term for those that refuse to accept change brought about through technological innovation: luddites.

The Luddites were a group of artisans and framework knitters that were part of the cottage industries at the turn of the 17th century. Faced with the rise of steam technology that powered industrial weaving machines, the Luddites began a campaign breaking frames in industrial factories in 1811 (Kirkpatrick, 1995). This anti-industrial technology campaign lasted three years and was eventually put down through state sanctioned force, leading to the execution and imprisonment of the presumed Luddite leaders.

While today the term luddite is steeped in pejorative connotations of backwards, anti-technological, and reactionary, some historians consider this the first major resistance to industrial technology that was quickly changing the social, economic, and political landscape of the time (Binfield, 2004). The advent of steam technology was shifting production from a small, distributed cottage industry to consolidation in factories outfitted with new labour displacing technologies. These machines, which could be operated by less skilled workers, could dramatically out-producing tradespeople. Although there were concerns at the time regarding the impact of these new innovations on society, the general sentiment was a resignation to the inevitability of progress (Kirkpatrick, 1995). The steam powered loom could not be un-invented and the imperatives of the time - the growing demand for standardized goods and the need for more employment in industrializing cities - were considered part of the inevitable technological trajectory.

From the Second Agricultural Revolution that led to the Industrial Revolution, to the crop science and bioengineering that ushered in the Green Revolution in the 1970s, farming has been deeply impacted with each historical period of rapid innovation. As with the current discourse surrounding the imperatives for the AG 4.0, the justification for the negative impacts of these previous periods instrumentalized ideas of progress and inevitability.

The second agricultural revolution was linked to the discovery that nitrogen, phosphorus, and potassium were three key nutrients required for plant growth. In addition to this, the advent of technology powered by fossil resources shifted agriculture from multi-generational, intensive, subsistence farming, enabling farmers to produce at an industrial scale. But these technologies did not come without impacts on other areas of society and the environment (Fraser, 2013). Labour reducing machines led to a dramatic shift in population, driving urbanization as people migrated to industrializing cities. The effects on the environment were equally transformative, and often detrimental. Over time farming, powered by fossil fuels, chemical fertilizers, and the tractor, began to lead to major issues of soil erosion and destruction of natural ecosystems as ‘agriculture’ shifted to ‘agribusiness’ (Berry, 2015). During this period of industrialization in the western world, imperatives of modernization and economic advancement were the driving themes. Like the displacement of cottage industries in Europe, this transformation of rural landscapes was part of the price of progress.

The Third Agricultural Revolution, also known as the Green Revolution, was premised on a new purported crisis: world hunger (Shiva, 1991). Developing countries were considered under threat of food insecurity and civil unrest. Technological advances in crop yields along with mechanization were suggested as not only a solution but a moral necessity (Moseley, 2016). Despite the fact that critics of the Green Revolution have challenged the questionable efficacy and neocolonial motives behind it, this period is still often referred to as a positive turning point in the development of countries like India, Mexico, and Bangladesh (Shiva, 2012). As with the Second Agricultural Revolution, the rapid deployment of technological innovation in developing countries led to similar transformations of rural populations where subsistence agriculture had been the primary livelihood. The mass rural to urban migration and mounting environmental issues these countries are now experiencing have been linked in part to the unforeseen consequences of Green Revolution (Shiva, 1991).

As this brief review of agricultural innovation highlights, the social, economic, environmental, and cultural disruption is often measured against notions of net benefits and the slow movement towards a better future. But it is this linear history of technological determinacy, with its built-in cost of progress narrative that we must question, especially now that the same imperatives have again been invoked to justify a fourth agricultural revolution. If not considered luddites, through the periods of industrialization and modernization that drove urbanization, farmers and rural areas have been seen as behind the times.

Even now, as digital innovation and technological adoption moves at a rapid pace in cities, the countryside, with its sprawling fields and worn-down infrastructure seems to be from another era. With the climate crisis pressure mounting and the growing knowledge of the impact conventional agriculture has on the environment, farming is ripe for disruption (Kim *et al.*, 2020). Just as the previous agricultural revolutions wove together ideas of progress and technological determinism with moral and social imperatives, AG 4.0 has added the pressing environmental crisis as a justification for disruptive innovation. Is this latest revolution not a continuation of the same logic that attempts to solve the problems caused by the previous periods of innovation? Like its predecessors the narratives around AG 4.0 leave very little room to question this vision of the future, positioning it as both necessary and inevitable.

1.6 The social construction of technology

As we have seen, the essentialist and deterministic view of technology has remained surprisingly persistent over time. Even those who have critiqued technology for the negative impact it can have on society and the environment often do so from an essentialist perspective (Winner, 2020). They call for reduction of the dependence on technology rather than questioning the ingrained assumptions about what constitutes technology. While it is important to draw attention to the issues that are often a direct result of technological innovation, simply calling for less of it can leave us repeating the arguments for simpler times and a nostalgia for what was. Like the luddite movement, these critiques are seen as resistance against progress and the inevitable future. In addition to critically assessing the potential impact of emerging technologies we need to ask more fundamental questions: is technology on a set trajectory? Is society inevitably forced to adapt and reorganize around technological progress?

The sociology of technology grew out of the body of work that critically examined the history of science (Law, 2004). Moving away from framing scientists as discoverers of objective truth, science studies scholars suggested that scientific facts were socially constructed (Latour et Woolgar, 1979). Building on this approach, Pinch and Bijker (Pinch et Bijker, 1984) argued that technology studies would also benefit by taking a constructivist view of innovation. The field of Science and Technology Studies (STS) trouble the determinist and essentialist views of technology, emphasizing the role of society in shaping technology. Exploring the origins of the safety bike, what is considered today as the standard bicycle, Pinch and Bjiker challenge the deterministic view of how the bicycle came to be. Rather than suggesting that the dominant model of bicycle succeeded due to inherently superior design – a deterministic and linear approach to innovation - they highlight the many competing models that existed at the time. They show how differing values and needs of relevant social groups impacted the trajectory and popularization of the safety bicycle.

In response to the linear conceptions of technology, Pinch and Bijker propose a multi-directional approach to the history of innovation. They point out how for many years the dominant cycling group was composed of young athletic men that saw the high wheeled bicycle as the ideal for showcasing fitness and skill. They then demonstrate how different social groups saw this as a non-useful technology (older and less abled people) and how social norms of the time influenced whether certain groups could use the technology (women, for example were excluded). These varying levels of inclusion of actors in different groups play an important role in creating tensions which can lead to a reinterpretation and shift in the technological artifact. Thus, the social constructivist perspective aims to show how the intersecting interests of these groups impact technological trajectories, bringing about change, stabilization and eventual closure. The result of this process is considered the dominant understanding, or group consensus, of the technological artifact.

While this constructivist approach offered a new lens in which to view innovation, the theory has been critiqued for taking a politically agnostic perspective on how technologies eventually stabilize. Critics point out that this approach to understanding technologic innovation assumes a form of consent amongst groups as the technology stabilizes and reaches closure. With the emphasis on relevant social groups and social interests, the theory tacitly leaves out those with no voice and less power (Winner, 2020). Furthermore, the focus on empiricism can lead to overlooking the structural, political, and economic origins for the social choice of a technology (Ibid).

In his seminal work *Transforming Technology*, Feenberg (2002) develops a critical perspective that draws attention to power relations in the shaping of technology. Building on the constructivist approach, Feenberg challenges the idea that society is determined by technology. Indeed, he suggests that the dominant values of society are what shape the major technologies. Feenberg proposes that the success of an innovation has more to do with relations to power than the inherent superiority of a particular technology, underlining that dominant groups have an outsized advantage in determining and shaping the trajectories of innovation.

Thus, if we accept that technology is shaped by society, and more importantly by dominant groups within society, we arrive at the crux of a critical theory of innovation: dominant technologies reflect the values of those with power and it is in the best interest of those groups to naturalize and obscure unequal power relations in order to maintain the status quo. Drawing on Foucault's theory of power and knowledge, Feenberg puts it this way:

> "Modern forms of oppression are based not so much on false ideologies as on the specific technical 'truths' that found and reproduce the dominant hegemony. So long as the contingency of the choice of 'truth' remains hidden, the deterministic image of a technically justified social order is protected" (Feeberg, 2010, pg. 18).

Restated, an essentialist and deterministic view of technology not only naturalizes unequal power relations, but it also obscures the motives and values of dominant groups. While many critics of technology argue for a reduction of technology or low-tech forms of innovation, Feenberg suggests that these criticisms will always be challenged as impractically nostalgic. Instead, he calls for a democratization of the innovation process. If we understand that a technology will reflect the values of its makers, beyond simply challenging dominant forms of innovation, democratic technology requires bringing more people into the process of innovation itself.

1.7 Exploring the motives behind the imperatives

A critical theory of technology opens two fruitful paths to explore the discourse around the future of farming. First, it demands a critical examination of the motives and values that might be hidden behind deterministic and essentialist arguments for the inevitability of AG 4.0. Second, it draws attention to the potential for other forms of technological innovation that go unnoticed - possible alternative trajectories marginalized by unequal access to resources and power. Returning to the narratives explored in the first part of this chapter, we see how the emergence of digital agriculture is framed as a natural evolution of the trajectory of technology. This framing suggests that the fourth agricultural revolution, like its antecedents, is an unavoidable and indeed necessary step of progress. According to this line of reasoning the price of progress, whether the reduction in labour due to automation or the rupture between people and the environment, is both justified and necessary. To challenge this logic is to open the space to ask who really stands to gain from disruptive innovation.

To begin to answer that question, we could start by looking at the unprecedented level of investment going into ag tech. As the report from the World Government Summit declares, "agritech start-ups are booming, with entrepreneurs and investors showing a voracious appetite for the sector"(Clercq *et al.*, 2018, p. 11). By way of example, in addition to investing in cultured meat, Bill Gates' investment fund has poured money into the proprietary precision ag tech being developed by John Deere (Roth, 2019). SoftBank Vision Fund, the investment vehicle of Masayoshi Son, has invested $200 million into Plenty, a vertical agriculture start-up that has also received funding from Jeff Bezos, former CEO of Amazon (Clercq *et al.*, 2018). The list of wealthy individual and venture firms investing in agriculture is extensive. A report from Agfunder, a venture capital portfolio and Agri-tech investment tracker, highlights that $19.8 billion has been invested into the sector in 2019 alone (*AgFunder Agri-FoodTech Investing Report - 2019 | AgFunder*, 2020). Listing the highlights from the year, the portfolio cites the success of the Beyond Meat IPO which reached a $9 billion dollar valuation.

While ag tech appears a lucrative investment opportunity, it seems farmers have been more or less left on the sidelines. A review of the speakers for the 2021 Agri-Tech conference in Silicon Valley provides an interesting portrait of this emerging sector (World Agri-Tech Innovation Summit, s. d.). Of the 115 presenters there was only one farmer. The rest of the panel presenters were made up of investment firms, start-ups, a handful of policy makers, and the representatives from the largest tech firms in the U.S and abroad. It appears that while the tech industry plans to disrupt the farming industry and usher in the fourth agricultural revolution, farmers may be the last people to find out.

Therefore, it is necessary to tease apart the narratives around the optimistic future outlined by Ag 4.0 and its reliance on a deterministic perspective of technology. On the one hand, arguments for these technological innovations are based on the positive impact it will have on society. On the other hand, the teleological conceptions sidestep both the issue of possible negative impacts and obscure the inherent values of those that stand to benefit. Speaking of the history of dominant technological innovation, Feenberg puts it this way: “the particular form in which these achievements are realized in the West incorporates values that are not at all universal but belong to a definite culture and economic system. Modern Western technology is uniquely rooted in capitalist enterprise. As such it privileges the narrow goals of production and profit”(Feenberg, 2000, pg. 310).

What is particularly problematic with the normalization of these discourses is that it at once justifies the imperative to deploy emerging innovation while absolving those behind it from the negative consequences. If automation is inevitable, the company that produces the machines that replace the farm laborer is not at fault. Imperatives of these sorts of technological solutions are an updated version of the same well-worn arguments that have led each successive agricultural revolution. If it was the expanding economy during industrialization, or feeding the developing world during the Green Revolution, today’s proponents for the Fourth Agricultural Revolution have simply added the urgent environmental crisis to the list of reasons to intensify production.

1.8 Troubling the inevitably of AG 4.0

It is not the objective of this chapter to suggest that modern technology is not useful or has not brought about significant benefits to the societies in which they have been integrated. The first three agricultural revolutions have undoubtedly increased certain kinds of efficiency and capacity to scale food production. But there is a growing awareness that these once ground-breaking innovations have also been responsible for environmental damage caused by over application of chemical pesticides and fertilizers (Nicolopoulou-Stamati et al., 2016) , social disruption due to expanding commodity farming (IPES-Food & ETC Group, 2021), and the consolidation of wealth and land. Ironically, these previous revolutions are at least partially responsible or the same crises within the food system that AG 4.0 proponents use to justify the need for their technologies. It is at best short-sighted to invoke the technology of past agricultural revolutions as a justification for the necessity of a fourth, where the primary objective is to do more of the same, just more efficiently.

As we will explore in the later chapters, emerging innovation, such as Internet and Communication Technologies, have played an important role in rural agricultural communities in the last two decades. However, despite the potential of some of the emerging innovations related to the Ag-Tech sphere, most follow the same type of logic found in previous generations of technology. Just as each successive iteration of the tractor has allowed for a reduction of labour and an increase in farm scale, the future outlined by proponents of AG 4.0 replaces the tractor and the farmer with autonomous drones. Similarly, each advancement in this trajectory of technology has seen a further abstraction of the relationship between the farmer and the land. Within this conception the farmer will be a technician who combs through data, not from the dash of a tractor but from the comfort of some far-off place. As a report from the Bank of Canada predicts: “farmer 4.0 will be working in office towers, data centres and engineering labs around the country”(Stackhouse *et al.*, 2019, p. 10).

Sifting through technology white papers, conferences, presentation slide decks and investment ‘deal books’ it becomes clear: the farm of the future will mirror the reality and values of technologists and designers bringing it into existence. While proponents of this nascent form of agriculture continually suggest that we will hardly recognize the new farm, we need only look at their working environments, housed in office blocks, laboratories, and data centers to get a glimpse of this future. As the CEO of Small Robot, an agricultural drone company declares: “in practice, what this future will look like is swarms of small machines out in the fields at all times planting, monitoring, treating and eventually even harvesting all of our crops autonomously, and plant by plant” (Jones, 2019). He goes on to say: “farmers will have a greatly increased freedom of time, which they will use to add value to their businesses and their products in new ways and to spend time communicating with consumers about how their food has been produced” (Ibid).

Freed from manual labor, the farmer can become a pitchman, spending their time explaining the technology they use to consumers. It seems, with no sense of irony, that those proposing this future are describing their own work. The same discourses seem to come from an echo chamber driving us, knowingly or not, towards a future built on the same motives and values that have led to our present intersecting crises. If there is any truth to Keven Kelly's technium, it is that the values of those conceiving of the technology have a profound power to shape the world in which their visions are deployed.

Yet, even as the inevitably AG 4.0 is spoken of with the confidence of a well-rehearsed tech-launch, for the time being these ideas are in beta mode. So, while the chance of siting an autonomous drone in a field is increasing, most of this technology is still in R&D, subsidized through a mix of speculative venture capital and public research funds. Although the pockets of investors seem to be bottomless, AG 4.0 is still a promissory note of a potential future. A critical perspective of technology offers us the possibility to shed light on the motives and values behind this vision of agriculture. Even more, it requires that we look to the margins to see what other agricultural technologies might exist and how they point to alternative trajectories for innovation. To do this we must question the deterministic view of singular technological trajectory and broaden our understanding of innovation to include practices that often go unnoticed. In short, we must look for emerging forms of technology that open new pathways and alternative futures.

CHAPITRE 2

Alternative Futures and Designs - A Conceptual Framework

2.1 Confronting the gap in innovation and appropriate farm technology firsthand

There's a thin line between a virtuous and vicious cycle, with the confirmation of preconceptions tending to reinforce the idea that you are headed in the right direction. If we have arrived in a place where AG 4.0 seems inevitable, it is no doubt due to a vicious feedback loop, which has built in certain measurements of success at the expense of many others. Though increases in efficiency, profitability for industrial producers, and productivity have expanded with each wave of technological innovation in agriculture, the impact on environmental and society have, until now been largely ignored by conventional industry and government alike. So it is that, over the last 100 years, with agriculture's movement toward industrialization there has been an entwined trend: as the farms got bigger so too did the technology. Success in agriculture was measured in scale, with watchwords like "Go big or get out," being promoted by the U.S. Secretary of Agriculture in the 1980's (Berry, 2015).

In the U.S, for example, between 1900 to 2021 the total amount of farms has dropped from 6 million to just over two million (*USDA ERS - Farming and Farm Income*, s. d.), while the total amount of land being farmed has stayed steady. Over this same period the average farm size has gone from 145 acres in 1900 to 440 in 2021 (Ibid). In other words, if you wanted to practice farming at a smaller scale you faced an uphill struggle in finding not only financial support but the appropriate tools and technologies for a rapidly disappearing form of agriculture. This trend continues to this day, and I encountered it firsthand while managing a small-scale farm in 2015. Drawn to farming for environmental and social motivations I soon found that the tools needed for organic and sustainable agriculture were often a mix of retrofitting ancestral machinery or hacking together new tools and technologies. I also realized I was not alone in this make-shift approach to addressing a lack of appropriate and affordable tools, as over the years, I encountered peers and eventually networks, of farmers that were cobbling together their own technologies.

Scholars (Smith, 2017) have noted a similar pattern in grassroots innovation movements: dominant, lock-in technologies and a lack of market alternatives can catalyse communities to develop their own solutions. Indeed, there is a rich history of innovation emerging within the grassroots, from the appropriate technology movements of the 1960s, to the contemporary citizen and public science movements that have flourished in India (Smith, 2017). While these different initiatives have had varying degrees of success, in regard to broad level adoption of grassroots innovations, they have been instrumental in demonstrating how alternative technological trajectories can and do exist. What's more, Smith and Sterling (2016) have drawn connections between the bottom-up innovation emerging from these grassroots movements and what Feenberg's concept of democratic technology. This approach to innovation shifts away from traditional centers of power and experts to participatory innovation that is from and for the margins (Gupta, 2020).

2.2 Emerging forms of production and the democratization of innovation

With the rise of internet and communications technologies there has been a growing interest in how these emerging technologies might further democratize innovation and catalyse grassroots technology movements (Smith, 2017). Makerspaces and fab-labs, and the low-cost, small-scale technologies housed in these spaces, have been described as potential sites for the rebirth of micro-production and innovation reminiscent of the pre-industrial cottage industries (Bauwens *et al.*, 2019). Responding to the tension between the need for both reduced consumption and a sustainable form of production, Kostakis et al. (2015) have outlined a model of localized manufacturing that builds on globalized information and knowledge sharing. They call this system Design Global Manufacture Local (DG-ML).

DG-ML emerges at the convergence of information and communication technologies, socially innovative practices, new accessible technologies, and the increase of distributed micro-factories (Kostakis *et al.*, 2018). Kostakis et al. suggest that DG-ML is inherently sustainable as it shifts away from globalized distribution and planned obsolescence to regional production based on user needs rather than traditional market forces. Put simply, DG-ML outlines a production system in which what is heavy (manufacturing, resources extraction) becomes local, and what is light (knowledge, design, information) becomes global (Ibid).

Researchers have identified four features that are considered central to examples of DG-ML systems. The first of these is the emphasis of design for sustainability. The second feature are commons-based property regimes, in which resources are governed with the goal of creating fair access and governance. The third defining feature of DG-ML is the sharing of resources, or what Kostakis et al. call "the real sharing economy" (2018). The emphasis here is on cooperation and mutualization of resources, whether physical space or immaterial knowledge. The fourth feature is rise in distributed machinery, where new technologies, like 3D printers, have allowed previously specialized tools to be accessed and employed by many users. While much of the scholarship on this emerging form of production has focused on urban centers and digital spaces, agriculture has become an unlikely site of active research on how communities of practice are addressing real world problems through these hybrid models of production.

2.3 Farm hackers and peasant workshops

Giotitsas (2019) and Pantazis and Meyers (2020) have highlighted in their research on grassroots agricultural innovation networks how these groups embody many of the DG-ML principles. Based in France, L'Atelier Paysan is one of the most established of these networks. Founded by farmers in the early 2000's, the organization develops custom small-scale farm tools, organizes fabrication workshops, and hosts skill building and education sessions. The group hosts an online platform offering access to all the plans for their tools. The designs are developed under creative commons licenses, which means they can be reproduced and modified by anyone for non-commercial purposes.

Farm Hack is an organization based in the United States which was started around 2008. Like l'Atelier Paysan, the network hosts hackathons, cross disciplinary events where farmers, engineers, designers, and activist can collectively prototype new technology. But Farm Hack is perhaps best known as an online, open source, repository of farm tools and technology. The site is developed on a wiki-platform which means anyone can join and contribute their own design or modify or 'hack' existing tools.

Like the grassroots innovation scholarship on appropriate technology movements, Giotitsas (Giotitsas, 2019) has suggested that these farmer-led innovation networks offer alternative trajectories for agricultural technology. Drawing on Feenberg's critical theory of technology, Giotitsas underlines the open and indeterminate nature of farmer-led innovation networks. Giotitsas contrasts this with the deterministic and essentialist views of innovation, noting that in grassroots indeterminist innovation: "technological development follows technological branches that may reach a high level on more than one track. Such development is not a determining factor for society but is rather overdetermined by social and technical factors alike" (Giotitsas, pg. 72, 2019). As noted in the opening chapter of this thesis, the shift towards questioning the determinist and essentialist readings of technology opens us to questions around the values and objectives of those that are creating technology, revealing the kinds of futures they imagine. In other words, by questioning the intent of those behind technology, we are challenging the inevitability of the future these technologies entail, and thus we broach deeper questions of design.

2.4 Alternative designs

What do I mean by design? Science and technology scholars and technology critics rightly point out the political and power relations inherent in technological innovation, advocating for democratic and participatory alternatives. So, by the same reasoning, alternative ways of doing technology might lead to alternative futures. When we ask what a desired future might look like we are fundamentally asking a design question. Arguing that design is the first tradition aimed at shaping intentional change, Nelson and Stolterman have this to say: "Design is the ability to imagine that-which-does-not-yet-exist, to make it appear in concrete form as a new, purposeful addition to the real world" (Nelson et Stolterman, 2012, pg. 12). Herbert Simon suggests that the designer "is concerned with how things ought to be - *how they ought to be in order to attain goals*" (Simon, 1996, p. 4) (my emphasis in italics). Understood this way, design is about imagining preferred states and bringing these desired states into being. It is a normative position which is both creative and intentional and therefore the outcomes of a design process are far from neutral.

This perspective of design aligns with the position I have outlined in the first chapter of this thesis: technology is not neutral, rather it must be understood as a manifestation of the values and objectives of those who create it. The following statement by Winograd and Flores (2008) captures this tension beautifully: "we encounter the deep question of design when we recognize that in designing tools, we are designing ways of being" (p. xi). In other words, designers of technologies shape not only artifacts, but tools which will themselves shape environments and social norms, which in turn shape the designer!

We have touched-on this theme of feedback loops and vicious cycles in the previous chapter on digital technologies in agriculture. But my intent here is not to suggest that designers developing tools for AG 4.0 are somehow intentionally concealing their objectives. Rather, my objective is to highlight how a common-sense view of technology perpetuates assumptions about how things ought to be; how an uncritical approach to designing leads us towards reinforcing the status quo. If a critical perspective of technology opens the black box to reveal the intent of designers, a design perspective might also help us move beyond the critique to imagine how things could be.

2.5 Stumbling into design

Years ago, when I was discussing the grassroots network La CAPÉ with a colleague, I was asked to describe what made the group network innovative. The question forced me to reconsider the process and reflect on my experience as both a participant and observer. Having grown accustomed to sketching out ideas as part of my approach to making tools I jotted down what I understood at that time to be the process of the Autoconstruction group (see Figure 2.1 below). The word Autoconstruction here translates literally to Do-it-yourself, or self-fabrication, and *le Groupe d'Autoconstruction* is a working group within the CAPÉ. At the time that I created the schema, I had already begun shifting my focus away from the tools the network was producing to trying to understand the broader processes that were emerging around this production model.

For many years the diagram sat above my desk and while I continued collaborate with the network, it was not until 2020, when I returned to school to explore the processes from a design perspective, that I revisited this schema. In examining the simple sketch, I was surprised to see how much I had captured in a quick diagram. With no prior formal design training, the immersion in an intensive design curriculum left me with a realization: I had always been doing this, but I had never had the vocabulary to describe what 'this' was.

In *Design When Everyone Designs* Manzini (2015) argues that the crises of our time require the design of radical alternatives if we are to transition towards a sustainable future. Making the case for design as a catalyst for social innovation, Manzini, like other transition design scholars (Gaziulusoy et E. Oztekin, 2019 ; IIT Institute of Design, 2019 ; Manzini, 2015), suggests that the role of the designer has been shifting with the democratization of design tools and new forms of organization. He argues that, given the scope and magnitude of the problems we face, we must all become designers. Indeed, Manzini goes further, suggesting that design is close to an inherent instinct. He puts it this way: "when confronted with new problems, human beings tend to use their innate creativity and design capacity to invent and realize something new: they innovate" (2015 pg. 9). This echoes what Nelson and Stottelman are suggesting when they argue that design is the first tradition. "Design," they say, "is a natural and ancient human ability— the first tradition among many traditions of human inquiry and action. Everyone is designing most of the time— whether they are conscious of it, or not" (2015, pg. 1).

What then is this new role for the designer that Manzini is referring to? And if we (re: humans writ large) have always had the capacity to design, how have we ended up designing ourselves into a world of wicked problems (Churchman, 1967)? We will, in the course of this literature review, return to the questions of the role of the expert designer in a rapidly changing world and how we might rediscover our own innate capacity for design - but first a brief survey of the contemporary history of design will help us understand how we got here and where we might be headed.

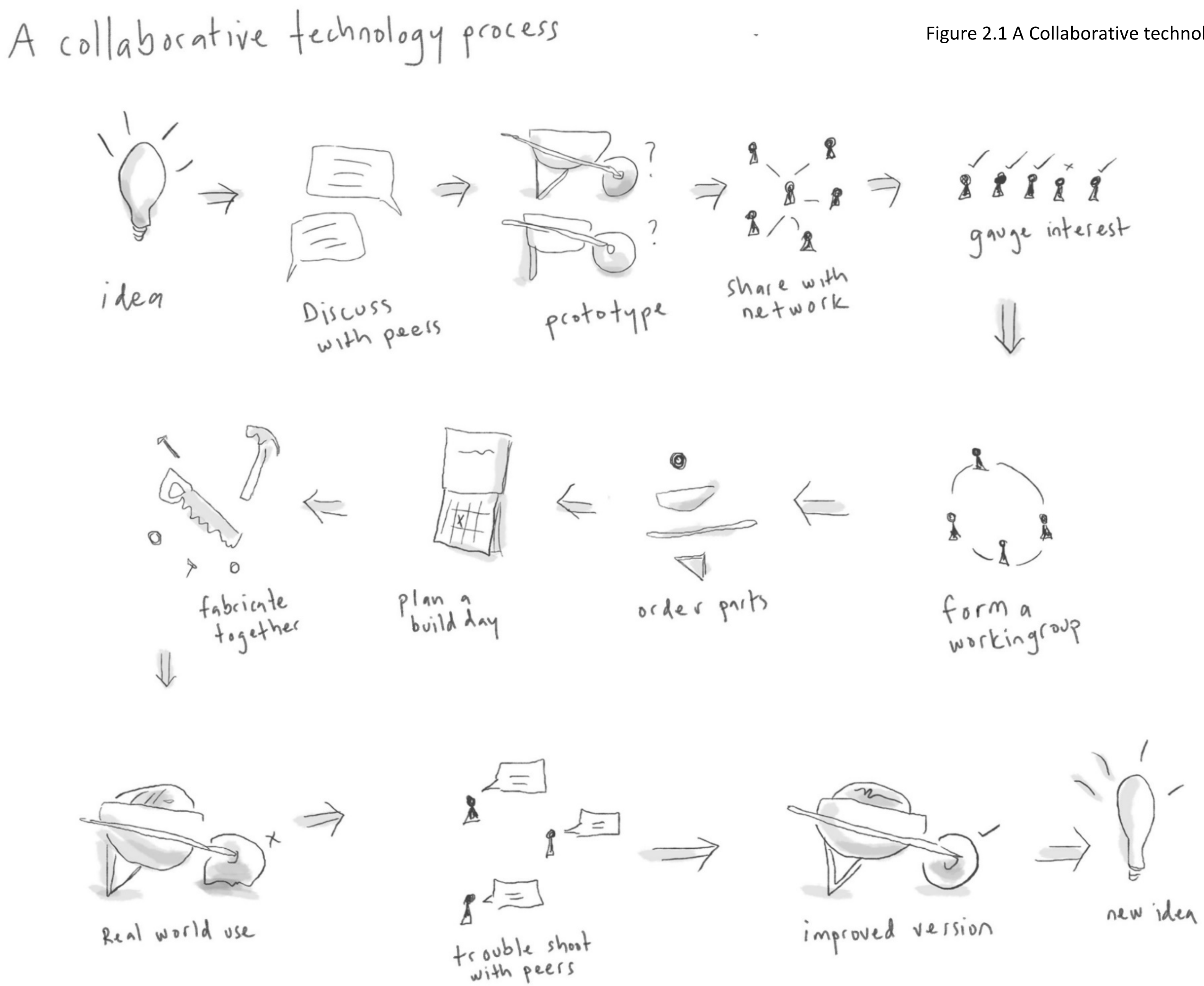


Figure 2.1 A Collaborative technology process

2.6 Design and industrialization

How did design go from an intuitive, instinctual process to encompasses a range formal discipline, spanning the object to the built environment? In his expansive history on the subject, Margolin (2015), makes a distinction between the longstanding human practice of design with lower case d, and design with a capital D, which he associates with formalization that emerged with industrialization (Heller, 2015) Indeed the word 'design' only entered popular lexicon when what was known as the decorative arts met industry (Vial, 2014).

Ferebee and Byles (2011) suggest that industrial design evolved in three distinct but overlapping phases: the Victorian Decorative Arts, Art Nouveau, and Modernism. The formalization of design emerged not as logical conclusion of industrial technology but a series of critical movements that grew in response to the rapidly changing social, economic and political landscape beginning in the mid 1700's. The process of land enclosures and displacement of farmers across the rural regions of England and the parallel growth of factories in cities like London drove unprecedented migration to urban centers. From agriculture to the cottage industries, the advent of steam power dramatically shifted labour relations. What was formerly done by craftsmen working in guilds could now be accomplished at an expedited rate with less skilled labourers. The shifting labour practices and the new productive capabilities drove both new supply and demand for industrially produced goods.

Beginning in the mid 1800's, the start of the Victorian Era, mass production of household goods, from kettles to furniture, were becoming available to the growing labour class. The shift from craftspeople conceiving of and producing goods to a division of labour, marked the beginning of design as a distinct vocation. The Victorian Decorative Arts era is considered to be more of a precursor to design as it was characterized as a period that aimed to reproduce older styles for mass consumption - with draftsmen copying traditional motifs and patterns to be produced by industrial machines. At the height of the Victorian Era, Britain would organize the Great Exhibition in London, the first World's Fair, to showcase the nation's ingenuity and the productive capabilities of the industrial age. The Great Exhibition was hosted in a purpose-built venue a cast steel and glass structure called the Crystal Palace, which was itself a testament to the power of industrial technologies. Despite the perceived significance of the Great Exhibition as a testament of industrialization and progress, it did not garner universal acclaim (Ferebee et Byles, 2011). At the time there was a group known as the Reformists that were critical of the poor working conditions of factory workers and highlighted the degradation of quality and beauty of industrial goods. The reformists highlighted the lack of cohesion between the ornamentation of these goods and the way in which they were produced.

This critique would be further advanced by writer and philosopher John Ruskin. Like the Reformists, Ruskin argued that the designer must be connected to his production. For Ruskin, the industrial production led to the loss of traditional skill and craft. Ruskin's work would be influential on the Arts and Crafts movement that grew out of this critique of the separation of craft and production. William Morris, perhaps one of the best-known figures of the movement, advocated for designers to be engaged in the production process, calling for a renewal of handicraft. Like Ruskin, Morris decried industrial manufacturing replacing skilled workers and producing cheap imitative goods.

Perhaps the best-known evolution of the Arts and Craft philosophy was captured in what would come to be known as the Art Nouveau. Varying stylistically, this international movement drew heavily on the Arts and Crafts ideals and aimed to bring beauty and art to society at large. The movement sought to break down the distinction between fine and decorative arts and decried the poor quality and tired historicism of mass production (Raizman, 2010). Despite this shared philosophy of uniting art with craft, Art Nouveau designers began to incorporate industrial materials, like glass, reinforced concrete, cast iron and steel into their works. These materials created new avenues for design. Art Nouveau marked a shift from the reproduction of old motifs that characterized the Victorian Era, to a vibrant movement that emphasized organic, serpentine lines and nature inspired motifs. While France and Belgium were the epicenter of Art Nouveau, the movement drew heavily on both regional and international traditions as it spread across Europe, from 1890 to its abrupt ending at the beginning of the First World War in 1914.

The ideas of marrying art and craft with emerging technical capabilities would find their true potential in the Constructivist and Modern Design movements that were beginning to take root in the lead up to the First World War. Just as Art Nouveau pushed past the boundaries of Arts and Crafts, to explore new industrial materials, at the turn of the 20th century designers in Europe, like the German Werkbund, were beginning to explore the potential of industrial production techniques. The Werkbund was supported by the German state in efforts to improve the country's competitiveness and early on it sought to move toward a more sober approach to ornamentation than Art Nouveau. Peter Behrens, a founder of the Werkbund, is largely considered to be the first industrial designer. Behrens' logo, product design, and graphic treatment of the German electric company AEG signaled a precursor to the cohesive vision for a unified design that would come to typify modernism (Ferebee et Byles, 2011). Indeed, Walter Gropius, who worked with Behrens, would go on to found and direct the Bauhaus, a major influence on Modern design.

The vision for the Bauhaus school was to bring the arts, design, and architecture together to train designers that could work from the object to the built environment. It had antecedents in both the Arts and Crafts and Art Nouveau philosophies and during the early years of the school, Gropius and the instructors emphasized the importance of craft. Over time, however, Bauhaus shifted from this craft focus, bringing in instructors aligned with Constructivist movements that emphasized the need to master industrial production techniques and new materials (Raizman, 2010). The potential of mechanization and standardization aligned with a vision of progressive design that used the power of mass production to transform society. "Industrial design," says Raizman (2003), "emerged as a theoretical attitude appropriate to a new, universal, egalitarian state in which artists directed their energies to meeting the perceived, minimum needs of mass society"(pg. 236). The relocation of the Bauhaus from Weimar to the industrial city of Dessau in 1926 firmly rooted it in the emerging International Style and what would come to be known as modernism.

In the aftermath of the First World War, industrial design took on different meanings on the two sides of the Atlantic (Raizman 2003). Devastated by the damage wrought by the War, in Europe there was an urgent need for reconstruction and the proponents of the International Style turned their efforts to reimagining how design and industry could transform society for the better. In Europe, the interwar period was marked by a radical experimentation with new materials and advancement in mass production techniques that were harnessed to address issues like social housing.

In the US, which avoided direct conflict on its own soil, industrial production of consumer goods was fueled by the emerging advertising industry and the growing middle class. Speaking of this period, Raizman (2003) says: "The culmination of these efforts was the 1939 New York World's Fair and its vision of a single clean, rational, streamlined "world of tomorrow" offering a steady flow of new products and gadgets that demonstrate the relationship between new technology and the improvement of the quality of life for all" (pg. 237) Just as the Grand Exhibition in England marked the start of the industrial era, the World's Fair in New York signaled a new vision for the modern industrial society.

Following the post-war boom-era the unintended effects of industrialization were beginning to make themselves known, underlining a deeper crisis in modernity. By the end of the Second World War, the egalitarian visions that had driven early modern design were slowly supplanted by an emphasis on individualism, consumption, and leisure. The technology and means of production that had been geared toward fighting the war had been turned towards mass consumer goods (Papanek, 2009).

2.7 Design and democracy

By the 1960's, the rampant consumption driven by industrial design faced mounting critiques as designers like Victor Papanek challenged Western development strategies aimed at the Global South (Papanek, 2009). Papanek suggested that modern design mostly produced useless objects that are marketed to consumers to meet useless needs. In contrast, he proposed that design should aim to satisfy essential needs. Papanek's work in developing countries and his focus on working with traditionally underrepresented communities (such as: the disabled, elderly, and children) led him to emphasize the social imperatives of design, challenging the notion of global (i.e., dominant Western) solutions to local problems. Papanek called for an approach to design that included the participation of experts from multiple disciplines as well as users and communities. Along with this collaborative approach, Papanek was an early advocate for an end to proprietary design and patents, emphasizing that shared knowledge and ideas were crucial to overcoming complex problems.

Across design disciplines, the changing social and political climate during the 1960' sparked radical approaches which emphasized democratic forms of design. In Scandinavia, the threat of computer automation in the workplace brought workers, designers, and researchers together to prototype democratic and participatory forms of design (Ehn *et al.*, 2014). Worth noting as well are the parallel alternative movements that were cropping up in different domains. For example, economist E.F Schumacher Small is Beautiful (Schumacher, 1993) set in motion what would become the Appropriate technology movement (Pursell, 1993), with strong parallels to Papanek's work and the participatory design research. The While each of these movements emerged in different contexts, they were responding to the downstream issues stemming from industrialization.

For proponents of participatory design, practicing prototyping with workers was a way to build both alternative designs as well reinforce social cohesion. Speaking of the power of practice and participatory design, Pelle Ehn, a leading figure of the early movement, put it this way, "Through practice we produce the world, both the world of objects and our knowledge about this world. Practice is both action and reflection. But practice is also a social activity; it is produced in cooperation with others" (Ehn, 1993, pg. 118). He goes on to say:

> "However, this production of the world and our understanding of it takes place in an already existing world. The world is also a product of former practice. Hence, as a part of practice, knowledge has to be understood socially - a producing or reproducing social process and structures as well as being a product of it" (Ibid).

Ehn captures beautifully in this quotation the structuring effect of practicing design and how the designed world both shapes and is shaped by us. In the context of workers being replaced by computer automation, participatory design was understood as a way to not only challenge this reality but enable impacted communities to build their own alternatives together.

2.8 Design for sustainability

In parallel to this turn towards a socially motivated design, the growing awareness of human impact on the environment also began to influence designers. Buckminster Fuller, a contemporary and friend of Papanek, called attention to the finite nature of the planet, perhaps best summarized by the title of his short book a *Manual for Spaceship Earth* (Fuller et Snyder, 2008). This spaceship metaphor proved a powerful galvanizing image in design, even if the technically inclined Fuller was known to butt heads with Papanek who emphasized a less technologically oriented approach. Indeed, outer space was an important theme for the global collective at the time, and Kazazian (2003) has suggested that the first image of the earth taken from space changed our relationship to the planet - giving us a new perspective of our roles and our capacity to alter our environment.

Through technology, science and design, modernity had proudly proclaimed this capacity to shape the environment and society. As the motto from 1933 World's Fair in Chicago stated: "Science Finds, Industry Applies, Man conforms." But as these domains began to sense the previously ignored consequences of industrial actions on the planet and society, the realization that there is no getting off the spaceship started to sink in. The intractability of intersecting global challenges led design theorist Horst Rittel to dub them wicked problems (Churchman, 1967), suggesting that there was no clear cut, single solution that could solve them. In 1972, Donella Meadows, with the Club of Rome, published *Limits to Growth* (Meadows *et* *al.*, 2004), one of the first scientific publications that looked at the impact of humans on the interconnected systems of the earth. The release of the UN's Brundtland report in 1987 (Brundtland, 1987) drove these messages home, and sustainability increasingly became a rallying point among different actors within design, science, policy, public, and private spheres (Vaillancourt, 1998). Given the urgency of these crises, Ceschin and Gaziulusoy (2016) suggested sustainability must in fact be a central objective for all design disciplines.

The different approaches to sustainability in design are typically grouped into the field of Design for Sustainability (DfS) (Vezzoli *et al.*, 2018). While early DfS proponents focused on resource use, life cycles (McDonough et Braungart, 2002), and green products, the scale and complexity of wicked problems has highlighted the need for designers to take a systems-level approach to support transitions to sustainability (Irwin, 2015). Ceschin and Gaziulusoy (2016) highlight three overarching tendencies in the evolution of DfS: a shift away from technocentric to human-centered design; an expanded notion of sustainability (i.e., beyond the environment); and a widening of the design scope from products to entire systems. This emerging field of design practice and research, which explores the role of design in supporting systems level change, is called alternately Transitions Design (Irwin, 2015 ; Tonkinwise *et al.*, s. d.) and Design for Sustainability Transitions (DfST) (Gaziulusoy et E. Oztekin, 2019).

2.9 Designing for transitions

> "The background to the book is the great transition: a process of change in which humanity is beginning to come to terms with the limits of the planet, and which is also leading us to make better use of the connectivity that is available to us: a dual dynamic merging into a single process in which we can already see certain characteristics. Starting with these it is possible to outline a design scenario built on a culture that joins the local with the global (cosmopolitan localism), and a resilient infrastructure capable of requalifying work and bringing production closer to consumption (distributed systems)." (Manzini, 2015, p. 2)

The theme of transitions has found its way into design through a series of interconnected movements and research initiatives aimed at responding to the current unsustainability of industrial society (Escobar, 2018). The Great Transition, that Manzini refers to in the above quotation, draws on the work of the Global Scenarios Group (Raskin et Tellus Institute, 2016) which proposes that humanity has gone through a series of major transitions throughout our history. We are now at the crossroads of a global great transition. Our actions today, the authors suggest, can transition us towards an ecologically grounded, sustainable society or towards escalating crisis, inequality, and environmental catastrophe (Ibid). Transitions Design has equally been influenced by grassroots organizing, like the Transitions Towns movement, an international network of villages, cities, and towns that aim to reduce dependence on fossil fuels through promoting localized solutions and direct action (Hopkins, 2008).

The fact that the great transition has been so embraced by design theorists speaks to something that is at the heart of this thesis and design itself: design is an explicit preferred state - a proposition for the way things ought to be. This represents something of a discontinuity with essentialized and deterministic views of technology, along with ideas of progress and modernity which naturalize the dominant worldview and obscure (and absolve us of) our responsibility for individual and collective action. If technology has set in motion an inescapable trajectory, what does it matter what we do? In contrast, to take a design orientation is to accept that our actions are shaped by and shape our environments, and therefore our intentions and objectives inevitably shape worlds (Escobar, 2018).

Design is a normative discipline (Stegall, 2006) where designers make ethical choices for what is desirable and undesirable. Echoing Papanek, Manzini (2003). argues that design must be aimed at trying to improve well-being and to do this we need to ensure we have a sustainable vision of what it means to live well. More than just switching products, Manzini (2015) suggests this requires socially innovative behavior. He notes that designers must draw inspiration from existing groups which have developed socially innovative practices and find ways to foster this through design work. As design becomes more 'diffuse,' that is, as it moves beyond the domain of experts, the role of the professional designer is also shifting. Speaking of the distinction between diffuse design and expert design, Manzini suggests that "the role of design experts is to conceive and enhance a multiplicity of design initiatives to be promoted at the different nodes of the designing network. These design initiatives are a coherent sequence of design actions geared to triggering and supporting a co-design process" (2015, pg. 52). Elaborating on this statement, he suggests this might entail: "carrying out and communicating ethnographic analysis; effectively mapping the physical and social resources in a particular area; creating communicative artifacts geared to fueling conversation about the future that foster choices between alternatives; creating a prototype or pilot to make an opportunity tangible to wider audiences" (Ibid, pg. 52). In essence, design for social innovation shifts the lens away from technical artifacts to designing for novel social practices.

2.10 Design at the systems level

Despite the shift away from technological solutionism in contemporary design movements, technology nonetheless plays an important role in Transitions Design - we are, after all, entangled in socio-technical systems (Geels, 2010). As Science and Technology Studies underscores, society and technology are mutually constituted (Pinch et Bijker, 1984). TD research is aimed at understanding how to enact transitions from current environmentally destructive and unjust socio-technical systems to sustainable systems (Tonkinwise *et al.*, s. d.). However, the difficulty with achieving this kind of structural change is that unsustainable systems are perpetuated through 'lock-in' infrastructures, technologies, and investments that are reinforced through industry practices, consumer behaviours, and policies (Geels, 2011). Consequently, the core analytical puzzle for sustainable transition researchers, according to Geels, is to "understand how environmental innovations emerge and how these can replace, transform or reconfigure existing systems'' (Geels, 2011, p.25).

While we can see in this evolution of design how the discipline has enlarged its scope of action - from early systems thinkers to present day transition design - the question remains: how exactly can one enact change at a systems level? Beyond the design disciplines, Transitions Design draws on insight from the fields of Transitions Studies and Sustainability Studies (see Geels and Raven) to help conceptualize systems change frameworks (Gaziulusoy et Brezet, 2015). A particularly useful heuristic employed in TD is the Multi-Level-Perspective (MLP) framework, adapted by Geels (2005). The MLP is an analytical frame that conceptualizes socio-technical transitions as non-linear, multi-level processes where incremental niche level innovation can shift, and eventually replace, dominant systems over time (Raven *et al.*, 2010). This approach stands in contrast to linear conceptions of innovation which purport that technologies follow a predictable route, from research to conception to adoption by user groups. Instead, the MLP attempts to outline socio-technical transitions which are catalyzed by radical innovation that deviates from dominant practices and technologies (Geels, 2005). While a full treatment of this literature is beyond the scope of this thesis, it is worth briefly noting here as we conceptualize the potential of grassroots innovation happening in agricultural technology networks.

For example, TD scholars emphasize how grassroots (i.e., niche level) innovation can put pressure on entrenched socio-technical systems (i.e., regimes) and how crises can open windows of opportunity for emerging innovations to replace or reconfigure dominant systems (Ceschin et Gaziulusoy, 2016). The point of intervention for transition designers is this niche level, where practitioners can support innovative groups and networks through various design tactics. For example, Ceschin (2014) outlines a form of strategic niche management to catalyze radical innovation. Other researchers point to design-oriented scenarios as a way to embed sustainability objectives in innovation work to foster transition pathways (Ceschin et Gaziulusoy, 2016).

Despite its utility as a heuristic, the MLP, along with other systems level design frameworks, have been critiqued for being overly theoretical. This is also a valid concern for this research project which straddles theoretical propositions of systems change with the tangible, small-scale actions of grassroots innovators and networks that are less focused on transforming the system than they are on addressing everyday challenges. It is also particularly relevant when we consider that grassroots innovation often emerges within groups that are far removed conventional power structures and, therefore, their capacity to effect policy change or influence decision makers at a structural level is already low. Responding to some of these issues of high-level systems change frameworks, Escobar (2018) contributes to transitions design through outlining a perspective of design rooted in embodied practice, emphasizing the interrelation between personal change and systemic transformation. Echoing our earlier definition of design as the practice of enacting desired change in the world, Escobar calls for an ontologically oriented, autonomous design aimed at bringing forth new worlds through direct participation.

2.11 Ontological and autonomous design: bringing us back to the potential of the here and now

> "The "abstract reasoning" account of knowledge leaves out of the picture a hugely important feature of knowledge production that design thinking does not: the fact that creation is always emergent, in the two registers of emergence: self-organized and other-organized, the latter qualifier meaning that the scholar/designer also lays down elements and makes decisions that enable the self-organizing dynamic to take off and do its thing." (Escobar, 2018, pg. XV)

Arturo Escobar's *Designs for the Pluriverse* (2018) engages with the Transitions Design literature adding an emphasis for design practice grounded in direct experience and relationality. The books subtitle: *Radical Interdependence, Autonomy, and the Making of Worlds* captures the core of what Escobar calls autonomous design. For Escobar, autonomy does not connote 'going it alone,' or a kind of rugged individualism, but the notion of sovereignty which emerged from Indigenous movements in Latin America that are fighting for the right to self-determination and the concept of *autopoiesis*: the self assembling of natural systems. In line with this idea of autonomy, Escobar suggests that design is ontological. Recalling the work of Winograd and Flores, he states "in designing tools, we (humans) design the conditions of our existence and, in turn, the conditions of our designing. We design tools, and these tools design us back," (Escobar, 2018, p. 110). *Autonomous design,* then*,* is about the rights of individuals and communities to co-create the worlds they desire, acting with the explicit understanding that the things we create also shape us. Escobar effectively illustrates this point by contrasting the *Maloca,* the longhouse used by Amazonian Indigenous communities, with the architecture of the prototypical suburban home. He suggests the *Maloca,* a kind of collective housing, engenders a relational and interdependent community, in comparison to the 'atomized' and 'de-communalized' nuclear family units that constitute Western, suburban life.

Fundamentally, Escobar is underscoring the power of design, and hence designers, in shaping both our world and our behaviours. In this sense, he acknowledges how effective modernist schemes have been in locking us into dominant systems and ways of being. Tracking back through cartesian rationalism, colonialism, imperialism, and modernism, Escobar suggests that these 'onto-epistemes' have been premised on a 'one-world world,' which simultaneously eradicate alternative ways of knowing and being. This is, according to Escobar, a kind of 'defuturing,' which locks in unsustainable systems and infrastructures that increasingly jeopardize the very possibility of a future. As design scholar Terry Fry puts it: "[modernity] did not just take the future away from the peoples it damaged and exploited but set a process in motion that negated the future, and defutured both the born and the unborn" (Fry, 2017, pg. 6).

In response to this, autonomous design takes seriously the Zapatista movements call for a 'world where many worlds fit.' These worlds co-arise through the mutual shaping between us (humans) and the environments (including the other-than-human beings) and tools we create. Therefore, the future is not something we plan for and anticipate but a reality we enact in the here and now. This orientation towards direct action, or the capacity to enact alternative worlds through practicing alternative ways of 'being-knowing-doing,' is at the center of Escobar's autonomous design. The world does not exist out there, apart from us, but is created through our engagement with it, and thus the future is emergent, interdependent, and unraveling in response to the actions and dynamic processes of everyday life.

2.12 Individual, community, and systemic transformation: connecting personal action and systems change

The emphasis on enacting alternative worlds through practice has much in common with what Jégou (2008) has called 'everyday life projects,' in his research on design for social innovation. In this work he emphasizes the transformative potential of communities practicing alternative behaviors in their quotidian life. From organizing ridesharing, to Community Supported Agriculture, Jégou suggests that these practices can shift groups, and indeed society, out of current unsustainable behaviours. Accordingly, design for social innovation is about finding ways to spark and foster these kinds of experimental, grassroots approaches to sustainability with the aim of connecting them to broader movements. What is important for Jégou, like transitions designers, is the connections and relationships between the different levels in which we engage - from the individual, the community or network, to that of a system. Distinguishing between these scales, Manzini (2015) suggests that where socially innovative local initiatives aim to address concrete, tangible issues, 'framework projects' are aimed at coordinating, networking, and enhancing these kinds of solutions in order to enact transformation at the level of socio-technical systems.

Such successful framework projects require establishing supportive environments and the designer here must work across the different levels to help foster enabling ecosystems, or what Manzini (2015) describes as 'infrastructure' that goes beyond single design projects and initiatives. Here Manzini draws on the participatory design scholarship, in particular the idea of 'infrastructuring,' or the process of establishing favourable conditions in which innovation can emerge. Infrastructure here does not so much denote the physical things, as it does the less tangible relations and resources that are built over an extended period of time and become vital in enabling an innovation ecosystem (Ehn *et al.*, 2014). In this sense, we can also understand how specific design projects (i.e., a local ride sharing initiative, a CSA farm) also contribute to building this broader infrastructure through expanding resources and fostering relationships. Hence a systemic view of interrelated projects, networks, and relationships is a key element for both design for social innovation and transitions design, as there is a feedback mechanism established between the collective local projects and the broader framework projects which feed into one another.

Transitions scholars have likened the heterogenous sociotechnical systems to emergent assemblages, and in designing with and for these dynamic systems, we must understand how a change in one part can affect the whole. Indeed, the theory of assemblage has become a useful framework for scholars exploring emerging self-organizing structures both in nature and human organization patterns, particularly in regard to the rise of networks (Johnson, 2004). DeLanda (2019), for example, has likened a nation state to an assemblage of smaller autonomous, but interrelated parts – from the neighbourhood and townships to the cities and the state. In an emergent system, the sum is greater than the parts. In the case of networks, the assemblage expresses a collective intelligence. What's more, assemblages are not locked into a specific arrangement but can reconfigure and adapt as the system changes. While assemblage theory proves to be another useful heuristic, as the wide-ranging work of Escobar makes clear, it is important to strike a balance between the theoretical and grounded action.

2.13 Summarizing what we've discussed and how it applies to this research project

This review of the literature has attempted to establish an understanding of design as the capacity to imagine and enact desired changes in the world – while recognizing the implications that our actions and designs both shape and are shaped by our environments. When it comes to questions of agricultural innovation, a design perspective which is informed by the critical scholarship provides a novel lens as it acknowledges that technology is not neutral but a product of the values, objectives, and visions of those who create it. Thus, the act of designing always has a political dimension and through it we can move beyond critiquing dominant technologies, to enacting forms of innovation that support alternative ways of being and knowing. To design then, is to both imagine and bring another world into being.

Practically speaking, what does this mean for this research project, which is centered on grassroots agricultural innovation networks? If the digital future outlined by proponents of AG 4.0 is not inevitable what other futures might be possible? Drawing on the ideas emanating from transitions design, design for social innovation, autonomous design, this research explores the novel practices emerging within small-scale farmer-led innovation groups in Quebec with a focus on understanding the potential for this kind of social innovation to spread beyond individuals and networks.

Thus, in regard to grassroots agricultural innovation networks, a design perspective must not be limited to the 'plans' or 'open-source designs.' Nor should it be purely theoretical. Design is informed by the motives and desires of tool producers and therefore has much broader implications – it offers us a way to understand how these networks see the world because, as I show in the following chapters, the kinds of future they want are embedded processes that they enact. In other words, my focus is not so much the things (i.e., the designs) that are being produced by these networks as it is the way in which members set about bringing things into existence (i.e., the designing) and how this process reinforces and expands the potential of the network itself. This line of inquiry is animated by three questions.

1. What are the novel design practices emerging within grassroots agricultural innovation networks?
2. What are the merits of this approach and how can we gauge its success?
3. How can we understand the broader potential of this approach?

CHAPITRE 3
Research Design and Methodology

3.1 Introduction

While the bulk of the research and writing for this thesis took place between 2020 - 2022, my relation to the themes of technology, innovation, and the environment stem from personal experience as a farmer. I first began to consider questions of the role of technology in agriculture when I began my farming career as an idealistic 'greenhorn' around 2011. Inspired by the works of Helen and Scott Nearing, Wendell Berry, and other agrarian writers, I was often caught between a nostalgia for the simple, pastoral world of which they wrote and the realities of managing a market garden with very real make or break profit margins. The scale of the farm, the ever-present financial pressures, and my own interest in emulating the back to the land scrappiness of my favourite thinkers of the time, led to an ongoing interest in solving problems through creative, DIY solutions.

During those years I was also surrounded by practitioners working in food justice movements, many of whom who were modeling new forms of organizing in response to the fragmented food system. From 2012-2016 I worked at Santropol Roulant, a Montreal based community food organization that focuses on grassroots solutions to food security and mobility issues in the city. The organization's core work is preparing and distributing meals-on-wheel to people living with a loss of autonomy. Building on the vision of closing the loop between food production and distribution, in 2012 I co-founded the Santropol Roulant Farm on a nature reserve in the city of Montreal. Along with meals on wheels and farming programming, the organization also serves as an incubator for community-led initiatives like urban fruit tree gleaning, mushroom cultivation, and urban bee keeping.

As I transitioned away from managing the farm, my interest in small-scale agricultural technology began to take a more prevalent role in my life. In 2016, I decided to leave the farm and entered a more reflective period, writing about my observations of emerging technologies in the agriculture movements in which I was active. Following an independent research project in 2016-2017, I decided to return to formal studies to complete an honours degree in Anthropology. That project focused on the intersection of the commons and the emerging agricultural networks developing open-source technologies.

As I considered graduate programs, I knew I wanted to shift from a purely academic focus. Beyond research, I was looking for a way to engage my experience as a designer and producer of technology. This is what attracted me to continue exploring this research through the graduate design program at UQAM. It is in this spirit that this research was conducted and as such it reflects my background in anthropology and my experience as a designer through incorporating the methodologies of research-through-design and ethnography.

In section 3.2 I introduce the concept of design ethnography and explore how it relates to research through design methods. In section 3.3 I focus on a research-through-design method that has been integral to this project: the diagram. The fourth section breaks down the research design and structure of this thesis. Here I focus on how data from coursework and ateliers informed the early development of the thesis. I then turn to how I planned and conducted the field research and analysis. Section 3.5 speaks to ethical considerations of this research. Section 3.7 offers some final thoughts and notes on writing style.

3.2 Design ethnography as research through design

In approaching research for this project my instinct was to lean into the ethnographic training I had received during undergraduate studies. My reason for this was two-fold. First of all, as a reader I have always connected with the narrative style that is unique to ethnographic research. Stories stick with me more than figures and statistics. The second reason I opted for ethnography as a methodology is based on the depth of relationship I have with my subject of research. I have been engaged in alternative agricultural technology movements for the last ten years – alternating between the different roles of participant, researcher, and documentarian. While this offered a unique window into the movement, my proximity to the research also posed significant challenges. How could I overcome engrained perspectives and biases in order to see this work in from a new perspective? Is ethnography well suited to overcoming these blind spots? In the context of design research, can ethnography be an appropriate methodology?

"Outline of an inventory of strictly visible things" (Perec et Lowenthal, 2010). So begins George Perec's *An Attempt to Exhaust a Place in Paris*, where the author sets out to catalogue the details of a Paris street corner for three days. Perec takes the reader on a journey into the minutiae of daily life, describing faithfully his observations of the quotidian - a bus passing, a person crossing the road, a color, a loaf of bread. Speaking of this method he states:

> "How should we take account of, question, describe what happens every day and recurs every day: the banal, the quotidian, the obvious, the common, the ordinary, the *infraordinary*, the background noise, the habitual." (Perec, 1989)

Perec suggests that through a process of exhaustive inventorying of the common place, our relationship to what otherwise seems obvious begins to change. We begin to see the world we take for granted in a new light – or, as he writes from his street corner, we find ourselves in a foreign city. Perec's observations get to the heart of the ethnographic method, where the researcher embeds themselves within a place or community in order to uncover something new about that world (Pink *et al.*, 2022).

Developed as a research method in anthropology and sociology in the late nineteenth century, the root term ethnography is derived from the Greek meaning "description of a foreign people" (Müller, 2021). This interest in the 'foreign' was quite literal in early anthropology where western researchers focused on the 'other.' Most often this meant living within indigenous communities or cultures different to the researcher for extended periods. As a foreigner, the embedded researcher could observe the environment from a different (often colonial) perspective, exploring what otherwise seemed to be commonplace practices and beliefs to the local inhabitants.

Over time ethnography has shifted from this focus on the other to researchers questioning the engrained believes and values in their own communities and cultures (Pink *et al.*, 2022). To do this, the ethnographer must first challenge their own assumptions of the world. Second, they must observe their environment, community, place, or practice with an open curiosity. The goal is not to state what one knows, it is an attempt to describe what one observes and, through this process, begin to shift perspectives to see in a new light what was once obvious.

In this regard there is a common thread between design - which challenges the status quo through proposing alternatives - and ethnography - which aims to bring forward new ways of seeing. Speaking to ethnography as a method for design research, Müller (2021) suggests that the design project itself can be seen as form of ethnography. The designer is not simply trying to reproduce what they know but bring forth something new. Kenniff et Lévesque (2021) make a similar observation on the potential of the exhaustive inventory, *à la* George Perec, as a design methodology.

But even with this shared pursuit of creativity in ethnography and design, is the ethnographic method suitable for design research? What constitutes design research is an ongoing debate within design scholarship (Vial, Gauthier, Lechot Hirt). Broadly understood, research is a systematic inquiry into a specific subject with the goal of making that knowledge communicable (Nelson et Stolterman, 2012). Nelson and Stolterman have suggested that design is a unique discipline with a distinct form of knowledge and thus design research cannot rely on traditional scientific methodologies. Speaking to this challenge, Müller claims that the knowledge that most designers have is implicit, derived from an intuitive approach that is "guided by internalized experiential knowledge." So, the question is how to make implicit knowledge explicit. Findeli et Coste (2007) have suggested that design research can be distinguished by three categories:

1) Research for design
2) Research on design
3) Research through design

Research for design is best understood as the research a designer undertakes in relation to a specific design project. The objective of this approach is not so much to communicate design knowledge as it is to support the design process. Findelli and Coste argue that this form of research has 'no memory,' remaining locked in the experience and work of the designer.

Research on design is generally associated with design science movements that aim to bring legitimacy to design research. This approach incorporates traditional scientific methods of inquiry in an effort further design knowledge (Gauthier, 2015). Notably, proponents of research on design are critical of methodologies that incorporate design praxis into research. On the other hand, critics of research on design suggest that its reliance on scientific positivism means it cannot capture the creative nature of design. Design, they argue, does not happen in a linear or predictable fashion – it is, rather, a mix of art and technique (Léchot-Hirt, 2015).

Research through design offers an alternative to the positivistic design research, advocating instead for the unique processes and methodologies of design practice to be integrated into design research (Zimmerman *et al.*, 2010). This speaks to Nelson and Stottelman's argument that design is a distinct form of knowledge and in order to research it one requires an equally distinct methodological approach.

Research through design proposes that methodology can take the form of research-creation (Findeli et Coste, 2007), where knowledge and know-how are derived through design projects (Léchot-Hirt, 2015).

Where does this place ethnography within design research? According to Müller (2021), "Ethnography is a more complex, unstructured and chaotic process than scientific research" (pg. 3). Drawing on the work of Findelli (2004), Müller suggests that design ethnography is a form of project-led-research, stating: "the design ethnographer observes actions - and acts. They generate knowledge - through praxis" (Müller, 2021, pg. 25). In the tradition of research through design, design ethnography "not only investigates designed realities - it also brings them forth" (Ibid). Pink et al (2022) summarize design ethnography as “a blended practice and a continuous process of investigation, learning, experimentation, intervention and the imaginative and creative opening up of possibilities” (pg. 20).

Through ongoing feedback of observation, conversation and analysis, the ethnographer attempts to see in a new light what might otherwise seem to be a mundane practice or situation. This task is perhaps easier in the case where the ethnographer is researching a group, or culture with which they are not familiar. When researching a group in which you are a part, it becomes doubly important not to take practices, beliefs, and cultural norms as givens. Just as the ethnographer challenges their own preconceptions and ideas, the designer challenges obvious solutions or common-sense ways of seeing in order to arrive at novel propositions.

Yet, ethnography does not aim to be an objective description of reality. The anthropologist Clifford Geertz, known for popularizing the ‘thick description’ style of ethnography, has said that: “what we call our data are really our own constructions of other people’s constructions of what they and their compatriots are up to” (Geertz, 1973, pg. 9). In other words, ethnography is an interpretation. As such, the ethnographer must accept and acknowledge their subjective perspective. We may, through rigorous observation, begin to see things with new eyes - nonetheless we are bound by our own experience and cultural baggage. The same thing can be said about design – as designers we are conditioned by our backgrounds and experience. Ethnographic researchers have embraced the subjective nature of this methodology, pushing against the pressure to present findings as objective.

Speaking of the tendency to try to turn qualitative data into quantitative analysis, Müller states that “the resulting tables and pie charts may create the appearance of scientific objectivity, but it is precisely such approaches that lack an explorative engagement with the data” (2021, pg. 77). According to Müller the meaning of analysis is to “unbind” - where the researcher attempts to pry through the data to make new connections and reveal new insights. It is, thus, both a creative and interpretative endeavor.

While there are hazards to subjectivity in research, this methodological approach to ethnography embraces the creative tension inherent in qualitative research. Rather than obscuring or attempting to erase themselves from the process, the researcher situates their own positionality within the project and clarifies the perspective which they are bringing. Again, we see here the commonality between design ethnography and design practice – both are pushing against conventional views of how things are, working to unearth something new while acknowledging their own subjective experience within the process.

This perspective proves particularly pertinent when researching technology, a domain which is steeped in positivistic and objectivist language. Shifting our focus from the technological artifacts to the upstream design processes, we can examine how the values and objectives of those who make technologies play a significant role in the kinds of technology they produce. In other words, we can explore how a given technology is the result of a design process, not a natural, linear, or inevitable outcome.

3.3 Research through design and the diagram

> “ […] un diagramme ne fonctionne jamais pour représenter un monde objectivé ; au contraire il organise un nouveau type de réalité. Le diagramme n’est pas une science, il est toujours affaire de politique. Il n’est pas un sujet de l’histoire, ni qui surplombe l’histoire. Il fait de l’histoire en défaisant les réalités et les significations précédentes, constituant autant de points d’émergence ou de créationnisme, de conjonctions inattendues, de continuums improbables. Il double l’histoire avec un devenir.” (Deleuze, 2004, pg. 43)

> “[...] a diagram never functions to represent an objectified world; on the contrary, it organizes a new type of reality. The diagram is not a science, it is always a matter of politics. It is not a subject of history, nor does it overshadow history. It makes history by undoing realities and previous meanings, through constituting the many points of emergent creativity, of unexpected conjunctions, of improbable continuums. It doubles as history in the process of becoming.” (Deleuze, 2004, pg. 43).

As this project is focused on the design of a specific type of *knowledge* and know-*how,* I have approached this work through a research through design methodology. Diagrams have been fundamental to this process, serving as both exploratory and analytical tools. But what exactly do I mean by the diagram? Zdebek suggests that the diagram “does not represent, but rather maps out possibilities prior to their appearance” (Zdebik, 2012). Linking the diagram to design and architectural practice (Bosco e Silva *et al.*, 2014) put it this way: “More than expose, the diagram simulates creativity; more than “explain” situations, it presents possibilities” (pg. 489). As the introductory quote from Deleuze (2004) suggests, the diagram should be seen as generative.

In his research on reflective practice, Schön (2017) outlines an example of how the diagram is a creative extension of the designer by observing an architecture professor and a student drawing a plan. They interact with spoken words and with pen gestures on the page. In this interaction, the student is stuck on a particular problem and the professor makes a mark to represent a possible change in the building’s structure. The student responds to this move and makes a new gesture. So, the process is a generative dialogue, or what Schön has called 'conversations in action.'

This notion of a conversation captures my own process as a designer. In my work, a pen, paper, and the diagram serve as a method to externalize and work through otherwise abstract ideas. The diagram exists between a thought and something tangible. The pen and paper become tools for sparking a dialogue and puzzling through an otherwise intangible question. The diagram presented in chapter two is an excellent case in point. In attempting to articulate the innovative process emerging in the CAPÉ I started working it out on paper. I did not necessarily know what I was trying to draw when I began. But as I worked through the diagram, I uncovered things I had not previously considered. This new information then fed back into making changes to the diagram.

Throughout this research the diagram is used in this way as part of what I have called *design explorations*. Each of these projects have tackled a particular aspect of research and, while discreet in scope, all the explorations build on one another. As with the example of the diagram in chapter two, it is not about communicating something that is known but revealing something unexpected, some new insight. In the context of this project, the focus is an organization with which I am intimately familiar and so the difficulty has not been describing what I know, but in challenging these familiar ideas and pushing my own understanding into new territory.

3.4 Research design and structure

3.4.1 Developing a proposal and preliminary data as part of the curriculum

In this section I outline how I set about researching this subject and how the methodologies described above supported this process. This research took place between 2020 and 2022. The coursework and ateliers undertaken in the first half of the program, from fall through winter 2020, provided a solid foundation for the initial research design. I conducted a literature review as part of course DES8001. This review provided a broad overview of the farm innovation landscape, allowing me to explore global peer to peer-based farm technology movements. Findings from this portion of the research had two significant impacts on the development of the project. The review became the basis for a successful funding proposal to the Social Science and Humanities Research Council (SSHRC). The second important outcome was my discovery of research on grassroots technology movements being conducted by the Peer to Peer Lab in Greece. This connected me to a trove of literature and ideas which helped focus the scope of my project. It also opened an opportunity to have a Thesis Advisor from outside of the design discipline, bringing a new set of expertise and perspective to the research

During the fall of 2020 design research methodologies were explored in the design course DES8003. These different methods were further elaborated through DES8005, a design atelier. This atelier emphasised a research through design methodology which permitted a series of explorations of the *Coopérative pour l'agriculture de proximité écologique* (CAPÉ), a cooperative of small-scale, organic farmers in Quebec. The bulk of the design explorations presented in this thesis evolved from these DES8005 ateliers. The projects undertaken during this course were instigated by the following research question: what are the processes that farmer-led networks have developed around technological innovation? Each subsequent phase of the atelier led to further elaboration and refinement of this question.

There are three distinct but overlapping design explorations presented in this research project. These explorations are at the end of each of the data chapters (chapters 4-6) and serve two important functions in this thesis. The first is to demonstrate the utility of the design process as a form of exploratory research. Employing a research through design methodology has allowed me to tackle the subject from different perspectives, unearthing ideas and concepts that would likely not have been discovered through a purely academic process. Drawing on Manzini's (2018) suggestion that design is sense-making, these explorations have been a way to visually make sense of complex concepts and implicit processes that are otherwise invisible. Secondly, these explorations also bring to life the data and ideas that emerge as part of the field work. In many cases the concluding design explorations serve as connecting points between chapters - a liaison that prepares the reader for some of the ideas to come.

The first design exploration takes the form of an inventory and is drawn from the actual archives of the CAPÉ. In the spirit of Perec, this exploration uses the inventory as a design project (Kenniff et Lévesque, 2021) and is presented in chapter four. The second design exploration builds on the first, taking the form of dynamic cartography. The objective of this project was to see how presenting the data through different mapping exercises might surface a *problematique*. The idea of a *problematique,* is not so much a 'problem' but point of departure for the research or a *piste de recherche.* This project is presented in chapter five. The third design exploration builds on the first two. This exploration was developed in parallel to Course DES8210, which aimed to ground the research in a theoretical framework. This course introduced the themes of emergence and assemblage as central concepts for this thesis, and this work is presented in the design exploration at the end of chapter six.

Chapter two of this project is based on a paper developed as part of Course 8200. The assignment for this paper was to develop a critique in relation to the research subject. The paper takes a broader view of innovation and technological development within the agricultural sector, and eventually became what is chapter two in this project. The chapter situates the research, providing context to help frame the *problematique* which emerges in chapter three.

I developed an initial research outline and method as part of course DES8210. That proposal outlined a research-intervention, calling for a series of prototypes, presentations, and feedback from research collaborators. In addition to the CAPÉ, this initial plan also included working with agricultural innovation networks based in the U.S. and France. As the research project evolved, the scope was deemed too much for the time and scale of this program and the decision was taken to limit it to the CAPÉ, in Quebec, and the research explorations discussed above.

3.4.2 Ethnographic field research

In June 2021 I began the ethnographic fieldwork, which continued up until December of 2022. Data collection methods consisted of participant observation, interviews, and archival research. My entry point to this topic begins with the network of colleagues and associates I developed through my years as a farmer and participant in these different groups. The main organizations that I worked for this research were the CAPÉ - a grassroots, farmer-led organization that advocates for small scale agriculture; the Réseau des joyeux maraîchère écologique (RJME) listserv - a knowledge exchange, information, and resource sharing platform used by members of the CAPÉ; and the *Autoconstruction* group, a working group within the CAPÉ that plans, organizes, and facilitates tool construction events.

During this research I attended three in person Autoconstruction events, volunteered on farms and at *corvées* (community workdays), and met up with farmers from around the province. Participant observation took place at: *ExpoChamp Bio* – A CAPÉ event hosted in both August of 2020 and August 2021; *la Rendezvous automnal* - an annual gathering, hosted by the CAPE in November of 2022; and visits to five different farms from the summer of 2021 to winter 2022.

At these events I engaged in group activities - from food preparation and clean up, to sharing meals and attending workshops. At all of the farms I visited I either volunteered or participated in a *corvée*. Typically, the morning would be dedicated to working alongside my collaborators, and the afternoon would be set aside for an interview. Research can often be perceived as extractive and participation in shared work was very important for me in establishing a reciprocal relationship with my collaborators. What's more, as this research highlights, these cooperative workspaces can facilitate dynamic exchanges that I believe would be impossible to simulate in a formal academic setting.

Despite best laid plans, I was often unable to do an interview on days that I participated on the farms or at events. When this happened, I followed up with participants by email and we conducted interviews over video chat. It is also worth noting that this research took place at the height of the COVID-19 pandemic, and in the early months it was unclear whether field work would even be possible. Fortunately, most of my research was possible in outdoor settings. In the end, half of the interviews happened online.

I conducted interviews with five farmers from different regions, each of whom were engaged with the work of the Autoconstruction group in varying capacities. Participants were contacted in advance and notified about the topic of the research. Each participant was sent a copy of the consent form, and before the interview I asked if there were any clarification or concerns to be addressed. As part of the ethics certification training, I developed an interview guide. However, the interviews were much less formal. After a few prepared questions the conversations evolved in a free, unstructured format.

All the interviews were recorded and transcribed using a digital recording app on my phone. The recordings were saved on the hard drive of a password protected computer. In addition to these digital recordings, I took extensive notes and photos over the course of the research. Before taking photos of people oral consent was established. In the end I opted not to include photos from this field work in order to minimize privacy issues.

3.4.3 Analysis

Analysis was ongoing throughout the project - beginning with the papers developed as part of the course work and the design projects developed through the ateliers. When it came to writing I followed a consistent approach. The day after a field visit, I would write an exhaustive catalogue of the day. Most of this writing was done in a single document in a freeform style that did not attempt any kind of structure or narrative cohesion.

In parallel to the fieldwork notes I was conducting a more focused literature review. The initial literature I had outlined as part of the coursework proved too theoretical and less grounded in design. I began reading extensively from the design literature and the notes from this work were added to the same word document where I kept my field notes. In the fall of 2021, I began trying to organize that document based on themes which had emerged in both the field work and the research. This was a mostly quick and intuitive process. I blocked together overlaps in field notes or emerging and added related analytical writing.

The three data chapters in this project are arranged to create a cohesive narrative rather than chronological account. As a reader I gravitate towards narrative styles of writing and the ethnographic vignettes in this project reflect that preference. I have integrated some analysis into the data chapters, particularly at the end of the writing before the introduction of the design explorations.

Chapter 7, the more formal analysis portion of this research, evolved with these other chapters and the feedback I received from my advisors. The challenge with any research is to turn your findings into a concrete, novel knowledge contribution to the discipline. Within design, where much of the process is implicit, research is typically aimed at finding a way to make that knowledge explicit. In this research I have been focused not on designers, but an ecosystem and a collective process that shares a great deal with what we might understand as a design process. While there is a tangible output emerging from this network, the processes have mostly remained invisible. Chapter 7 articulates the salient features and internal processes of this movement, bringing together the insights developed through the design explorations and the fieldwork and situating it within the broader design literature. Chapter 8, the concluding chapter, explores the findings in relation to existing literature on grassroots innovation. This chapter highlights the unique characteristics of the CAPÉ in comparison to similar organizations and connects the research to the theoretical framework developed in chapter 3.

CHAPITRE 4

Case study – First Part

4.1 Seeding the network

4.1.1 Naissance de la CAPÉ: Exploring the origins of the small-scale organic farming movement in Quebec.

I arrived at l'Expo Champ in the early afternoon. It was the first big event the CAPÉ had planned since the pandemic. The fifteen-minute walk it took for me to get to the entrance, past rows of cars parked neatly along the rural highway, were a sign that people were excited to gather again. Throughout the day, I bumped into Jean, a prominent figure in the organic farming movement in Quebec. Jean was photographing, interviewing, and documenting each event right along side me. Jean had recently left his position as a professor at the CÉGEP Victoriaville, where he had spent the last decade developing the Farm School program. Between 2008-2017, the Farm School, which teaches the fundamentals of organic farming and business management, had grown in recognition across the province with hundreds of students passing through the two-year program. In spite of this success, he decided to leave the program to pursue two passion projects.

The first project was a documentary series and podcast tracing the origins, evolution, and current state of organic farming in Quebec. The second is a project called Wiki-Maraîchère, a collaborative online resource that Jean is developing in partnership with the CAPÉ, the Collège d'enseignement général et professionnel (CÉGEP) Victoriaville, and the *Centre d'expertise et de transfert en agriculture biologique et de proximité* (CETAB+). The online tool is based on the work of Anne Weil and Jean Duval, authors of what is seen as the definitive guide to organic farming in Quebec. Jean was traveling across the province visiting farms, documenting novel tools and techniques, and interviewing different generations of farmers for both of these projects. For his podcast series it was his intention to visit every farm within *La Réseau des ferme famille* (RFF), the Quebec community supported agriculture (CSA) network that had recently merged with the CAPÉ.

Given Jean's history in the movement I was eager to discuss the early beginnings of the CAPÉ and the *Réseau des joyeux maraîchère* (RJME), along with the other initiatives that had emerged over the course of the last thirty years. Jean and I were unable to find a moment for an interview during *l'Expo Champ* and over the next few months we crossed paths on different farms, as each of us conducted our own fieldwork.

It was not until the winter that we were finally able to sit down together for an interview. On a December morning in 2021, through a Zoom call, we reconnected to discuss his experience over the last 20 years of engagement in the different aspects of the organic farming movement in Quebec.

Like many of the farmers I have worked with and spoken to over the years, Jean's personal story weaves into the emergence of the CAPÉ, the RJME, and what he describes as the first, second, and third wave of organic agriculture in the province. Or as he calls it, "Bio 1.0, 2.0, and 3.0." For Jean, Quebec Bio 1.0 dates to around the late 1980s and early 1990s, where a first generation of young, back-to-the-landers began to take up market-scale gardening in the province. In addition to championing organic and ecological agriculture, this first wave of new market farmers was also responsible for pioneering the concept of Community Supported Agriculture (CSA) in Quebec, with some of the first CSAs in the region now going on 36 years. This group, stemming from counterculture and environmentalist movements, often had very little formal training in agriculture, developing their competencies and methods through years of trial and error.

Jean places himself in Quebec Bio 2.0, and his personal introduction to farming and agriculture is characteristic of much of this second wave of young farmers. Quebec has a long tradition of agriculture with many people being able to identify a grandparent or relative who came from a farming background. Despite this historic connection to the land, most of the second wave of organic farmers would in fact be considered first generation farmers as their parents and grandparents were part of migration from rural to urban centers. So, despite often having some family members connected to agriculture, most were not raised on farms and thus their introduction to farming was not as straightforward as taking over the family business.

Jean tells me his own interest in agriculture was sparked from a 'corvée' that his parents were invited to when he was in secondary school. The *corvée*, perhaps best translated as a 'worker bee' day, has a particularly storied past in Quebec history. Originally associated with the seigneurial system from France, where peasants were obligated to do a certain amount of unpaid labour for the seigneur, this feudal tradition was continued with the colonization of Quebec. Like the French system, during this period Quebecers were obligated to do *corvée*, or unpaid work, for several days of the year, often related to civic projects like road construction (Roberge, 2003). Despite the more negative connotations of the term, over time the *corvée* has been reinterpreted and appropriated by rural communities to become associated with ideas of mutual aid, social bonding, connection to place and seasonality.

In her research on the significance of this tradition in rural Quebec ethnographer Jeanne Pomerleau defines the *corvée* as: "work done in a group, without pay, for the purpose of helping each other or exchanging time, usually accompanied by a meal or two together and, sometimes, an evening of entertainment that includes dancing and games" (Mathieu, 2001, p. 1). It is in this latter sense that Jean uses the term, describing how his experience of helping at a farm with peers his own age, alongside adults and seniors, left a lasting impression on him. He tells me, "At the end of the day I said to my parents, 'I would like to be a farmer'" (Genest, 2021). By chance, another farmer who had come to help out that day overheard this comment and responded, "if you are really interested in agriculture, you can come and spend some time on our farm." After a visit to this second farm Jean told me his interest was cemented, and throughout high school and college he spent his vacation time working at that farm.

When I asked him what appealed most about farming, he said it would be difficult to attribute his attraction to a single thing or job, rather it was the whole experience of agriculture. From the social and community aspects to a clear way to engage with nature in a way that spoke to his interest in the environment. This is also where Jean encountered traditional contra music for the first time and he told me, "I discovered another one of my passions: traditional dancing, or contra, and calling, which is something I still do to this day" (Genest, 2021). Although trad-dances might seem a long way off from agricultural technology and innovation, there is indeed a through the line between gathering, celebration, mutual aid, and their role in supporting social cohesion, that is central to the CAPÉ and networks like the RJME. Like Jean, many new farmers encountered these traditions for the first time through agriculture and as the organizations they founded have evolved, these social and cultural elements have been integrated, reinterpreted, and mixed with contemporary practices.

While many of the 1.0 and 2.0 wave of organic producers in Quebec are first generation farmers, by the time Jean's cohort began pursuing careers in agriculture there were more formal education and training options available. Jean chose to do a degree in agronomy at Université Laval in Quebec, knowing it might offer opportunities to get involved in both agriculture and teaching in the future - two of his main interests at that time. Through the program he was exposed to other models of farming, and a notable experience on a vegetable farm inspired him to start a garden with a student run ecological agriculture group at the university. Jean tells me that this group, along with other student run organizations from across the province, would go on to become the second wave of organic farming in Quebec. Unsatisfied with the resources and information available on ecological agriculture at the institutional level, students from universities and colleges began organizing colloquiums where they could exchange knowledge and ideas on alternative models and techniques for farming. In 2003 *le Réseau des étudiante d'agriculture biologique* (REAB) was created. In addition to an email communication listserv which was hosted on the Université Laval servers, the group began organizing in-person gatherings each year, with the *Rendezvous automnal* in the fall and the *Rendezvous d'hiver* during the winter.

"It's funny," Jean remarked during our discussion, "in that initial network there was already the seed of what would later become the RJME and the CAPÉ." Indeed, after finishing formal studies and apprenticeships on established farms, many of these students went on to found their own small-scale organic market gardens, and the instinct to communicate, share, and exchange ideas openly through both in person and online environments was already firmly rooted. In 2007 these young farmers, many of which were instrumental in founding the REAB, formed the *Réseau des jeune maraîchère écologique* (RJME), or the Network of young ecological farmers in English. The 'jeune' was later changed to 'joyeuse,' or 'the network of happy farmers,' to include members of all ages. Like the student-run network, the RJME is an informal listserv, an email communication platform hosted on servers at the Université Laval. In its early stages the RJME network also adopted the tradition of collectively organizing an annual *Rendezvous Autumnal* in the spirit of the early student-led events.

Since its original founding membership of around 10 farms, the RJME has become a vital resource for organic farmers across Quebec. While differing in scale and approaches, what most of these member farms have in common is their commitment to ecological agriculture, as well as the adoption of the CSA model that was pioneered by the first wave of organic producers in the province. The CSA model of agriculture originated in Japan in the late 1960's, stemming from the rise of farmer cooperatives that were looking for alternative models of food production and distribution. The first documented CSAs were based on the '*Teikie'* system, translated as 'putting the farmer's face on food.' These early CSA's were developed by a producer-consumer partnership organized by a small group of Japanese women around 1965 (Kondo, 2021). The concept would later spread through Europe, starting in Germany in 1984. Not long after appearing in Europe, the first CSAs began showing up in the United States before moving north.

In Quebec, the CSA model has a strong association with the foundational work of the environmental advocacy group *Equiterre*, which created the *Reseau de fermes des famille* (RFF), or network of family farmers in 1994. Although Quebec farmers were not the first to use this direct-to-consumer model, early adoption, and the parallel development of the RFF, has made the province's CSA network one of the most robust and best organized in North America. What makes the RFF stand out in this regard is that most organic farms in Quebec are members of this network. Consumers from anywhere in the province can search an online map for CSA distribution points near their homes. This supports farmers in establishing direct partnerships with consumers as well as reducing overlap and competition within regions. Jean jokingly referred to this as "*Colabatition,*" a portmanteau of collaboration and competition. He also pointed out that most of the early RJME farms were members of the RFF and this overlap between the two networks is one of the factors that led to the creation of the CAPÉ in 2013. As these different networks grew it was increasingly apparent that there was a need for a more formal organization to advocate and organize on behalf of the movement for smaller-scale, ecological agriculture.

4.1.2 New beginnings and strong foundations

The year the CAPÉ was founded I was managing a small farm for a community organization in Montreal, and I attended the *Rendezvous automnal* for the first time that year. The *Rendezvous automnal* is an opportunity for farmers from across the province to gather in person to share ideas, techniques, and perhaps most importantly, connect with old friends. Quebec is a large province, and apart from a few of major urban centers, the regions are spread out and sparsely populated. With intense seasonal work, most farmers spend the majority of their time on the farm, and this can be isolating. While the RJME connects members through online communication, the *Rendezvous automnal* and other in-person events are important opportunities for this distributed network to reassemble in a physical place to celebrate the end of the farming season. Like traditional *corvées*, in addition to having the tangible objective of sharing knowledge and techniques, the event also reinforces social cohesion. The idea of mutual aid and collective organizing permeates the event with members coordinating three days of shared meals, a workshop series, music, and traditional dances.

In 2013, having only been in Quebec for three years, I was still unable to follow the intense discussions that took place in the evenings at the *Rendezvous*. But not long after the event I remember seeing a post from Jean with the heading 'Naissance de la CAPÉ': "As decided at a workshop at the last *Rendezvous automnal* of the RJME, the members decided to go one step further and to found a cooperative of producers: *la Coopérative pour l'agriculture de proximité écologique* (CAPÉ)." (Gigi, 2013). Even then, Jean was maintaining an active blog where he posted about farming techniques and his experience gleaned from exchanges to other countries. By this point he was also already working as a professor at the *CÉGEP de Victoriaville.* After having completed three seasons of managing his own organic farm, in 2008 the college had reached out to Jean to help further develop the farm school program as the current director was moving on to start an agriculture research institute. Between 2008 and 2013, the time the CAPÉ was founded, the Farm School became an established educational program for aspiring farmers.

I asked Jean about the important role he has played in the evolution of these different networks, and he was quick to point out that while he was proud of his contributions they were, to use his expression, "a single match within a larger pack". From my own observations of the first, second, and third wave of farmers, and the impact they have had on the organic farming in Quebec and beyond, it is indeed impossible to attach the rhizomatic spread of the movement to any single individual. Many within Jean's cohort have gone on to start very successful and well recognized farms, in addition to authoring popular books on the subject, hosting education seminars, and becoming professors, researchers and agronomists. We can track backward to find direct lineages between the early organic pioneers that sowed the first seeds of the movement and the apprentices to the student groups that sought to further develop their skills, to the knowledge sharing networks that led to the eventual formalization of CAPÉ. What become clear from this is that a synergy of time, a diverse set of actors, and the growing public awareness around environmental issues have all contributed to the emergence of the current state of ecological agriculture in Quebec.

When Jean first took over the Farm School in 2008 there were on average 3-6 students a year. By the time he left the program in 2017, that number had grown to 40 students per year. These new farmers are what Jean describes as Bio 3.0. Thus, the organic farm movement has blossomed – from a handful of first-generation farmers with no formal training that were looking for an alternative livelihood that aligned with their values, to more than 350 small-scale organic farms, several formal university and college programs, and numerous organizations and networks that are advocating for the advancement of small-scale ecological agriculture. All of this over the course of thirty-six years.

Building a network of builders: the emergence of the *Autoconstruction* group

From its initial founding in 2013, the CAPÉ has become an important player in the organic farming sector in Quebec and the organization's mandate has evolved in sync with the movement. From the initial offering of annual events, the CAPÉ now has seven distinct priorities: Collective purchases, in which the coop members can make bulk orders together for farm supplies; collective marketing, where members sell produce and winter CSA baskets under a combined label; the Réseau des fermier famille, the province wide CSA network; annual events, like the Rendezvous, Expo champs, and member farm tours; a regional peer education and knowledge sharing project; the *Autoconstruction* group, which is the focus of this thesis; and more recently a partnership with a tractor manufacturer to import custom small scale farm tractors and tools. This latter project grew out of the organization's *Autoconstruction* initiatives and is headed up by Andrew Alton, one of the principal coordinators of the *Autoconstruction* group.

It would be difficult to speak about the agricultural innovation in Quebec without mentioning Andrew, whom I first met in 2011. At this time, I had just moved to Quebec to take a farm management apprenticeship role at one of the several farms in Montreal. The farm is bordered by a nature arboretum, 700 acres of conservation and farm research lands that make up the McGill University's Macdonald Campus – including one of the original agricultural colleges in the province. The presence of the campus and the preservation of this agricultural greenspace has made this part of Quebec an agriculture hotspot, attracting students and budding farmers looking to get into farming.

Andrew, like Jean, falls into the second wave of organic agriculture in Quebec, having come from the same cohort of new farmers that cut their teeth apprenticing on established farms between their formal education. In his last year of studies at the Macdonald Campus in Ste Anne, Andrew co-founded Tournesol Cooperative Farm where he manages infrastructure and machinery. After many years of knowing Andrew as a technical person with an engineer's precision for fabricating tools and explaining complex ideas, I was surprised when a colleague of his told me that Andrew is not an engineer by training. When I mentioned this fact to him in one of our interviews Andrew laughed saying, "I prefer to think of myself as more of a mechanic" (Alton, 2021).

In contrast to these mechanical inclinations, Andrew had in fact studied environmental science and found his way into agriculture through political activism and food system movements. He told me these initiatives are what inspired him to change degrees to study at the Macdonald Campus–- where he soon found his passion for growing food, along with meeting his future farm co-founders. When I asked Andrew how he had honed his technical skills he told me that he had always had an interest in tinkering and figuring out how things work. He remarked that one particularly formative experience was being a volunteer mechanic at a student run bike shop. This experience opened him up seeing the power of both the technical side of problem solving as well as the more social aspects of working with people to figure things out together. His role on the farm today has evolved in part through personal interest and aptitude, along with trial and error during the early years as the co-op members tried out different positions.

Reflecting on this evolution, from keeping a few tools sharp and repaired to coordinating an extensive machinery workshop, Andrew (Alton, 2021) told me that it began with line of reasoning, “If I could just add another thing to this tool maybe it could do two jobs. Or if I can scrounge for parts I could get [a prototype] together and show it to the others. And if it works, they will all be thrilled.” This is how his competency and confidence expanded and each time he succeeded in solving a problem his enthusiasm was bolstered. Elaborating on how this process typically went, he told me: “With success. you can build an argument for more ambitious projects and how to dedicate more resources to it. So over time you can go from moving one thing to another, or adding another feature to a wheel hoe, to things like saying, " I have this ambitious project’ it's going to take me several weeks that are all going to be paid hours, an’ it's going to cost us three or four grand... But there is a budget both with time and money involved. It just becomes more concrete. You pitch the ideas, and in our case, I am always pitching new ideas to my colleagues, and they are a pretty good sounding board. But also, a tough audience, because they all have their ideas about what the next most important thing is.”

Andrew’s extensive knowledge and technical competencies has made him a go-to resource for me and many other young farmers. When I first started working in agriculture and was stumped by a technical problem, I would often get in touch with Andrew to pick his brain. Andrew was in fact the first person I reached out to in 2015 when I was having difficulty finding an affordable vegetable root washer on the market. That quick exchange with Andrew led to my introduction to the CAPÉ *Autoconstruction* group, prompting my first fabrication workshop, an event which in turn catalysed the years of research that have informed this thesis.

4.1.3 Stumbling into innovation

Over the years, through different farming events and activities I had begun to get a sense how farmers working at a smaller scale experienced similar challenges and a lack of appropriate tools in which to address them. I also remarked how many of my peers took it upon themselves to come up with their own novel solutions to solve these problems. Indeed, I had myself taken on several difficult construction projects when no alternative was available. So, when I was unable to find an affordable root washer on the market, I began to consider whether I could build one myself. In this particular case, it wasn't so much that the tools did not exist, it was just that the cost was far beyond what I could afford.

A root washer is not a complex technology and often the design is similar on both small- and large-scale farms, with some small differences. Root vegetables, like carrots and potatoes, are fed into a sideways barrel shaped machine. A perforated pipe runs through the center of the barrel which slowly turns. Like a clothes drying machine, the vegetables are pulled up the sides and tumble across each other, the abrasion and constant jet of water cleans the soil from the crop. Typically, the barrel slopes slightly from the input to output, creating a natural funnel for the cleaned vegetables to tumble towards storage bins. The major difference between a small- and large-scale machine is mostly the size of the tool and the mechanics of getting the vegetables in and out of the machine. An industrial machine typically has conveyors where bins are front loaded. Similarly, on the output side, conveyors feed the vegetables into read bins. For a smaller scale operation, the machine is scaled down and rollers often replace electronic conveyors.

Despite the relative simplicity of this design, after a few days of looking at existing models, I realized the tool was beyond my competency and I sent Andrew a short message asking whether this might be the kind of project the CAPÉ members would be interested in. I had a simple proposal in mind. Rather than using my budget to purchase a machine, what if we instead used these funds to design a new tool, buy the parts and organize a group workshop where those interested could help build the tool. In return I would document the process and share the plan with the broader group. I still recall his short email response, "that's a great idea, but I think there would be a lot more people interested in participating if they could build their own machine at the same time." The seed was planted.

Over the next months I received a crash course in collective organizing. We found an approximate design that we could modify from the Farmhack website. Sketches were sent back and forth; 3D plans were drawn up by a farmer in central Quebec; spreadsheets and part lists were edited and resent through email; wood was sourced from a local mill; and motors were salvaged from a college that was upgrading their shop equipment. The night before the workshop I was up until one o'clock in the morning doing last minute checks of material lists and stewing up a pot of chili. That day, I joined farmers from across the province at the Macdonald Campus to build fourteen root washers. The event was reminiscent of traditional barn raising: a modern ‘corvée’ where high tech tools and self-organization mixed in with more traditional practices. It was an intense 24 hours, and the experience left a marked impression. From this initial encounter, a curiosity was sparked which I have continued to pursue in an effort to understand this emerging form of technological innovation. Throughout the years Andrew has remained a close collaborator and sounding board as my focus has shifted from participation in workshops to ongoing documentation and research of the CAPÉ’s model of innovation.

Even at the time of the first root washer workshop, the CAPÉ *Autoconstruction* group was already beginning to take shape. The event, according to Andrew, was characteristic of how past events and indeed the group itself was formed. In one of our many conversations on the origin of the group Andrew told me: "It evolved quite fluidly out of the logical, totally normal sharing of ideas that farmers do every year... particularly in the winter when the first network of our cohort of organic farmers started sharing information at the RJME meeting [and on the] listserv” (Personal communication, 2018). Andrew went on to describe the evolution of this process:

> "That sharing of information gradually becomes the background that you need in order for people to start tackling technical projects together. Initially it would be things like so and so at farm x, he or she wants to build a garden cart. They would send an idea out to the listserv and discover that two or three other people have built one, and the pitfalls and accomplishments of their designs.

Andrew told me that this back and forth on the email listserv eventually leads to other members becoming interested in acquiring the same tool. Andrew again:

> “Eventually a project like that will take the logical next step of two or three farms that say "I want to build one too, should we get together on a weekend in February and build them together at your place or mine? We'll be more people together so it will be more fun and easier. And if we have parts to purchase, we can buy twice as many and maybe get a break. " A third person joins and then all of the sudden one person takes on a coordinating role, and says, "listen I will draw up the plans and circulate them for validation, and once we have plans, I can buy parts and throw everything in my car or truck and meet at Susan's house next weekend and we can take it from there." And that is basically an *Autoconstruction* project in its most logical or original form" (Ibid).

Andrew’s summary of the organization’s tool development process touches on a number of important elements that are linked to the broader cooperative movement. There is a long history of agricultural cooperatives in Quebec, where farmers have pooled together resources to develop mutual funds, reduce the costs of inputs and insurance, and collectively market their produce (Saint-Pierre, 2018). The first coops in the province appeared around 1882, and the emergence of the coop movement has been linked to the tradition of *entraide (*mutual support*)* and the *corvée* at the heart of rural communities during this period. When the RJME formalized it is work as a cooperative, as Andrew put it, these ‘totally normal’ practices, became part of the group’s approach to collaboratively designing and building their own technology. As my own experience with the root washer illustrates, from the start, the group has always been interested in more than just developing plans and sharing ideas. The cooperative model of group buying has been an important part for this model where collectively sourcing parts and raw material reduces the upstream costs of the tools and technologies.

4.1.4 Making connections and refining the process

What shifted the organization from this ad hoc, informal process, is when they discovered the work of l'Atelier Paysan, a parallel farmer-led technological innovation cooperative in France. At that time l'Atelier Paysan was working under the banner of Adabio, an organization focused on sustainable agriculture. One of the coordinators of this network, Joseph Templier, was invited to give a lecture about his farm at Cégep de Victoriaville and he presented some of the tools the group had constructed. Not long after Allain, a professor from another technical school who had attended the event, organized a trip to France to visit Templier’s farm. There he realized the extent of Adabio's work. Speaking of this early cross pollination between the networks, Andrew told me:

> "Alain is technically minded, and he could see what they were working on with their group. It was Templier with a bunch of innovative farmers who had made prototypes and [they] were sharing their ideas and information. They were just starting to build a concrete network and broaden the scope of what they were doing in order to share what they had learned."

At the time Adabio had recently published a manual with all the tool plans. That publication, Andrew told me, was significant for the Quebec group. "It was something that a couple of us in Quebec bought copies of and in fact,” he remarked, “that might have been one of the first group purchases of the *Autoconstruction* network: buying a bunch of books from France."

That exchange between the networks fostered a fruitful cross-pollination for what would become l'Atelier Paysan in France and the CAPÉ *Autoconstruction* group in Quebec. One early event, around 2013, was when the group invited Joseph Templier to coordinate a workshop to make one of l'Atelier Paysan's tractor cultivation implements. This was followed by a quick attach triangle hitch workshop, also based on l'Atelier Paysan's plans. In Andrew's opinion, the CAPÉ today is about where l'Atelier Paysan was when the two organizations first crossed paths. Just as l'Atelier Paysan had moved toward formalizing their processes, homing in on a specific set of tools, and developing a stronger outreach mandate, the CAPÉ has been able to shift from spontaneous workshops between a few people, to planning, coordinating, and offering a series of annual builds to the network's more than 250 members.

Comparing the trajectories of the two organizations, Andrew says one of the main differences comes down to geography. Quebec does not have the same population density of France, and therefore demand and participation from producers here simply cannot sustain the same level of funding and human resources that the l'Atelier Paysan has been able to achieve. The *Autoconstruction* group is a priority for the CAPÉ and yet there has never been a full-time employee dedicated to coordination. In contrast, l'Atelier Paysan has around 6-8 employees working year-round on everything from workshops to knowledge mobilization and political advocacy.

These constraints have led the CAPÉ to come up with their own novel approach to coordination and development. Since the root washer event in 2015, the group moved away from purely volunteerism where one or two people would take on the task of spearheading a project to the current model of compensating workshop coordinators for their time. In the beginning it was mostly Andrew and Yan, another of the original group coordinators, volunteering to organize the events. As interest grew, other members took on volunteer coordinator roles based on specific tools that they were interested in building. "This worked for the beginning," said Andrew, "but it also demonstrated the limitations of volunteerism as an [organizing] structure." By shifting to compensating coordinators, the group is able to encourage people that might not actually want a tool, but that may have necessary competencies and know how to help organize an event. The group can remunerate these temporary coordinators through charging a small participation fee to members that want to participate in the workshop.

As both a participant and observer I have seen how this process, and indeed the organization and group, has been refined since those first workshops. Each year the *Autoconstruction* group presents an overview of their work at the CAPÉ's *Rendezvous autumnal,* and it is here that one can get a general sense of the it's evolution. I recall, for example, that at 2014 *Rendezvous autumnal* the group met in a small room with around 20 attendees present. That year people informally discussed projects they had been working on, with some members bringing photos of their tools. By 2019 the group was occupying the second largest hall at the *Rendezvous* venue, with around 80 participants, some of whom brought in prototypes of their tools. At that point the group was discussing a roster of well-developed technologies that would be tackled in the coming season and members were encouraged to join working groups to help coordinate ateliers. In 2022, after two years of postponing the *Rendezvous* due to the pandemic, the *Autoconstruction* group presentation was in the largest hall at the venue. On the agenda for that meeting: discussions around the funding for a full-time coordinator, the launch of an online wiki-platform for collaboration, and a list of kits and pre-assembled tools for some of the more popular projects.

The increasing formalization of the group and the growing enthusiasm and participation is one clear way to gauge success of the Autoconstruction group. But what of the tools and technologies themselves? In the concluding section of this chapter, we will turn to the first of a series of exploratory design projects that examines the different facets of the group's innovations.

4.2 Design Exploration One

4.2.1 A technological Inventory - assembling the traces left from the production of open-source farm technology

In the first of these design explorations, we shift our focus to the tools that have been developed by the Autoconstruction group. This project was undertaken in 2021 during a six-month design studio as part of the *Maîtrise en Design de l'environnement*. Under the direction of Professor Thomas-Bernard Kenniff this project takes the form of inventory. "The inventory as a research project," suggest Kenniff and Lévesque (2021), "attempts to take advantage of the primary act of enumeration in order to improve our understanding of the world around us. Through this process, it becomes necessary to find a meaning, to put in relation things which are at first sight disparate and to be interested in the particularities thus brought to light" (2021, pg. 8). In other words, the inventory is not so much interested in simply cataloging what is known, as it is about revealing new insights through a methodical and rigorous process of documenting and refining what might otherwise seem mundane.

For this project I took on the seemingly straightforward task of inventorying the different tools the *Autoconstruction* group developed between 2015 and 2020. To accomplish this task, I drew from the groups shared online *Drive* folder, which contained the plans, drawings, spreadsheets, and other important documents produced for each of the specific tools. I also referenced my both my own extensive archive of photographs as well as the photos from the groups Facebook page. This process of archiving was not as linear as I had expected. In *Archive Everything: Mapping the Everyday* Giannachi (2016) states that the archive is not some objective reality or history but a reflection of the archivist. Immediately upon taking up this project it became clear to me the subjective nature of this sort of task. Afterall, I was the one choosing what was relevant in the vast amounts of information I had to sort through, and, what's more, I was also the one drawing relations between these elements.

As the project evolved, my objective was to see how presenting the different tools in a chronological order might reveal something about the group's process of innovation. Recalling the initial schema, I had developed some years before to describe the group's design process, I wanted to understand how to articulate the particularities of the innovation method through exposing the tools themselves. The resulting poster displays five tools developed by the group between 2015 and 2019. Each tool has been pulled apart, or deconstructed, similar to an exploded diagram used in patent drawings. However, rather than enumerating parts, the poster attempts to display the different processes that go into the creation of a tool. For this project, I broke the processes into four main categories: problematique, planning, fabrication, and product. Each of these then had a corresponding set of sub-categories. For example, under the planning category I included: precedents, organizing, and conception. These broad categories and sub-categories offered a rough methodology for triaging the thousands of files and images which I had to parse through.

While the initial objective of displaying the data in this format was to facilitate easy comparisons between the different projects, the process of sorting through extensive archives yielded some unexpected insights. While the goal of open-source hardware initiatives is often to share the plans that will allow others to replicate and build on the original idea, much of the data in the archive is neither visual, nor explanatory. Indeed, a large portion of the archive is made up of spreadsheets, word documents, budgets, receipts, and part orders. This disproportionate amount of material represents the less visible work of turning designs into reality, revealing one of the biggest challenges to the uptake of open-source hardware. In contrast to software, the designs cannot simply be copied and pasted like code. Perhaps buried in these archives are the more easily replicable data, the equivalent to the duplicable code of open-source software.

In addition to making visible some of the less apparent work that goes into hardware innovation, the inventory brought to light how processes and systems developed for one tool can be reinterpreted and repurposed for another. A budget spreadsheet from the root washer might be used as a framework for building a budget for the green's washer or some other tool. Through deconstructing the tools and making visible the process rather than the parts we begin to get a sense of how each tool, each workshop, contributes to the collective expansion of the CAPÉ Autoconstruction group's capacity by sharpening our organizing skills and construction knowledge. This is an interesting observation in relation to the objectives of similar farm technology networks, like Farm Hack, which often prioritizes creating open-source plans and designs. Even with the potential benefits of Farm Hack's decentralized and distributed model, it becomes clear that many other factors at play in order to reproduce technologies.

4.2.2 Diagrams and figures

Figure 4.1 *Fiche Technique* exploring the tool as a series of process

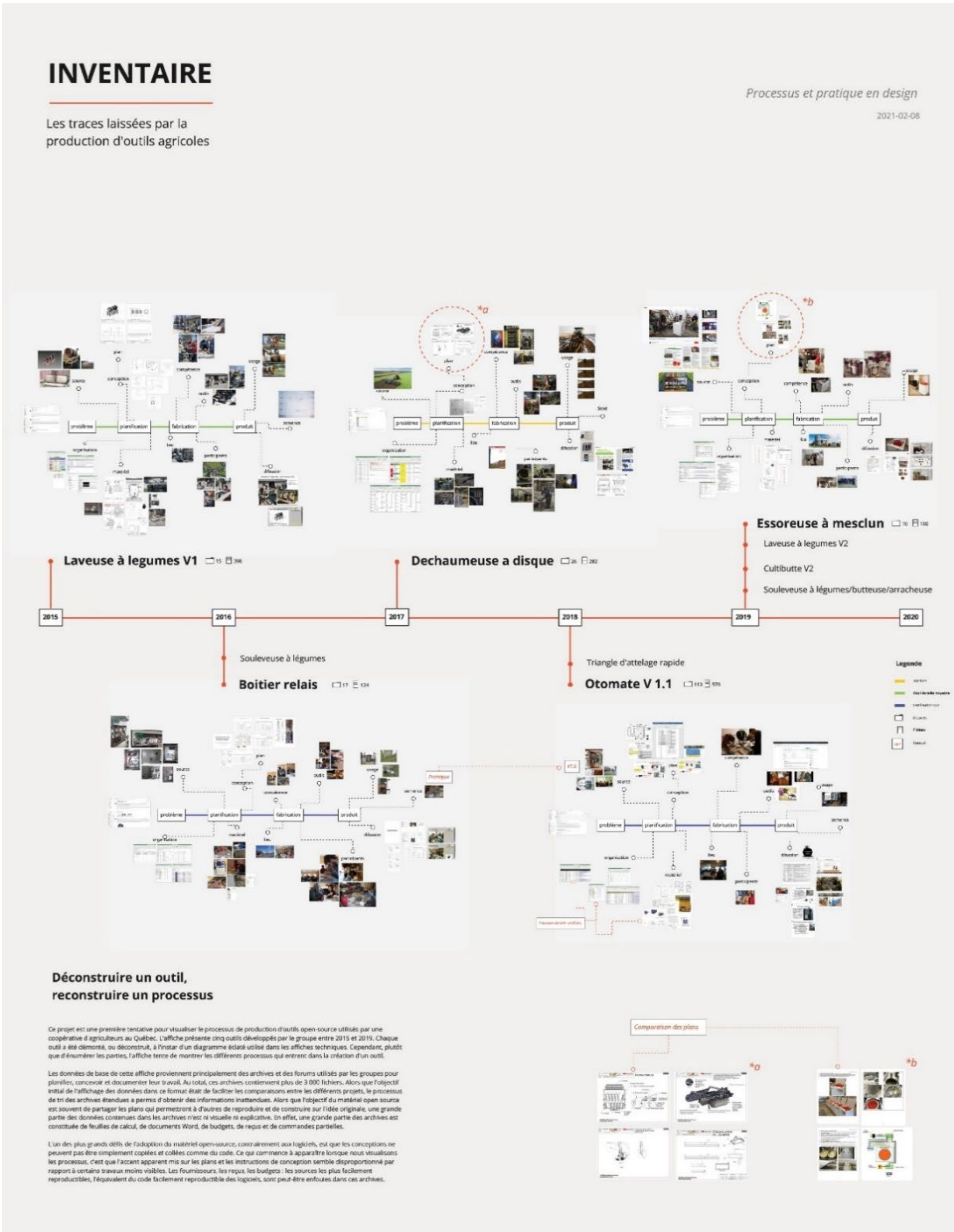


Figure 4.2 Zoom in on Laveuse à légumes

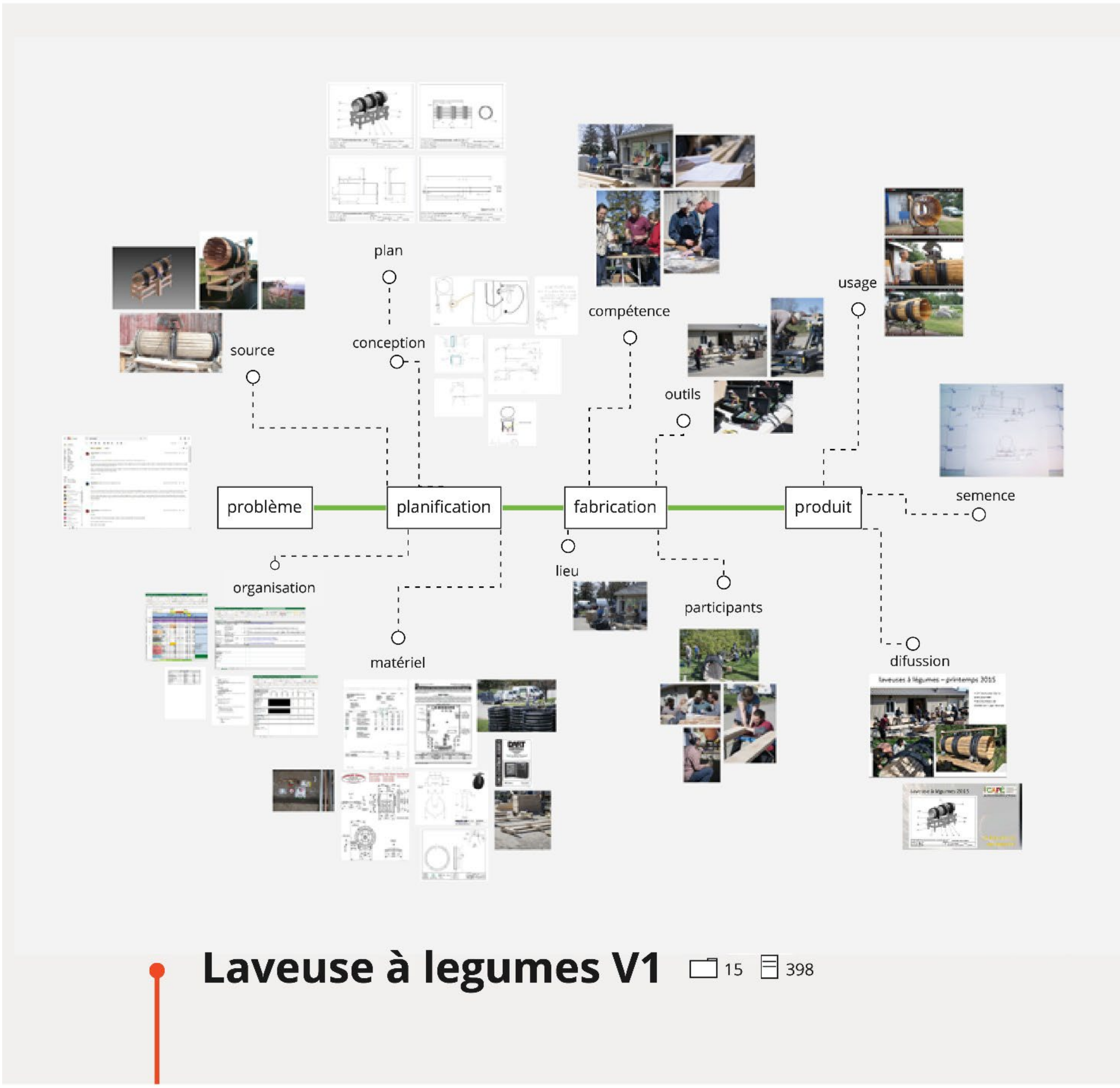


Figure 4.3 Zoom on evolution of the *Otomate*

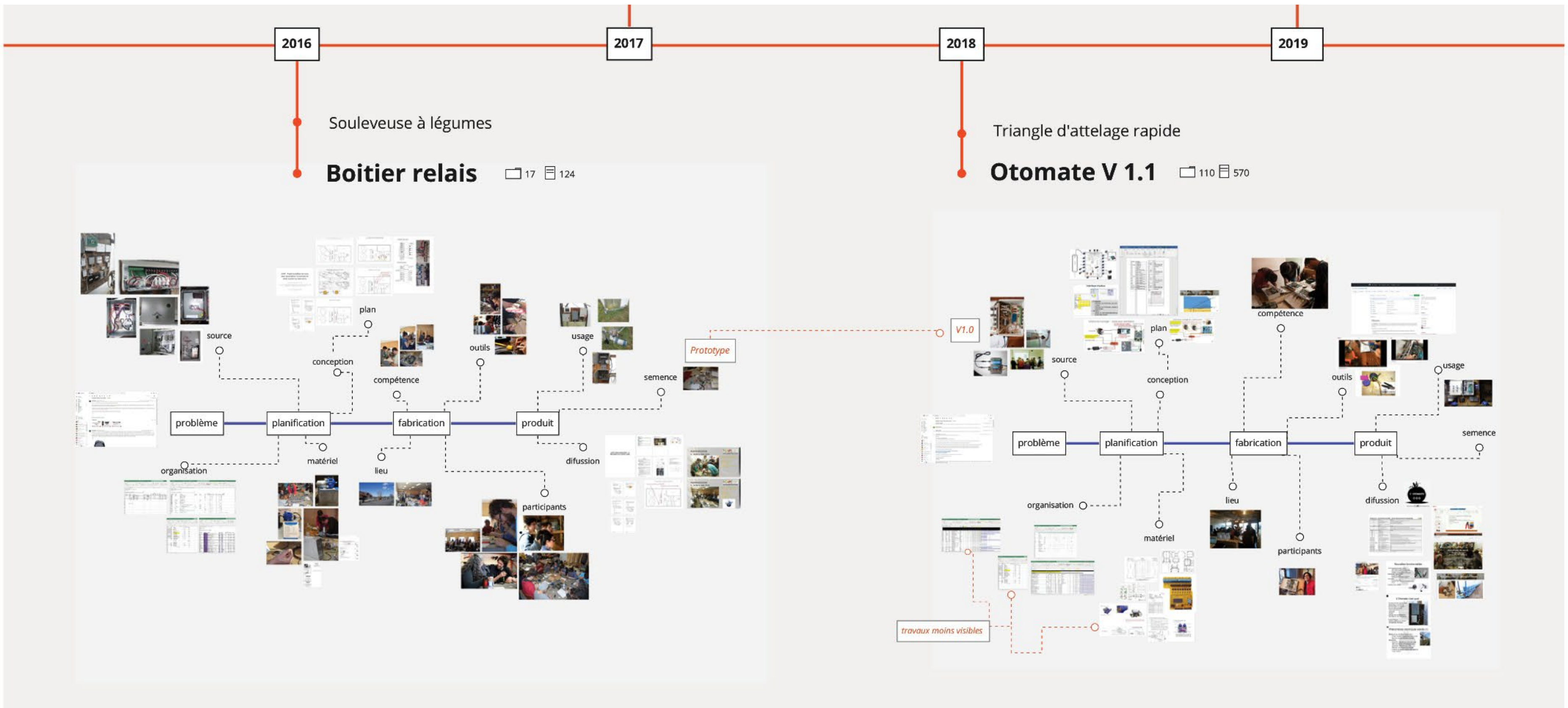


Figure 4.4 Zoom on Essoreuse à mesclun

CHAPITRE 5 Case Study – Second Part

5.1 Innovation at the edges

5.1.1 Drawing from the margins to develop novel prototypes

As my research has progressed, I have begun thinking about how the innovation model of the CAPÉ manages to bring together skills, knowledge, and ideas from a range of fields and applications. My own experience in developing the root washer aligns with Andrew's description of how the network has organically formed. This organizing approach seems to allow the group the capacity to maintain consistency in organizational knowledge, while training and bringing in new members who, in time, will have deeper engagement with the work of the CAPÉ. While the approach seems to be effective for producing tools that the network has brought to a certain level of refinement, the fee charged for participation does not cover the research and development hours that go into bringing a tool from concept to prototype. In other words, for tools the organization has already gotten to a refined state - where they can rely on the established procedures, sourcing of parts, and a rough budget - the participation feed can usually keep the event at a break even. But for new tools and technology to find their way into the group there is a much different process, one which I have found reminiscent of the Andrew's approach to getting buy-in from colleagues on his farm for new ideas (described in the previous chapter).

In the following section we shift our attention to the upstream processes of creation - the precursors to the tools that will eventually find their way through the network. Before a tool is refined and brought into production by the organization, there is the original idea along with the investment of time in conceptualizing, trialing, and developing a prototype, or beta version, that can be pitched to the group. From my own observations and discussions with members of the CAPÉ, I have begun to think of these processes as interrelated but discreet steps within the organization's innovation process. While the group has refined the coproduction and diffusion of its tools amongst its membership, the initial germ of a tool seems to happen outside of formal processes

But what are the processes for an innovation to evolve from a good idea into something the network might want to adopt? One example that offers insight into these early stages in the life of a CAPÉ tool is the *Otomate,* a greenhouse automation tool which has now been adopted by more than a hundred Quebec farms. As we will see, this story has many overlaps with other tools - both in terms of the individuals propelling it forward and the way in which it has supported the emergence of the other innovations. Nonetheless, tracking its origins can help us understand how technology within the network moves from the margins, where it evolves through informal relations, to broader refinement and adoption by the group.

5.1.2 The *Otomate* and the spread of DIY greenhouse automation

In November of 2022, I headed to a farm near the Quebec-Ontario border to meet with Serina Janson, a farmer and technology tinkerer that has gained a reputation in the network as *bricoleuse*. I had known Serina for years before I discovered she had also completed a doctorate in forest ecology, a fact a colleague casually let slip while we were dismantling a tractor. This lines up with Serina's unassuming but confident demeanor, where she can move seamlessly between troubleshooting an engine repair, to programming an *Arduino* digital microcontroller, or explaining a complex idea, like information transfer between tree root systems. Like Andrew, Serina has often been on the leading edge of technological innovation in the small-scale farm technology scene, and I was eager to discuss the different projects she has developed over the years. More specifically, I was curious to learn how some of her early prototypes had found their way into the *Autoconstruction* group.

When I pulled up to the farm, Serina was in the barn working on an Allis Chalmers 'G' tractor which she had converted to electric power the previous summer. I had been following Serina's conversion of the tractor through an online Facebook group and was of course eager to see the refurbished machine in person. The tractor looked almost new, with a battery box skillfully integrated in place of the old engine. Serina, who at another time was a hot rod enthusiast, told me she had first intended to touch up a few rust spots and soon ended up repainting the entire tractor. While I was excited to learn more about Serina's tractor, my real reason for meeting with her that morning was to discuss another technology she had played a key role in developing for the network: the *Otomate*, a greenhouse automation system.

In northern climates, greenhouses are an important investment on most vegetable farms. Here seedlings can be started during the coldest months of the spring, and the fall growing season can be extended for crops like tomatoes and peppers that thrive on heat. Greenhouses are often heated early in the season, but as the weather gets warmer, the primary way of managing temperatures is through venting the sides and roof. On hot days, where temperatures can rise rapidly, the sides are rolled up incrementally to let out excess heat. Likewise, on cold days, closing the sides ensures captured solar heat is retained in the space. This is a relatively simple but effective low-tech solution.

Despite its utility, a greenhouse can also be a source of considerable problems on a farm. A cloudy sky, a sudden rainstorm, or a gust of wind can cause dramatic spikes and declines in temperatures, which means the roll-up sides of the greenhouse are constantly having to be adjusted according to changes in the weather. In the course of a day, this can happen often, and on small-scale farms this means someone is constantly having to open and close the sides from morning to night. Most larger scale commercial greenhouses have automated this task, but the cost of the technology has, up until quite recently, remained prohibitively expensive for smaller scale farmers like Serina.

Regardless of the size of the greenhouse, the automation process is quite straightforward. A thermostat in the greenhouse reads the temperature. If it is above or below a certain threshold, a microcontroller signals a mechanical relay box that activates a motor which is attached to the sides. This motor simply cranks the sides up or down depending on whether the goal is to cool or heat the space.

In April of 2016, the CAPÉ had decided to tackle part of this process. The group had purchased or salvaged microcontrollers made for larger greenhouses, so the network decided to focus on developing the mechanical components to roll up the sides. Andrew, along with the help of a farm apprentice, Francois, had developed a mechanical relay box that could be easily used with different proprietary microcontrollers. So, in 2016, the members of the network gathered at a farm in central Quebec to manufacture 30 of these relay boxes which each participant could then pair with whatever micro controller they were able to afford.

I had attended that event to take photographs to support the group's documentation efforts and in the back of the room I spied Serina and a few other farmers working together, surrounded by laptops and electronic parts. When I asked another participant what they were up to I was told that they were checking out the DIY microcontroller Serina had developed for her own greenhouse automation. While the rest of the group was building the mechanical relay box to be used with expensive off the shelf controllers, Serina had rigged the relay to her own system built on a $30 *Arduino*.

The prototype Serina had brought along sparked the interest of several other farmers at the event. Rather than purchasing a proprietary controller for $1000-$2000, a handful of the farmers asked Serina if they could organize a follow-up workshop on her farm. I also attended that follow-up event in 2016, and over the course of an afternoon eight of us turned her living room and kitchen into a small electronics workshop where we made another six of these DIY microcontrollers.

5.1.3 Tracking back to the original spark of the *Otomate*

Six years after that event I returned to Serina's kitchen, only now she was busily straining whey from a batch of cheese, while I asked her questions about the origins of her microcontroller project and how it eventually became the basis for CAPÉ's *Otomate* system. I asked how she had initially thought of using an *Arduino* to automate her greenhouse roll-ups. She told me that the idea came from seeing the heating system that Andrew had set up in his greenhouse which was using a mechanical thermostat to switch on and off an oil furnace. Referring to Andrew's mechanical version she says, "The thermostat cost $60 and it didn't do very much, just a mechanical thermostat. And I was like, is there a way for me to switch a relay based on an external parameter? And I quickly came across *Arduinos*" (Janson, 2021). Serina continued:

> "One of the first [Arduino tools] I built was a timer for my lights in the basement. So, I had two circuits coming in and two circuits going out to run all my seedling germination lights. It was just a timer, pretty straightforward. Then I did another one that just turned on and off the temperature, which is how I initially ran the furnace."

Her first prototype, what would become the *Otomate*, was simply a thermostat that would switch the furnace on and off. She had cobbled it together using her own knowledge on automation along with information from forums and online videos produced by home micro-brewing enthusiasts. When it came to programming the *Arduino* Serina told me: "I hadn't coded a lot, except for in a statistics course in Grad school, where I was a huge geek for a program called 'R'. And 'R' has its own language based on C+ and we would create these programs and loops. One of my research papers was a huge model of how trees die in a forest and create wood and habitat for insects and decay and disappear." She explained:

> "By looking at the death rate of trees, it'll estimate, how many snags were being formed? How many logs were being formed every year and then it put them through a decay gradient until they disappeared. And it was all just based on loops, right? Iterations and loops. And it's exactly how the Arduino works. You have this setup period and then you just have a loop that starts running and so for a thermostat, your loop is: get the temperature and then an if statement. If the

> temperature... is less than 14 degrees, then you put this pin on high and that's going to turn on your furnace."

She went on to tell me that once she figured out how to turn on and off the furnace, she decided it would be worth tracking temperatures and added a data logging chip to the *Arduino*. The interesting thing here is that she did not set out to develop a system for rolling up the sides. It was only once more people had gotten interested in automation that Serina realized her system was also capable of venting the side of the greenhouse.

> "So, in that first workshop," she told me, "It was the relay box that could be attached to an I-grow or any kind of available commercial controller. To save some money I was like, oh that next step seems dead easy. And I tried to make it as simple as possible. You know. No buttons, no displays. It was just a box that could control this other box based on the temperature that went in."

As I spoke with Serina, I began to get a better sense of how ideation moves to invention in this kind of distributed, user-driven network. Serina, an avid tinkerer, was inspired first by Andrew's more conventional system. Realizing the potential to do something similar with DIY parts she created a prototype that performed a comparable basic function. To do this she drew from a diverse pool of knowledge and skill: from her own training and experience to information found in online enthusiast forums dedicated to home brewing and smart house technology. From the initial version she continued to add new features and capabilities, eventually seeing the possibility of using it to manage the greenhouse side roll ups that were being developed by other farmers for off the shelf controllers.

What emerges with this story is the complex way in which this technology came into being, where Serina acted as a *bricoleuse*, pulling the technology together from many sources. Drawing on her own expertise, the ideas from other farmers, and inspiration from totally unrelated fields, she eventually produced something that had value beyond her initial thermostat concept. It is at this stage, having created a viable prototype, that the broader network itself begins to have a larger role in this process. Had Serina not been engaged or aware of the CAPÉ, her early automation model might have remained on her farm, clicking away, unbeknownst to the many farmers working at a similar scale that would have benefited from the technology. However, Serina's connection to the organization offered a point of reference that would inspire her to modify her early design, and a pathway for other farmers to see the prototype. Once others saw the potential of the new technology, it took on a life of its own.

It is in this way that the ongoing small-scale inventions happening on farms like Serina's or Andrew's, amongst the many other active members, go through a process of user driven research and development - with ideas slowly evolving into rough prototypes that have potential value beyond their initial designers. While Serina's story offers us some insight into how these early technologies emerge, there is still a significant gap between a rough prototype and a refined technology that can be adopted broadly within the network. In the following section, we continue tracking the *Otomate*, as it begins to move beyond Serina's farm.

5.1.4 Refining a prototype

Let's return to May of 2016, where members of the CAPÉ had gathered to build the mechanical relay box for opening the greenhouse sides. This was the first time Serina had brought her automation prototype to a CAPÉ event. At that workshop several of the participants recognized the potential of Serina's early model and went on to work with it as a basis for the organization's *Otomate* tool. Reflecting on this event Serina told me: "After that workshop, I started meeting with Henri, Mathew, and Francois who wanted to scale this up and make something more out of it." The group gathered several times before her busy schedule made it to difficult to continue participating. Reflecting on this Serina said, "You know, I let them kind of take off with it and it became more than I could keep up with given all the other things I was working on. And that's where the *Otomate* came from." The name *Otomate*, a clever portmanteau of the words tomato and automate, was proposed by a young farmer named Henri. Along with Mathew and Francois, Henri saw the potential of Serina's DIY greenhouse controller, and in the months that followed the first 2016 workshop he began building out the concept.

Over the years I have met with Henri and Mathew to discuss the project's evolution, from Serina's prototype to current version 2.0 that has a custom designed and manufactured circuit board. Winter is normally a downtime for farmers in Quebec, and in December of 2021 I reached out to Henri to discuss the latest iteration of the project. In response to my request for an interview, Henri invited me to brave the snow and join him in a *corvée* at his cooperative farm, where he, along with friends and family, would be building a new greenhouse.

Henri's farm is three hours east of Montreal. I spotted the place from a distance the outline of steel arches and small clusters of people moving rapidly through snow-white landscape giving it away. Within the group of volunteers pre-assembling greenhouse arches, I recognized Henri's father, Renaud, who had also been at the 2016 workshop. For the rest of the morning I worked alongside Renaud, fumbling with the frozen nuts and bolts as we put the arches together. The time passed quickly and at noon we stopped and headed into town to Henri's house for lunch. I joined Renaud in his car and as we drove the conversation turned to the *Otomate*. "I am really impressed by what Henri and the others have been able to do with the *Arduino* system," Renaud told me. It is a subject that Renaud is quite familiar with as he is a programmer by profession and a DIY electronics enthusiast.

Renaud explained how he had attended the workshop in 2016 to help Henri with the electrical work for the mechanical relay and he too had been fascinated with Serina's *Arduino* based microcontroller. Prior to that event, Renaud told me, Henri had not been interested in electrical engineering, but after seeing the direct applicability of Serina's project Henri started working on a version based on her model. Henri had told me something similar himself, suggesting that the workshop sparked an 'aha moment' for him. Reflecting on the experience during one of our conversations he told me: "I had participated in a first workshop in 2016, 100% 'noob' in electro-mechanics and I came out of it with 2-3 really practical notions, a vocabulary, and especially the experience of having handled the tools related to electrical equipment" (Racine, 2021). He went on, "It just made it much easier for me to tackle this kind of problem after that experience. Because even if we didn't get a DIY controller out of that workshop it at least broke down some barriers in my head." Following the 2016 event, and working with the initial concept from Serina's prototype, Henri had built an automation system for the farm he was apprenticing on.

The CAPÉ's workshops happen on an on-demand basis, and each year members are asked which tools they are interested in having workshops for in the coming season. In 2018, as members expressed interest in another greenhouse roll-up workshop, there was an additional inquiry about whether they could incorporate an inhouse design for a DIY microcontroller. "Basically, we got feedback from a few people who were interested in doing a workshop similar to 2016," Henri told me (Racine, 2021). "I showed interest in organizing it, since I had already *bricoléd* an automated greenhouse system for the farm. And then Andrew put me in touch with Mathew and Francois and boom, we became a team."

5.1.5 Tapping the collective intelligence

As a group they began researching what existed on the market. This research, according to Henri, further confirmed that there was nothing available that met the needs they had for an affordable greenhouse automation system. After some consultations with Serina, whose busy schedule made it impossible to keep working on the project, the three set to developing their own model. “We decided to build a version that would do specifically what we wanted, 100% farm proof and ‘noob proof’ electrically, and that anyone could fix without blowing stuff up.”

What made the group particularly strong, according to Henri, is that they each brought specific competencies. Francois, for example, was an electrical engineer, and he had in fact developed the mechanical relay system with Andrew in 2016. Mathew, who had a background in supply chain procurement, opened up an entirely different set of possibilities for the technology. “I think for all three of us it was kind of a chance to do a project collectively, efficiently with a clear deadline, and take advantage of resources and skills that we didn't have on our own” Henri told me. To which he added jokingly, “and we are three geeks who have a particular attraction for electronic components and the smell of burnt silicone.”

Henri’s point about the different skills that each of the members brought is important aspect to explore further if we want to understand why the network has been successful. In a conversation with Mathew, I observed how he, like many others in the network, brought a wealth of very specialized knowledge. In Mathew’s case, he brought important connections to resources the network had not considered before. Though he was not a programmer, he played an integral role in getting the *Otomate* project off the ground because of his ability to make connections between many otherwise seemingly unrelated parts. His work in a mid-size lighting technology company exposed him to manufacturing processes that allowed him to see how these resources might be brought into the CAPE's process. The custom *Otomate* circuit board is a perfect example of this.

In the early prototypes of the *Otomate*, the group had patched together a unit thanks to Francois’s experience as an electrical engineer. But the result was a technology that was quite complex and far more challenging to reproduce by less skilled individuals. What’s more, the amount of wiring and soldering required for Francois’s prototype made it difficult to accomplish producing the technology in the short time frame the group generally allotted for tool build events. Having spent a great deal of time in China working in supply chain procurement, Mathew proposed that the group should have their own circuit board made. "What people don't understand is that China has really built up an incredible capacity for manufacturing at any scale. While a custom circuit board might seem like an expensive proposition, its not, because of the way they are manufactured,” Mathew told me (Levin, 2021).

> “Think of it like a business card. Printing a single business card would be expensive. When you order a whole bunch of cards, they print them in batches along with other cards. It is the same with circuit boards. Producing just one would be expensive, but if you add your order to a batch of circuit boards that are being manufactured at the same time its actually very affordable."

Although initially skeptical, Henri and Francois decided to take Mathew up on the idea of trying to put together a prototype based on a custom circuit board. Mathew introduced them to an open-source program used for drawing circuit boards and once they had a preliminary design, he reached out to a contact he had made through his work with the lighting company. Describing the process to me Mathew mentioned how the relationships he developed with individuals in China had been critical in sourcing components for his previous job. He was still in contact with many of the manufacturers he had met, often having spent time visiting with their families during his trips. The group sent off their design and a prototype shipped back, to which they made a few small corrections before ordering 60 circuit boards.

If you were to look at the third and latest version of the Otomate, it would be hard to pinpoint Serina’s contribution. But tracking back through the history of the technology you get a sense of how even a small invention within the network, like Serina’s, can have a major impact. These observations are also true in regard to the roles of Henri, Mathew, and Francois, each of whom have contributed different refining aspects. Francois brough an engineer’s precision and competencies, finding a clear way to adapt Serina’s model to the mechanical relay he had helped Andrew design. Serina’s concept catalysed Henri’s curiosity and he learned programming and basics of electrical engineering as a result. It was only by chance that I discovered Mathew's role in the project, although we had been in contact over the years. Individuals like Mathew can easily be overlooked in this process as their contributions are often less technical and instead geared toward making connections to possible resources and alternatives approaches.

As I have explored the evolution of technologies developed by the *Autoconstruction* network, what stands out is how the process of refinement deepens users’ involvement through fostering their innate curiosity and experience. A comparison with a conventional technology might help to illustrate this point. Consider how with most technology the user is reliant on the company that is developing the proprietary technology to improve, service or update it. While a user could hack or repurpose the tool for different means, within the conventional model it is difficult and, in most cases, rare for user feedback or experience to inform the technology upstream. In contrast, within a grassroots innovation network a participant can move between being a user to a producer, or from a participant to an innovator. That is to say, the experience and knowledge of the user becomes vitally important in surfacing and refining new technologies developed by the network. Participants in the network often move between different roles for different project. For example, a member that is a participant for the salad green washer, might take on the role of coordinator for a root washer workshop. As is evident in the examples of Henri, Mathew, and Francois, throughout this process the background of individual participants, which may seem unrelated to the challenge at hand, can actually propel the innovation in novel and unpredictable directions.

In this way the CAPÉ *Autoconstruction* network might be seen as an emergent system in which the personal experience of participants feeds into the collective potential of the network. Each member brings their unique perspectives and skills which in turn shape the technologies and the innovation process itself. It is the technology, which is designed to be open and accessible, and the novel processes the organization has developed that facilitates this feedback mechanism. Just as Jean describes an early experience of participating in a corvée as planting the seed of becoming a farmer, Henri's participation in the 2016 workshop sparked his curiosity in electronics. This seemingly inconsequential interaction ultimately led to the development of the organization's most popular tool. Because this open process is designed to bring more people into active roles within the organization, the diverse skillsets of members like Mathew and Francois can be tapped, leading to increasingly complex technologies.

"No-one can do what everyone can do," says systems theorist Alexander Lazlo (Veem, s. d.). This collective intelligence, or 'sum is greater than the parts,' observation is captured by Henri when he points out that collectively the *Otomate* team was able to "take advantage of resources and skills that we didn't have on our own." Within this model, innovation can come from anywhere at anytime. So, while the organization is addressing real challenges through creating new tools, what is perhaps more important than any individual technology is the innovation ecosystem which is emerging through this dynamic process. As the evolution of the *Otomate* demonstrates, the *Autoconstruction* group has developed a novel approach that emphasizes building members' capacity, a self-reinforcing process which in turn surfaces opportunities for deeper engagement and new ideas sourced from the many nodes of the network.

5.2 Design exploration Two

5.2.1 A Cartography of Innovation

How do you track the evolution of a technology from concept to material artifact? In this second design exploration, we build on the research-creation project presented in the previous chapter through the development of a cartography of innovation. As with the first project, this exploration was undertaken as part of the same six-month design studio during the winter of 2021. With the first research-creation project, we saw how an inventory might be used to help categorize and visualize the different processes that go into the fabrication of a tool. By developing a set of technical posters, we revealed a series of insights related to the process and methodologies used the CAPÉ *Autoconstruction* group. In particular, because the archives were mostly text based, it became clear just how much of the development process remains invisible.

Building on this theme of revealing the less visible aspects of the CAPÉ's process, this second project aims to develop a cartography which shows the early evolution of tools and technology as they move from abstract concepts to tangible artifacts. The data for this project was pulled from the organization's archives, primarily the online forums of the RJME listserv. The objective of this mapping process was to understand how the online exchange of ideas between farmers feeds into the innovation process. To begin, I combed through several years of exchanges using key words for specific tools to see how many instances of that word occurred to understand whether there was a correlation between frequency of mentions and eventual production of a that specific tool.

When building out the map I struggled with how to visually represent this process of moving from the abstract to the concrete. I realized that a static map was not really able to offer the kind of dynamic evolution and narrative I was interested in conveying. As the project evolved, I realized there was just too much information overwhelming the visuals, so I chose to put together a more interactive prototype built on a website. Appended below are screenshots of this prototype. The goal here was not to create a comprehensive list of all the tools or an entirely functional site. Rather I wanted to explore how I might create a tool that could articulate the complexity of this work while bringing to light new insights.

The maps engage interrelated scales, each of which straddle both temporal and geographic boundaries. Conversations from the online forum have been arranged chronologically based on mentions of keywords related to a specific tool. The timeline along the bottom contains color coded points designating tool building events that have occurred.

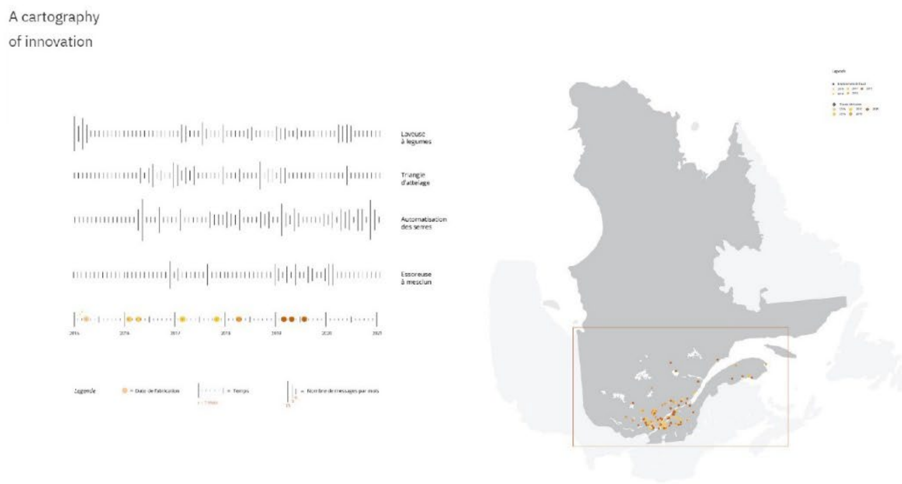
The large, adjacent map delimits the geographic extents of where the tools are currently in use. The color code corresponds to the date of fabrication. Each unique conversation chronology focuses on a specific tool. By clicking on a specific conversational chronology of a tool a third map is revealed. This map represents a tool building event. It is an imprint, a trace of the ephemeral event where the new technology moves from the abstract to the concrete. A zoom in on the larger map situates the tools once they have left the fabrication workshop to be deployed in different regions of Quebec. Each map can be understood as an attempt to capture different traces of the innovation process as it moves between temporal, geographic, and conceptual scales.

As with the first research-creation project the process of visualing things across scales surfaced new insights. A core reading for the atelier was on Bruno Latour's concept of Immutable mobiles and, as the visuals suggest, the point of interest is in how the different maps attempt to capture a trace of different aspects of the technological development process.

The finding from this project that was most helpful in advancing my overall research was that the CAPÉ's approach to innovation and production transfers much more than an artefact. On the one hand there is technology transfer, represented by the points on the map where the different farms have adopted a specific technology. But what is perhaps more salient is knowledge transfer. Each of the nodes on the map also represent people that participated directly in the fabrication of that tool, and therefore have acquired some level of technical and theoretical competence related to fabrication. In this map we begin to see how individuals play a vital role not only building tools but building the size and abilities of the network itself. Looking at the larger map, we can see this network effect happening - what might be described as a virtuous cycle - where more and more people are participating in events and subsequently increasing the capacity of the network and the potential for new innovation.

5.2.2 Diagrams and figures

Figure 5.1 *Cartographie de l'innovation* - landing page of website



Guide de l'utilisateur

Comment suivre une idée abstraite dans son évolution vers un artefact physique ? Centrée sur le développement de la technologie agricole open source, cette carte interactive tente d'explorer les différentes étapes de l'innovation utilisées par une coopérative d'agriculteurs basée au Québec. Plutôt que d'examiner les outils et la technologie elle-même, cette cartographie s'intéresse aux artefacts résiduels et éphémères de l'innovation technologique. Les cartes font appel à des échelles interdépendantes, chacune chevauchant des limites temporelles et géographiques.

Les conversations d'un forum en ligne ont été organisées en fonction de la chronologie et des mentions de mots clés liés à un outil spécifique. La chronologie du bas contient des points codés par couleur qui désignent les événements survenus dans la construction de l'outil. La carte adjacente délimite les étendues géographiques où les outils sont actuellement utilisés. Le code couleur correspond à la date de fabrication.

Chaque chronologie de conversation unique se concentre sur un outil spécifique. Ici, une troisième carte est révélée qui représente un événement de construction d'outil. Cette empreinte est une trace de l'événement éphémère où la nouvelle technologie passe de l'abstrait au concret. Un zoom sur la carte plus grande permet de situer les outils une fois qu'ils ont quitté l'atelier de fabrication pour être déployés dans différentes régions du Québec.

Chaque carte peut être comprise comme une tentative de saisir différentes traces du processus d'innovation lorsqu'il se déplace entre les échelles temporelle, géographique et conceptuelle.

Figure 5.2 Zoom in on *laveuse à legume* V1 and V2

CHAPITRE 6 Case Study – Third Part

6.1 A network assembling

6.1.1 Growing Complexity

Seven years out from the first root washer workshop, I found myself on zoom call with five farmers from across the province. We had all responded to a request for workshop coordinators for the CAPÉ's 2022 fall events. On the call there was Louis, a farmer that participated in a root washer workshop in 2019 and had been asked to join this group for guidance; Raphael, who would be organizing a salad greens washer workshop, and was curious to get a sense of how things were organized; Andreas, a younger farmer that was himself in need of the root washer and interested in helping plan the event; Lucas, who was still a farm management student and interested in learning more about the organization; and Pawel, a newly hired part time coordinator for the CAPÈ who was splitting his time between the *Autoconstruction* and the collective buying groups. As for me, I had agreed to help with organizing the 2022 root washer workshop in part out of a kind of satisfaction of ending where I began, but primarily because I wanted to understand how the organization's planning had evolved over the past seven years.

Even before the pandemic, the bulk of the coordination for the group happened at a distance, most of it by email, with the occasional phone call. Although synchronous file editing and sharing was beginning to be popularized in 2015, I recall that during the first root washer planning phase we relied much more on emailed spreadsheets and word documents. This time around we had all been given access to the organization's online shared drive folder. Here the files are organized by date, with a folder for each of the tools that has been constructed in that year. For example, in 2019 there were four tools built - a salad spinner, a triangle hitch, a salad washer, and the *Otomate*. Each of these tools had a folder that contained all the planning documents and designs that had been updated or created for that year.

The trend over time has been a steady increase in both the types of tools and amount of workshops each year – with the exception of 2020 when all events were canceled due to pandemic restrictions. Generally, each of the tools is on a two- or three-year rotation, depending on demand. When interest in a specific tool workshop grows to a certain level (say 10 or more farms) an event is planned for that tool. By way of example, the root washer was built in 2015, 2017, and 2019, meaning that every two years there has been enough interest to warrant planning a workshop. The *Otomate* is a notable exception. Because of the sustained interest from members, the organization now sells complete kits in addition to hosting collective workshops every two or so years.

The last root washer build was in 2019 and as I scanned through the plans, I noticed some major design changes. Perhaps the most significant difference was that the all-wood frame design had been changed to steel. This revised steel version was based on modifications that a farmer named Denis had made to his machine, sharing a video of it on the group's Facebook page. Denis had rightly noticed the all-wood frame was not only overkill in terms of engineering, but extremely heavy and near impossible to move around without a tractor. A number of others that participated in that first event, me included, realized this only after returning to the farm with our new machines.

On the one hand, the logic behind the all-wood version 1.0 was to make the construction more accessible. Given the event was to be held outside, we had planned it around tools that could be readily found in most garages. But the other reason that the first design called for wood frame simply had to do with a lack of experience - we had not anticipated how unwieldy that first model would be. I still see these version 1.0 models on the different farms across the province and I recall speaking to a long-time member of the group that had participated in organizing a number of events, including the first and second root washer builds. “We have learned a lot,” he laughed, pointing at the version 1.0 on his farm. “Since that workshop we discovered that we have to build a real prototype before going straight to manufacturing them!”

The iterative evolution of the root washer somewhat mirrors the way in which the organization itself has changed over the course of its seven-year development. Generally, when people speak of open-source technology and design, one immediately thinks of schematics and plans. Certainly, in the age of accessible CAD software like Sketchup, it is easy to quickly model and share 3D files instantly across regions. But in reality, a good design is only a small factor in the success of tools being developed by an organization like the CAPÉ. This is evident first in the many non-visual files and documents found in the organization's shared folder, and second in the less tangible institutional knowledge that is held by members of the organization.

As I continued to participate in the planning meetings for the 2022 root washer, the questions from the different participants highlighted the many variables that must be considered when producing these technologies. For example: what is the budget for the tool? Where were the materials sourced? What was the name of the contact at the last workshop? In many ways, these are the less attractive aspects of bringing something into a material reality. As I sifted through the shared folders, I saw how with each event the members have left traces as they addressed these questions. This might take the form of a large spreadsheet, in which I recognized some of the content from the original root washer in 2015. Or in lists of receipts and names of vendors which have expanded over the years. It can also be found in the precise budgets and lists of former participants. These small improvements can be seen as incremental learnings which add up over time, as the tool, the process, and the model are refined.

But these files also speak to the less tangible resources that are held by the network: the members themselves. As individuals engage in collective projects, they build up their own capacity. A member that has participated in an *Otomate* workshop one year will be able to engage even deeper the next time the tool is built. In this way, participants become an important part of the organization's institutional knowledge. Within an open-source framework all of these elements are important for the tool to be replicated. To put it simply, in order to avoid reinventing the wheel, it helps to know both what goes into making the tool and to have people around who have made it before.

Yet, the value of this process leads to more than just being able to reproduce the same tool. In many cases the learnings and processes from one piece of technology are often generalizable to others. For example, we can trace the template of the spreadsheet budget from the latest version of the *Otomate* back to tools like the root washer - when the organization first began formalizing certain protocols. With each event, those initial planning tools are updated, modified, and changed based on what the group learns throughout the process.

The same is true for relationships, contacts, and things as mundane as how to set up the workshop space before an event. All of these element's feed into a collective commons – a collection of resources that is drawn on and added to each time the organization takes on a project. In this way the organization has structured itself to reinforce a positive feedback loop across the different capacities that go into realizing a technological artifact. Whether it is a new member that first joins as a participant and later contributes as an organizer, or the way in which the technologies evolve emergently through members' collaboration, the common resources of the network expand with every new project.

6.1.2 The evolution of the technology as a means for tracking the expanding capacity of the network

The effect of expanding network complexity and collective intelligence can be seen in the evolving organizational processes, along with the tools themselves, as each of these builds on past successes and failures while drawing new resources into the system. For example, the 2022 root washer workshop coordinators had one major issue to resolve before choosing a date. Although it was still unclear how many members of the network were interested in the tool, the more pressing question was whether the root washer would be eligible for a provincial funding subsidy that would help reduce the cost for members. The subsidy in question is part of a program led by the Quebec *Ministère de l'Agriculture, des Pêcheries et de l'Alimentation* (MAPAQ) that aims to increase uptake of innovation that helps to reduce the environmental impact of farming. The grant allows farmers up to a 70 percent reimbursement for the purchase of new technologies that improve sustainability on the farm. Over the last few years, the CAPÉ has succeeded in having some of their tools qualified under this program. This development points to the network's growing capacity to draw in external resources while increasing membership and diffusion of their technologies. This formalization also supported the group along its trajectory away from ad hoc workshops to formal process which has allowed it to interface with institutions and public agencies.

Again, we can look to the tools themselves to better understand how this process has evolved. While the wooden root washer proved to be an inferior design, we have seen how the reasoning behind the first model was grounded in practicality: steel requires both specialized equipment and higher levels of technical competence. A steel framed root washer would require more skilled participants in addition to an industrial machine shop with space to accommodate large scale production runs. Arguably, in 2015 some of the workshop participants would have had the welding skills to accomplish this. But at the time finding an adequate shop space to accommodate 10 or more participants was certainly beyond the capacity of the network. What has changed since then?

In 2017, I photographed one of the CAPÉ's workshops for an article I was writing. This workshop was for a tool called a *déchaumeuse*, a tractor implement that mulches and incorporates green manure. Like many of the other technologies the organization has developed, there are versions of this tool on the market. However, the models available are too big and too expensive. For this event the CAPÉ had been working closely with a professor from a technical school to develop an appropriately sized design. Working with a technical expert on advance prototyping meant the group could avoid similar pitfalls that arose with the root washer (i.e., over engineering). Furthermore, the relationship with this professor also led to an opportunity to rent the technical facilities at the school, which made it possible to host the complex tool workshop. The *déchaumeuse* represented a major milestone for the organization in terms of technical ambition and partnership development.

I can still recall the stark contrast between the state-of-the-art technical shop that was used in 2017 and the pop-up workshop we had set up for the root washer in 2015. Steel cutters, welding booths, a boom for moving material through the space - it was clear that without a shop like this tackling a tool like the *déchaumeuse* would have been impossible. In turn, without a partnership with the professor and the school, entertaining this build would have been a moot point. Andrew was one of the organizers of the *déchaumeuse* event, and when I asked him about it, he could not keep his excitement in:

> "These farmers are doing really innovative work. I mean we just built a bunch of tools that you can't get this side of the Atlantic. And we built them for a fraction of what they would cost, even if you happen to live in France, or Germany, or Poland. The farmers just built them, and they are going to be all smiles in the spring. And rightly so. At the same time, we made gainful use of public assets held by a technical school which were going, not unused, but totally underutilized." (Alton, 2021).

The workshop marked a noticeable jump in the organization's capacity and the enthusiasm of the participants in the space was palpable. The relationships that were fostered from this event opened up new possibilities for the group. As we transitioned from sawhorses and hand tools to industrial machine shops, in the years that followed this event the range of projects that could be tackled expanded quite dramatically. It is no wonder then that the version 3.0 of the root washer reflected a more considered design – one that took into account the learnings of the previous prototypes, in addition to the new capacities that had been developed since the first model. That refinement is also reflected in the network itself, with each event serving as an opportunity to prototype the organization, expanding its technical capabilities as it builds its membership and connects with outside resources that can support its evolution.

Over the years the CAPÉ *Autoconstruction* group has developed strong ties to the *Cégep Victoriaville*, the *École professionnelle de Saint-Hyacinthe*, as well as the *Institut national d'agriculture biologique* (INAB), and the *Centre d'expertise et de transfert en agriculture biologique et de proximité* (CETAB+). It is these partnerships with colleges, technical schools, researchers, professors, and other sympathetic actors that add an additional level of generative potential to this process. In addition, these partnerships have also led to new opportunities to fund the CAPÉ's innovations through government support.

Which brings us back to the 2022 root washer event and the groups discussions around whether the tool would be eligible for provincial subsidies. Beyond providing material resources, these partnerships with institutions have led to a form of legitimization of both the organization and the tools they are making. This in turn has allowed certain tools to qualify for subsidies from the MAPAQ to incentivize uptake of emerging innovations. For example, tools like the *Otomate,* which the organization sells for around $1500, ends up costing the farmer closer to $400 after the provincial reimbursement. This has an added benefit of increasing the uptake of the organization's tools as well as attracting more members to the network.

As it has become legitimate within the eyes of government administration, through a combination of partnerships with institutions and more formal documentation, organizers have learned how to frame their work in a way that makes it eligible for this and similar programs. Another good example of this is how the organization has been able to tap into government funding for training and continued education for farmers. As discussed in the previous chapter, the participation fee for the workshops allows the group to cover the costs of organizing events and compensating workshop coordinators. Because the group has incorporated a component of training into the workshops the participation fee can be reimbursed to members through provincial training initiatives. For example, in the case of the root washer the organization offers a soldering training module.

Similarly, there are even greater incentives for members to participate as a workshop coordinator. In addition to receiving compensation for their time (covered by the member fees), if they are in need of one of the tools themselves, workshop coordinators are also eligible for the same innovation adoption subsidy. In other words, in certain circumstances it can actually pay to adopt the organization's technologies. Even as I highlight this point, I am hesitant to reduce the complexity of the organizations model to a purely financial incentive. From my observations and from the conversations I have had with members over the years, their motivations for participation have always been diverse. For example, Anna, an employee of a farm that had participated in of one of the previous washer workshops, told me she had volunteered to learn more about fabrication techniques. Similarly, members like Andrew, who have volunteered incalculable hours to building the network, are clearly not motivated by pure self interest.

6.1.3 Refining the process, refining the network: situating this work within the broader landscape of farm technology

For the last seven years, my interest in the innovative practices of organizations like the CAPÉ has continued to increase. As much of my research has focused on the less tangible aspects of their I have often felt somewhat isolated from my collaborators in the network who have been more focused on developing the technologies. However, over the last year there have been a number of developments that have led the group to begin reflecting on its processes, such as the organization working to increase the accessibility of their work. It is one thing for someone like Andrew, who has been engaged in the *Autoconstruction* group's work from the beginning, to be able to describe the process of developing a tool from 'a to z.' As the organization has grown and its tools are more widely adopted, interest in the group from external communities is also increasing. Therefore, the organization has highlighted a need to make the intricacies of the process more accessible to incoming members and well easier to adapt for other organizations.

Near the end of 2021, the CAPÉ hired Pawel to coordinate *Approvisionnment,* a dual role which includes both collective buying and the Autoconstruction group's work. I first met Pawel as part of the root washer planning call. As he was just getting his bearings in relation to all of the data, relationships, and resources necessary for coordinating the ateliers, he saw my research as potentially helpful in informing and refining the processes of the *Autoconstruction* group. Over the next months, he and I had series of calls where we discussed these topics at length.

In many cases the challenges the organization faces can be seen as a natural outcome of its own growth and success over the last eight years. As it moves towards formalizing processes, the legacy of ad hoc work and volunteer-led documentation and archiving has led to obvious inefficiencies. For example, while the group had kept good records of the different tool builds over the years, these files were hosted on a shared online drive folder and access to the plans were restricted to certain individuals. Any time a member who was interested in a tool wanted access to the plan they had to reach out to the group through email or Facebook. It was then necessary to go through a series of permissions which had to be granted by the groups administrators who were themselves busy farmers. What's more, as all of this work was managed by different individuals over time, there were inevitable idiosyncrasies between naming protocols and file formats which increased the complexity of distributing plans. Although the group has a section on the CAPÉ's webpage, to date there has been no formal way to access the plans from that site. An additional challenge was formalizing communication between members. Email remained the primary tool, although the group had attempted to start a forum hosted on a third-party platform that never seemed to take off.

The idea of a central website that could help address these issues had been an aspiration for many years, but a constant lack of human and financial resources had been significant barriers. In the late summer of 2022, the organization's application for a grant to prototype this digital infrastructure was approved. Having just completed his first season with the organization, Pawel took on the additional task of coordinating the development of the website. I took part in a series of discussions around the priorities of this future tool. For the first iteration the group identified the core features they wanted. The tool was to act as a central repository for the *Autoconstruction* plans, where members and the community at large could access the archive of tools and designs. A forum feature, where members could discuss ideas and coordinate with one another would also be integrated into the beta version of the site.

Early on in the process there was a discussion with Jean, who was coordinating the development of the Wiki-Maraîchère, about whether the two tools might compliment each other. Could the *Autoconstruction* groups site be nested within the Wiki-Maraîchère? The Wiki-Maraîchère, which the reader may recall, was an initiative proposed by Jean in partnership with the INAB, the CETAB+ and the CAPÉ. The wiki would be a resource based on the pathbreaking work of Anne Weil and Jean Duval, two researchers and agronomists who had written the authoritative text on organic farming in Quebec. The goal of the Wiki-Maraîchère was adapting this material to a digital format, making it accessible to a newer generation of farmers. The wiki format was chosen so that the tool could be responsive to the insight of members and adapt as the techniques and research progressed. The site would also allow members to develop a personal profile for their farm which would help connect people to resource within regions of the province.

Integrating the *Autoconstruction* site into the *Wiki-Maraîchère* seemed to be an obvious solution. However, both projects had received government funding from the same source and internal regulations prohibited them from being co-developed as part of a single tool. After some discussions with provincial funders and the agency responsible for the grant it was agreed the two sites could be built on the same platform. This was, of course, a major benefit for both projects. The idea of using a wiki format was central to both tools as each project was aimed at building sustained and meaningful engagement. With the proliferation of digital technology, the group had a lot of concerns around developing another online tool, which would mean yet another user login, another password, and adapting to a new user interface. The wiki format was chosen specifically for its familiarity and its capacity to enable users to modify, contribute, and improve the platform collectively.

In my conversations with Pawel and the other members on the committee, discussions often turned to similar existing platforms which could be points of reference for this new collaborative tool. For the *Autoconstruction* group, where collaboration to date has happened in a hybrid online and in person format, it was important to be responsive to this dual need. In these discussions, similar organizations like Farmhack and L'Atelier Paysan routinely came up, in addition to a more recent group called GOAT. GOAT, or the Gathering for open Agricultural Technologists, is both an online forum and bi-annual gathering that was founded by a mix of researchers, farmers, and technologists. The group is mostly oriented around digital tools and has been motivated by building out digital infrastructure and the 'tech stack' of open innovation for developers working on agriculture technology.

I attended the GOAT conference in both 2018 and 2022, and despite the global pandemic bracketed between those two dates, the topics of discussion were much the same: How to avoid duplication of efforts? How to develop technologies that farmers will actually adopt? How to ensure user's data and rights are respected? Unlike the CAPÉ or l'Atelier Paysan, GOAT is led by technologists, thus this question about whether the technologies they develop are based on users' actual needs is always present. At both the 2018 and 2022 conferences, there were very few farmer participants. However, one difference in tone that I observed in 2022 was the growing acknowledgement that farmers were wary of investing in new technologies where they had very little say in the development and evolution.

A story I heard from Jamie, a software developer working on a farm management tool, illustrates this issue perfectly. At the conference I quickly connected with Jamie over our mutual interest in cooperatives and we spent a number of meals discussing the potentials and shortcomings of digital innovation. During one of these conversations Jamie mentioned a farmer he had been working with who had soured to digital technology hype after a bad experience with a CSA management tool. The software had been complicated to learn, requiring several seasons for the farmer to figure out. Then one year, without much warning, the management tool was discontinued. Or, in industry speak, 'sunset,' a term used for when a digital tool is phased out. In this case, Jamie told me that the start-up that had developed the tech had been purchased by another company and the service was simply dropped. Feeling burned by this experience the farmer had gone back to using spread sheets and was now hesitant to adopt new software at the risk of having it sunset without warning.

While the example from Jamie is about a digital tool, there are obvious parallels to farm 'hardware' where small scale technologies and tools have rapidly disappeared over the last century. As we have seen, organizations like the CAPÉ have evolved directly out of this lack of appropriate tools - not to mention the issue of relying on innovations that lock farmers into relationships with vendors that have an outsized say in how the technology evolves. Indeed, as digital innovation increasingly permeates hardware this issue has become a rallying point for the 'right to repair' movement where the complexity of emerging innovations and patent laws effectively make these technologies a black box. Speaking of the vision behind keeping the *Otomate* open and easy for users to both understand and modify Henri put it to me this way:

> "When a tool is open-source, or minimally well documented, it gives you the opportunity to question each choice of design and really know if what you buy meets your needs. Otherwise, in my opinion, you may also be paying for the interests of someone else who may have very different objectives" (Personal communication, 2022).

For organizations like the CAPÉ, it is not simply a question of gaining access to affordable tools. Perhaps because of the history of innovation that has marginalized small-scale producers, there is a keen awareness of the ways in which technologies hinder and disenfranchise farmers that are working towards alternative models of agriculture. Henri's comments reflect the awareness of what's at play with emerging technologies and their potential to reproduce systems and models of farming which are in direct opposition to work of the *Autoconstruction* group.

But as the organization grows, they are faced with the tension of how to evolve to meet the needs of their membership while ensuring that they do not lose the more radical and generative potential that characterizes their model of innovation. Inevitably, there are risks associated with launching a new digital platform for an organization like the CAPÈ. As I have highlighted in this research project, a good part of the innovation that drives these kinds of grassroots networks happens in an organic way that can be hard to quantify. Thus, it remains to be seen whether the new online collaboration platform will be widely adopted by users and integrated into the organization's process. But there are also risks with romanticizing the ad-hoc and scrappy origins of the group. While a desire to keep the work uncorrupted from what seems like the all-consuming capacity of the digital world might be well intentioned, it also reifies grassroots movements which have always had to negotiate technology. Indeed, the CAPÉ, like l'Atelier Paysan and Farmhack, owe some of their success to the ubiquity of internet and communication technologies which have enabled cooperation at scale and accessibility to newcomers. There is not a definitive right answer to the role of digital technologies in the CAPÉ. What's important is that the CAPÉ continues to follow a democratic and small farmer-led process to make such decisions. In this sense, this research is not so much about trying to anticipate what technologies will define the future of farming, but how they will come into being. Will it be imposed by well meaning industry and policy makers? Or will it be enacted in the fields and workshops of farmers and communities that are experimenting with emergent forms of organizing and democratic technologies that are themselves in the process of becoming?

6.2 Design Exploration Three

6.2.1 Assemblage as an emergent innovation system

In the previous two design explorations I have drawn out some of the less visible aspects of the work of the CAPÉ. The first project did this through an inventory that explored the processes that go into the production of a technology. The second project used conceptual cartography to examine how tools evolve from abstract ideas to concrete realities. With both the research creation projects and field research, I have attempted to demonstrate how the network is assembling itself through assembling technologies. In this final design exploration, we dive into self-assembly and how it might support us in understanding the work of the CAPÉ. As with the previous two design explorations, this project was produced as part of the 2021 winter design studio led by Thomas-Bernard Kenniff.

How can the theory of assemblage and how it relates to the qualities of emergent systems help us think about the broader implications of the CAPÉ's model of innovation? While the literal definition of assemblage is the act of bringing different parts together, the concept was theorized by Deleuze and Guattari (1988) in their work A Thousand Plateaus. Drawing on this, De Landa (2019) proposes a clear definition of the concept - the sum of an assemblage is greater than the parts. For De Landa what distinguishes an assemblage from a simple collection of components is the relations between the parts. Assemblage theory rejects the idea that the components can only have meaning in a single configuration, as the components can be mixed together and reconfigured to produce new assemblages. This capacity is what gives assemblages emergent properties. While Delanda has used this approach to describe the organization of a society - from the individual through to the state - we can see assemblage as a possible tool for understanding the system of innovation emerging within the CAPÉ *Autoconstruction* network.

A simple descriptive example is illustrative of this concept. Taking the case of the root washer machine, we understand how the plans are useful as an assembly guide for the user or group looking to develop their own tool. Like any good manual it describes not only the components of the machine but how these parts fit together. If the user assembles these parts as per the instructions, they should arrive at some approximation of the desired tool. But without the manual, that is the knowledge of how the parts fit together, do the components themselves become useless? Said another way, do the parts only have meaning in a single configuration? Without stretching this example too far, we can intuit that much of the basic parts could be reconfigured to create an entirely different kind of assemblage. Perhaps, for example, a table.

Moving between scales, can we use this heuristic to better understand the network itself? Just as we can understand the components of the root washer as parts that are given a coherent meaning based on the way we configure them, the network itself might be understood as an assemblage of different components whose relations give it meaning. Just as physical components are drawn into the production of the root washer, the components and member of the network are likewise drawn together into relations to produce an artifact. From in person meetings where ideas and prototypes are shared, to the online forums and databases where members collaborate, the need for the tool draws in actors and resources from across scales. We can think of these ateliers and build events as temporary assemblages.

But what happens after these workshops once a tool is produced? These people, places, and plans do not just disappear. If we stick with our heuristic and remove the relations between the components, are we simply left with a collection of meaningless parts, or can the components be reconfigured? Like the root washer, where we see how the same components might be reassembled to produce something new, we can see that the system level components of previous assemblages can be reconfigured. For example, a workshop or a contact on a farm might be reactivated and drawn back into a new assemblage. From one tool to the next, different projects activate the same components and draw in new ones.

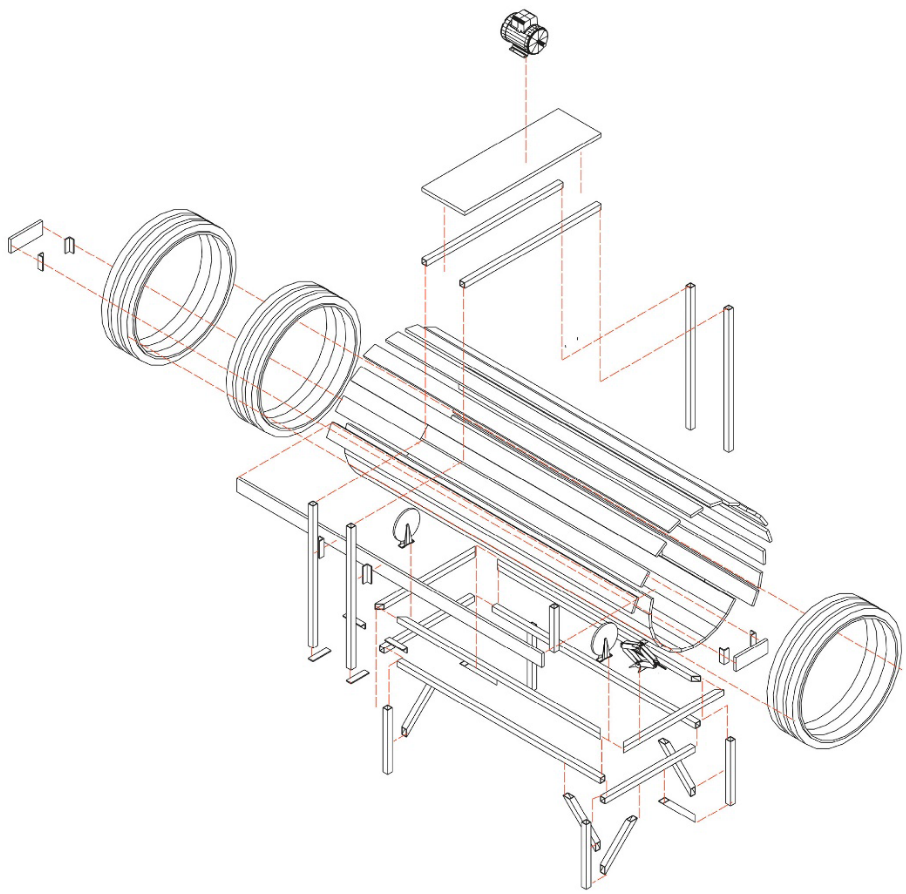
Since each tool creation process is an assemblage of the organization’s components at that moment, we can understand any tool produced by the network as a snapshot of the capacity of the organization at a given moment. One metric that represents this capacity is the complexity of the tool itself - say a wooden root washer in comparison to a metal one- which demonstrates the technical capacity that the organization is able to draw, such as funding, equipment, and technical expertise. An equally meaningful metric is the organizational complexity of the learning opportunities that the CAPÉ is able to provide through workshops, collective builds, kits, events etc. This organizing capacity demonstrates the non-tangible resources held by the organization, such as learnings, collective intelligence, relationships, communication tools, and partnerships of the organization in order to be realized.

These two metrics demonstrate not just a current snapshot of capacity, but a snapshot of the CAPÉ's potential to further the feedback loop of reputation, relationship-building, and knowledge building that continues to draw ever-more resources into the network. There may be no discernible connection between the root washer and the *Otomate*, for example, yet when we see how one enrolled the same organizational resources that were developed for the other, we can begin to understand the generative capacity of this emergent form of innovation. By generative, I mean it is expanding outward in an almost unpredictable fashion. All types of resources and members are useful, because at any given point they may find their way back into the system in some new assemblage.

6.2.2 Diagrams and figures

Figure 6.1 Exploded rootwasher diagram / Relations between the parts

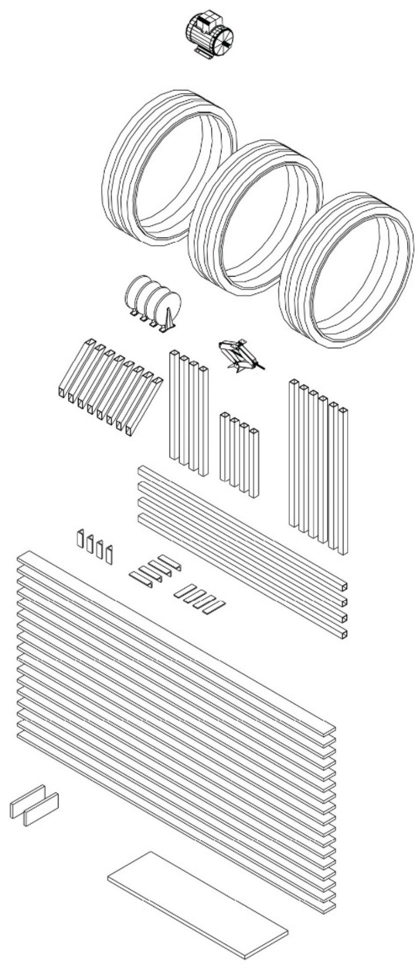
1.b



Relations entre les composants.

Figure 6.2 Parts without relations

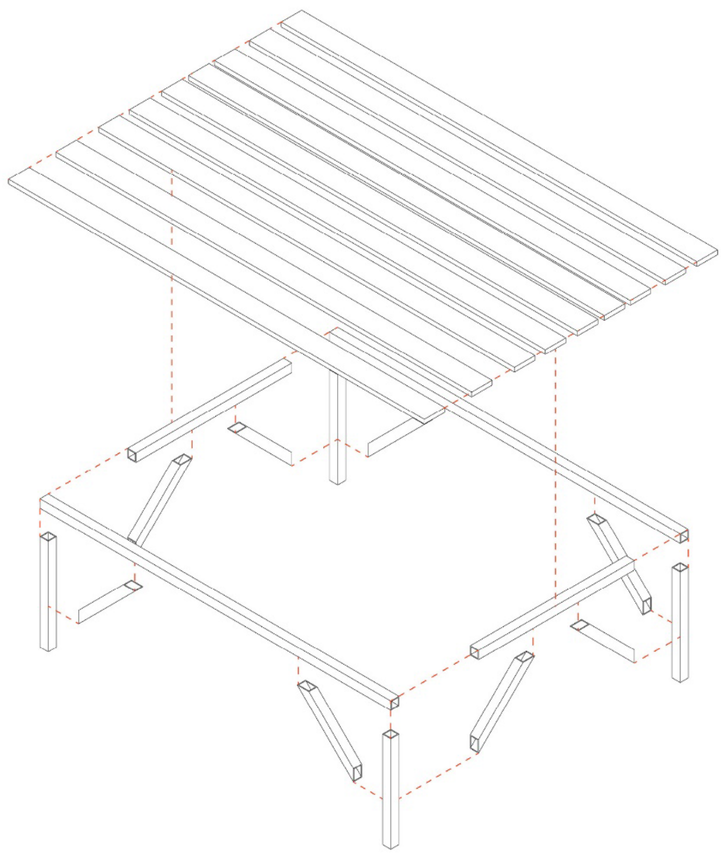
1.c



Composants sans relation.

Figure 6.3 The parts reconfigured through new relations

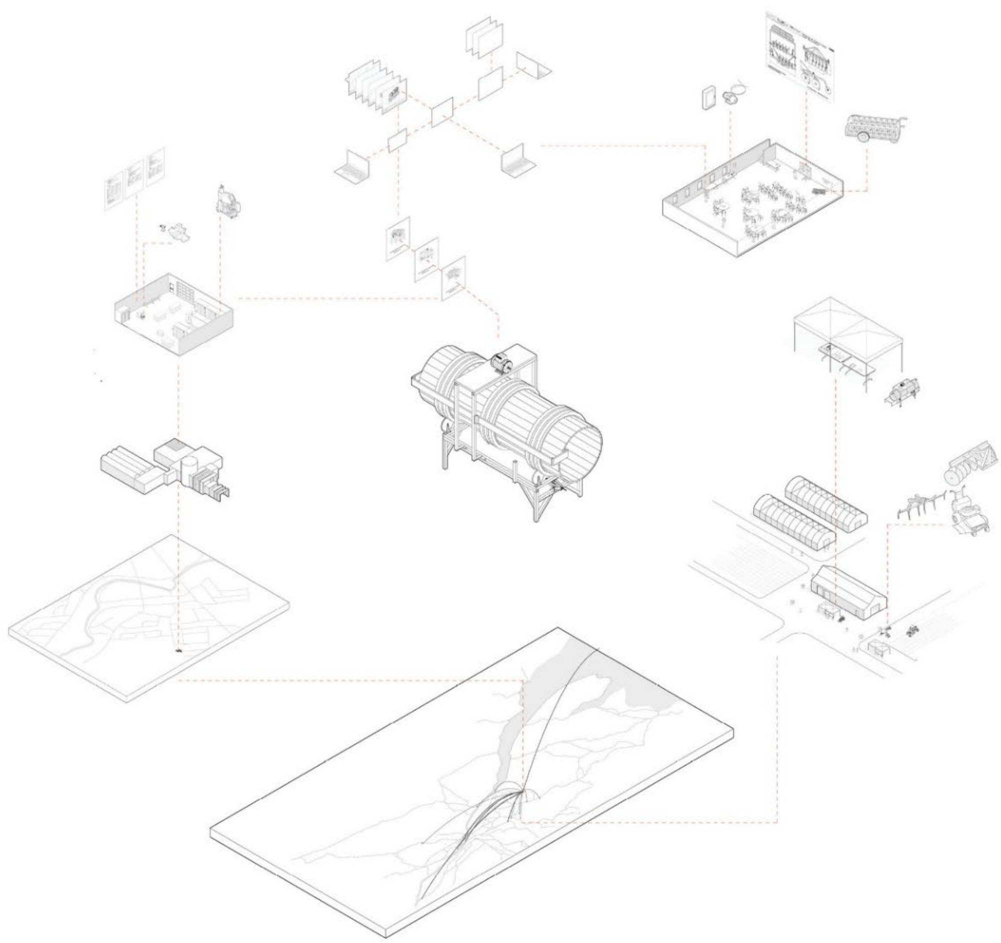
1.e



Les composants peuvent être reconfigurés.

Figure 6.4 New temporary assemblages created

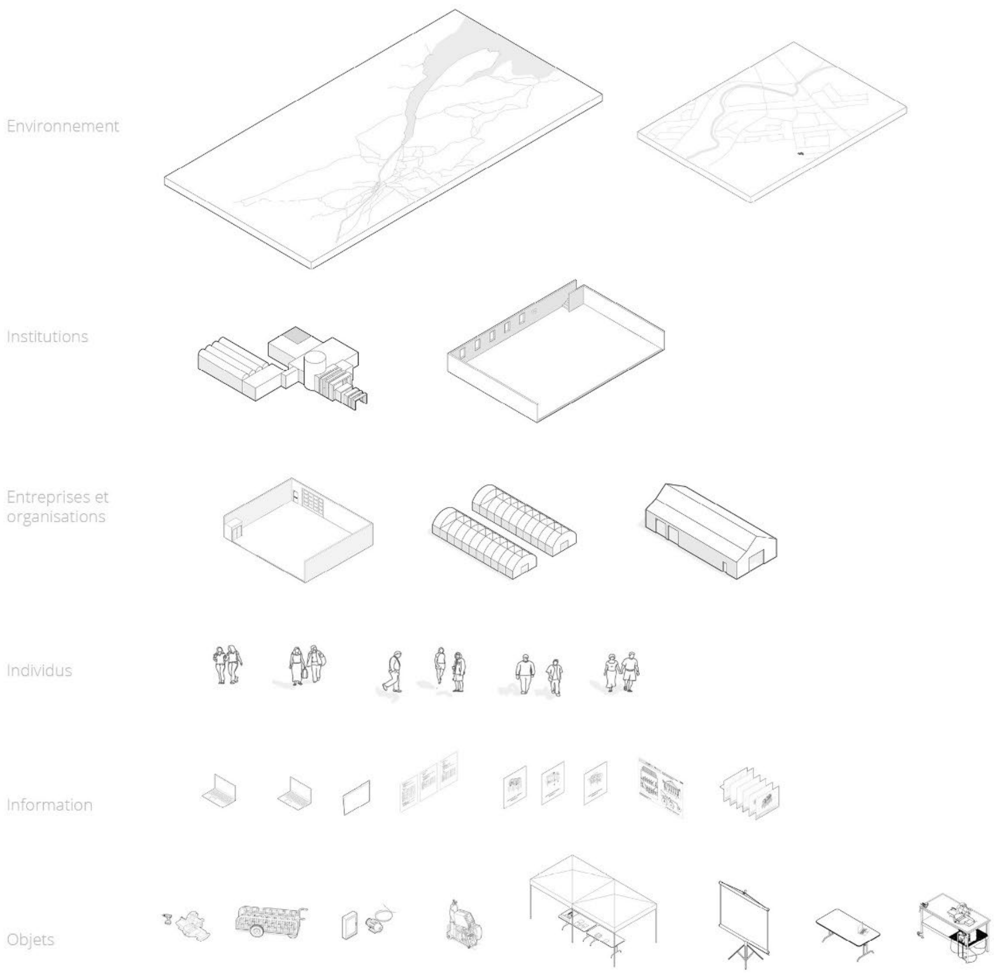
2.f



Mais que se passe-t-il lorsque l'outil est produit ?

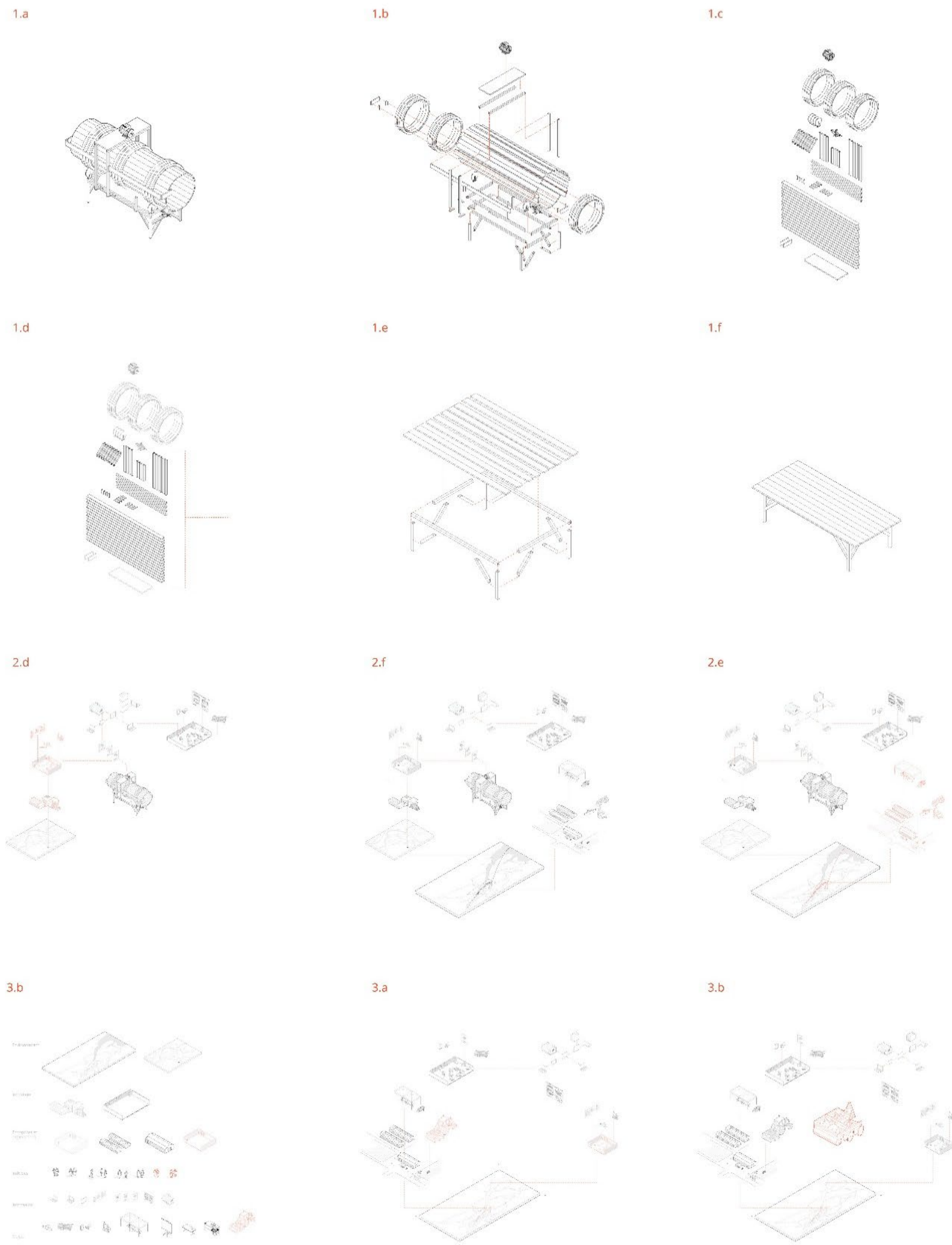
Figure 6.5 A system with the relations removed

2.g



Supprimons les relations entre les composants.

Figure 6.6 *Vue d’ensemble* of the systems as they assemble



CHAPITRE 7 Analysis – Bringing it together

7.1 Back to the future

Let's circle back to the introduction of this thesis where, in the late summer of 2021, I found myself on the bucolic *Trois Samson* farm, the location for the CAPÉ's *ExpoChamp Bio*. The event is a welcome punctuation to the hectic farm season, with coop members from around the province gathering to learn about different techniques and tools for small-scale ecological agriculture. The event also showcases new technologies, offering exhibit space for vendors to demonstrate tools aimed at this nascent agricultural sector. At that event I had been taken by surprise by the site of a small, autonomous weeding robot slowly roving through a newly germinated bean patch. The juxtaposition of this GPS guided drone next to more traditional farm technology and grassroots innovation captures the complexity of contemporary agriculture. On the one hand, the growing awareness of the harmful impacts of industrial-scale agribusiness has spurred the rapid growth of small-scale organic and ecological farming. Yet, even as this alternative movement of agriculture grows in popularity, emerging innovation and digital technologies driven by big agribusiness have been hailed as the next agricultural revolution, offering industry their own band-aid to supposedly reduce the harmful reliance on chemical fertilizers and pesticides. Drones, vertical farms, lab meat – the suite of innovations which fall under the heading of AG 4.0 collectively paint a picture of where agriculture could be headed. And, if we are to take the claims for these innovations at face value, it would appear that this trajectory is all but inevitable. Yet, as the scene at *Expo Champ* points to, and what I hope this research project reveals, this is a contested future.

Farmers have always tinkered with technology and built their own tools, but as technologists increasingly prioritize large-scale, industrial models of agriculture this tradition of 'making' has taken on new significance. Creating your own tool goes against the conventional grain, where, in much of our day to day lives, we have grown accustomed to the notion that technology is something that is designed by experts. Our role in the innovation process comes only as users and consumers.

So, what are the implications of communities designing and producing their own technologies? As we have seen in the preceding chapters, the tools coming from the CAPÉ are not some form of nostalgia for an historic and simpler past. These technologies emerge in hybrid contexts, where farmers participate in both online and in person spaces, co-creating tools that straddle the complexity of the contemporary worlds which they inhabit. As such, the technology the CAPÉ produces does not fit into simple categories like low-tech or appropriate tech. These complexities contribute an ever-present emergent quality to the organization and thus it would be difficult to try to anticipate where their approach to innovation will lead.

Nonetheless, if we are to understand the potential of such alternative technological trajectories and how these movements can be nurtured, we must understand what makes them unique. Through exploring the origins of the CAPÉ and the novel processes which they have developed over time, we can observe how the values, beliefs, and ideals of the people making technology play a significant role in shaping not only tools, but the worlds which we reproduce through our technologies. In other words, the future of agriculture is not some foregone conclusion determined by the inevitable march of technological progress, but something which is fashioned, negotiated, and imagined. I propose that this contestation can take place not only in the tech campuses of Silicon Valley or though media and industry discourse, but in the workshops, fields, meetups, and online discussions where farmers themselves collaboratively articulate agricultural futures through direct action.

Drawing on design theory and practice, through this research I have sought to understand how designing and producing technology has implications across the scales of the individual, the farm, and the broader ecosystems in which this emergent model of innovation can be found. This research has been led by a curiosity of how participation within a network changes our capacity to respond to the challenges we encounter as individuals and how our creative choices can impact the broader systems in which we act. In this analysis section, we will explore this proposal in greater depth, bringing together the salient findings from the field research, the design explorations, and the literature introduced at the outset of this thesis. The questions that have guided this inquiry are:

1. What are the novel design practices emerging within grassroots agricultural innovation networks?
2. What are the merits of this approach and how can we gauge its success?
3. How can we understand the broader potential of this approach?

While I have structured this chapter roughly around the guiding research questions, the analysis does not follow that specific order and there are clearly overlapping themes. This chapter begins by touching on the question of how to gauge the merit of the CAPÉ's approach – demonstrating that we might measure it's success by the how the technologies have transferred through the network. Following this, I highlight some issues with focusing on empirical data to assess the value of the organizations work. In section 7.3, I introduce a new diagram to synthesize the findings from the design and explorations and the field work.

7.2 Technically successful: A quantitative assessment of the CAPÉ's technology

We begin this chapter by switching tones. Thus far I have taken a qualitative approach to this research. While appropriate for a design project, in broaching questions of technology I would be remiss not to engage questions of the technical merit of the tools developed the CAPÉ. The organization is, after all, attempting to solve material challenges – how to wash vegetables efficiently, how to regulate greenhouse temperatures. If the tools they are making do not address these issues it would be hard to argue for their technological merit regardless of the innovative social practices or novel design methods. So, before turning to the qualitative data, we will first look at some ways in which to assess the group's technologies including (1) improvements of the technology over time and (2) technological transfer and uptake.

The *Autoconstruction* group emerged within the CAPÉ network in response to needs that were not being met through conventional industry and market forces. Over the group's evolution they have developed eight tools, all of which are currently in use by farmers across the province. Although the organization does not have a traditional approach to research and development like launching a new model or product every year, over time the technologies do evolve. Workshops for the same tools organized every second year or so lead to updates to both the process and the technologies. So, in looking to assess the performance and success of the group's tools, we can explore these different iterations to see in what ways they have improved from a technical standpoint.

In the case of the root washer, we have seen how the machine has been refined over the last seven years, with each version incorporating user feedback and collective learnings from the previous model. For example, there is a marked difference between the wooden 1.0 version I participated in and the current steel model. One clear advantage to this update is that it has made the tool lighter, which makes it easier to move and store on the farm.

There have also been small design changes to the structure of the tool. While the first model required two car jacks inserted into the legs to create the correct slope for crops to tumble through, the latest iteration has integrated a lift point at the center of the steel frame. From a purely technical perspective of improvement in efficiency, manufacturing ease, and portability, the tool has improved a great deal since the first workshop in 2015.

The *Otomate* has also undergone a comparable evolution over its seven-year history within the network. For example, Serina's version 0.0 was essentially serving as a thermostat. Her version 1.0 had two additional functions – it regulated heat through sensing ambient temperature by activated the mechanical greenhouse roll-ups. There were also noticeable problems with this early model. The electrical parts were housed in a repurposed steel breaker box which caused occasional condensation issues. It also required a laptop to get a data reading, which made it more complicated to troubleshoot.

Version 2.0, developed by Mathew, Henri, and Francois, was a noticeable jump from that early concept. The wiring was simplified, the code was improved, and the parts were standardized. To address the condensation issues, the electronics were housed in a watertight plastic box. To simplify the programming and troubleshooting errors, a digital screen was added. Of course, there were also bugs with this version 2.0, but on the whole, there was it was a noticeable improvement. The technology went from an innovative bricolage to a somewhat stable and easily reproducible device that could be used by most farmers in the network.

Version 3.0 of the *Otomate* took the technology even further. One major change was the design and sourcing of a custom circuit board which the group had manufactured in China. This dramatically improved the ease of assembly. Soldering onto a circuit board is much simpler than wiring many small parts and this change led to a reduction in the amount of time that had to be allocated for each fabrication workshop. In terms of technical specifications, the new model has also had increased functionality. In addition to greenhouse roll-ups and temperature, Version 3.0 is capable of controlling irrigation and has an external weather station integrated which enables the farmer to collect long term data on local weather patterns.

The latest *Otomate* model has also instigated a new approach to distributing the technology. Due to the pandemic restrictions in 2020, the group began pre-assembling and offering kits to members that were unable or simply not interested in participating in workshops. This novel approach to distribution, in parallel with the technical improvements, has made the *Otomate* one of the group's most popular tools. Looking at the improvements of the tool over time, we can see how the group has been able to build on Serina's early concept, simplifying the tool for less skilled users and building efficiency into the manufacturing and distribution phases.

A second approach to gauging merits of this process is through tracking the adoption of technologies within the network. This was the starting point for the design exploration in chapter five, which mapped uptake of four tools between 2015-2019. Tool adoption highlights that more farmers find the technology both useful and affordable. Technological adoption is a straightforward metric - we simply note how year over year more or less farms are adopting the tools. Again, the root washer and *Otomate* are useful case studies. In 2015 there were 14 root washers produced; In 2017 there were 18; in 2019 there were 16. So, in total there are close to 50 of these machines on farms throughout network. The Otomate presents a similar trajectory: 5 in 2016; 25 in 2018; 20 in 2019; and 30 in 2020. A total of 80 farms have adopted the technology over six years. Just looking at this rate of steady user uptake, it is safe to assume that the *Otomate* is performing well and that is encouraging more farmers to adopt it.

I've included these two empirical examples to demonstrate a concrete way in which we can assess the CAPÉ's output. Looking at both the adoption and the technical improvement of a tool over time are clear ways to measure the success of the networks process. It is important, after all, for the technologies to meet the actual needs of the members. If the tools are not technically successful, it would certainly be harder to make a case for the organization's approach to innovation.

There are obvious limitations to focusing on adoption and technical improvements to the organization's tools. Assessing the value of the tools based on increased technical complexity can privilege high-tech options over other design criteria. The issue of using complexity as a metric of success is that it can feed into a self-reinforcing cycle where technical sophistication is prioritized over other considerations like reproducibility, openness, and local sourcing of parts. This is evident in the case of the *Otomate*, which has seen significant increase in functionality and customization but has also incorporated global procurement of circuit boards. Elsewhere in this thesis we have seen how the 'high tech equals better' logic drives development towards conventional metrics of success like efficiency, increased production, and reduction in labour. The *Otomate*, like the group's other technology, remains fully open source. One can also argue that most of the parts in electronics today have dubious origins and so it would be difficult for the group to completely avoid global supply chains. Nonetheless, with an increase in technical sophistication comes a whole gamut of ethical questions along with considerations of how the tool improves or reduces the other aspects of the organization.

The root washer is a good example of a tool that remains relatively 'low tech,' yet has seen some major design improvements. The shift to a steel frame has provided obvious benefits but these also come with drawbacks. Steel requires welding machines, which necessitates a higher level of skill and better equipped shop space. If we were looking purely at the reproducibility of the improved root washer, we might actually surmise that going from wood to steel actually makes it harder for an individual farmer to make on their own.

This tension between technological improvements versus accessibility was captured in a post from Henri on the Autoconstruction Group's Facebook page some years ago. The post was a quote from the well-known organic farmer and writer Eliot Coleman where he cautioned against blind technological optimism. When I discussed this quote with Henri, he suggested that he felt the group must remember to prioritize accessible and 'appropriate' DIY solutions over exclusive and complex high-tech options. Thus, taking these other variables into consideration are important if we are to whether the groups technologies to respond to the needs of the community.

Similarly, while technology adoption and transfer is a good way to understand whether a technology is actually being used by farmers, it cannot capture the innovative social practices at the core of the network. Again, if the CAPÉ was to optimize for adoption, they might do away with the complexity that comes with organizing workshops, opting to outsource manufacturing to countries with a lower cost of production. Of course, the CAPÉ is routinely faced with these kinds of questions: Prioritize simplicity over functionality? Continue producing tools where market alternatives have emerged? If optimization, efficiency, and cost reduction were the sole objectives of the organization, choosing the path of least resistance would be the obvious choice.

For now, this has not been the case. The market for small-scale ecological farm technology is still nascent and this is one reason the group continues to pursue their own technological development. But as we will discuss in the following sections, through tackling these challenges together organizations like the CAPÉ seem to have arrived upon a model of design that inverts conventional expert-led, top down, innovation logic. Thus, while these groups have been able to successfully produce novel technologies, in the following sections I propose that the intangible outputs that result from this process could have more merit than the tools themselves. In order to interrogate this claim, we must shift focus from technological artifacts to the innovation process.

7.3 Making things visible: a diagrammatic exploration the innovation ecosystem

If the tools the network is producing do not in themselves represent the breadth of innovation emerging in the network, how can we begin to bring the less visible aspects of this process into view? While the organization's approach is implicitly understood by members, from an external perspective without initiation into the group it would be difficult to fully grasp the complexity of the model and its full potential. This is a common challenge within design research, where the objective is to make explicit intuitive practices that are like second nature to practitioners. If attempting to articulate the creative process of an individual is a difficult undertaking, the challenge is increased by an order of magnitude when faced with the creative practices of an emerging network.

Through the field research and design explorations we have begun to sense the contours of this form of innovation, approaching it from two overlapping methodologies: ethnography and research through design. Through the ethnographic work we have been able to track the origins of the organization and its evolution through case studies of specific tools and their development. The research through design has also worked toward making the different aspects of the organization's methodologies visible through a series of design explorations. Each of these explorations has fed into the other, allowing us to develop some preliminary analysis.

In this next section we continue working with this design centered approach to analysis, drawing together the insights from the previous explorations. Using data from the ethnographic fieldwork we then further refine the ideas developed through a conceptual diagram by offering clear examples of how this emergent system interacts as a whole.

Of course, there are limitations in any attempt to conceptualize complex and evolving practices. By deciding to highlight some aspects I am choosing to omit others. If research is inevitably an act of translation, the intention here is not to suggest that what I am describing is an objective reality, so much as a novel perspective of a rapidly evolving process. In approaching this as a design ethnography, the objective is to observe what might seem ordinary from a different vantage and thus reveal something yet unknown.

I have broken this task into two steps, each of which is based on a conceptual diagram. The first step we will call naming the parts. Drawing on the three previous design explorations, I present a synthesized diagram and describe seven key aspects of the organization's technological development process. This first step is meant to be descriptive and serves as annotative companion to the diagram. The concepts and presented here will be analysed in the following step.

This second step, which we will call 'understanding the relationship between the parts,' adds a layer complexity to the first diagram. Rather than representing the process as a linear flow, this revised diagram touches on the interactions between the parts in the system. I draw from the ethnographic data to elaborate how the built in feedback mechanism between the parts catalysis's points of emergence across what I suggest is an ecosystem.

7.3.1 Revisiting the previous explorations

In addition to these three diagrams, the sketch I developed prior to this research which was presented in chapters two and three is also a useful point of reference. Now six years ago, that initial diagram was an intuitive attempt at describing the CAPÉ *Autoconstruction* group. In that diagram I outlined a linear process that begins with an idea and moves through subsequent steps. In the model I suggest that the resulting tool would then be tested by members through real world use, with issues and problems prompting a redesign that kickstarted the process again.

The design exploration in chapter four used data from the organization's archives to develop a visual inventory. The challenge here was to impose a kind of logic to organize and represent the inventory. Like the previous diagram this exploration outlines a sequential development process for a series of tools. However, the diagram represents the tool not as a collection of technical parts, but processes which are instigated at each phase of the tool's development. In attempting to 'explode' the tool into overlapping processes the diagram highlights the many invisible aspects of this method. From spreadsheets and budgets to contacts and member competencies, this exploration pushes us to think about how these invisible parts are vital to reproducing a tool.

This interest in how to make the less tangible parts of the work visible was further elaborated through the innovation cartography presented in chapter five. The guiding question of this exploration was: how does a tool go from an abstract idea to a concrete reality? Using the RJME email listserv as the primary data source, forum member discussions of tools from 2015 and 2020 were plotted along a timeline. These mentions were then keyed to the fabrication dates of each tool. The concept behind this series of dynamic maps was to visualize how frequency and clustering of mentions corresponded with production of four tools: the salad green spinner, the root washer, the *Otomate*, and the triangle hitch. The first map shows the graphed mentions of each tool on the RJME listserv. A second larger map displays both the location of the workshop for each tool as well as the location of the farms that participated.

Taken together, these maps point to the increase in interest for the tools within the network, as well as how this interest has spread. The project further highlights how the expanding network can take on a new meaning if we consider that what is transferring is not simply technology but the practices of codesign, coproduction and mutual learning. We will return this proposition with the new diagram, but first let us conclude this summary with the final exploration presented in chapter six.

Building on the insights from previous explorations, the third diagram focused on the generative capacity of the network. This design plays with the idea of a tool assembly guide to explore the emergent quality of the network - mixing here the concepts of *assemblage,* collective intelligence, and self-assembling systems. The exploded technical diagram of a root washer serves as a point of departure for this conceptual model. The project draws a parallel between the reconfigurable parts of a tool, like the root washer, and the components of the innovation system. The proposition: just as parts of a machine can be reassembled to form new tools, we might consider how the different parts of the system can be mixed and reconfigured to yield novel innovations. It is not the parts, but the relation between them, that gives the whole emergent properties.

7.3.2 Step 1: Naming the parts in the system

> "Design is concerned with making sense of things - how they ought to be in order to create new meaningful entities... design becomes a producer of sense." (Manzini, 2015, pg. 35)

With each of the explorations above, I have attempted to make the networks model explicit through examining the process from different perspectives. This sensemaking continues in this section where I introduce a new diagram that draws the insights from the previous work together, naming the key parts of the system. The diagram is followed by an initial treatment of these seven parts:

1) The challenge
2) The individual

3) The prototype
4) The open exchange
5) The project
6) The institutional memory and collective commons
7) The extended network

NAMING THE PARTS OF THE SYSTEM

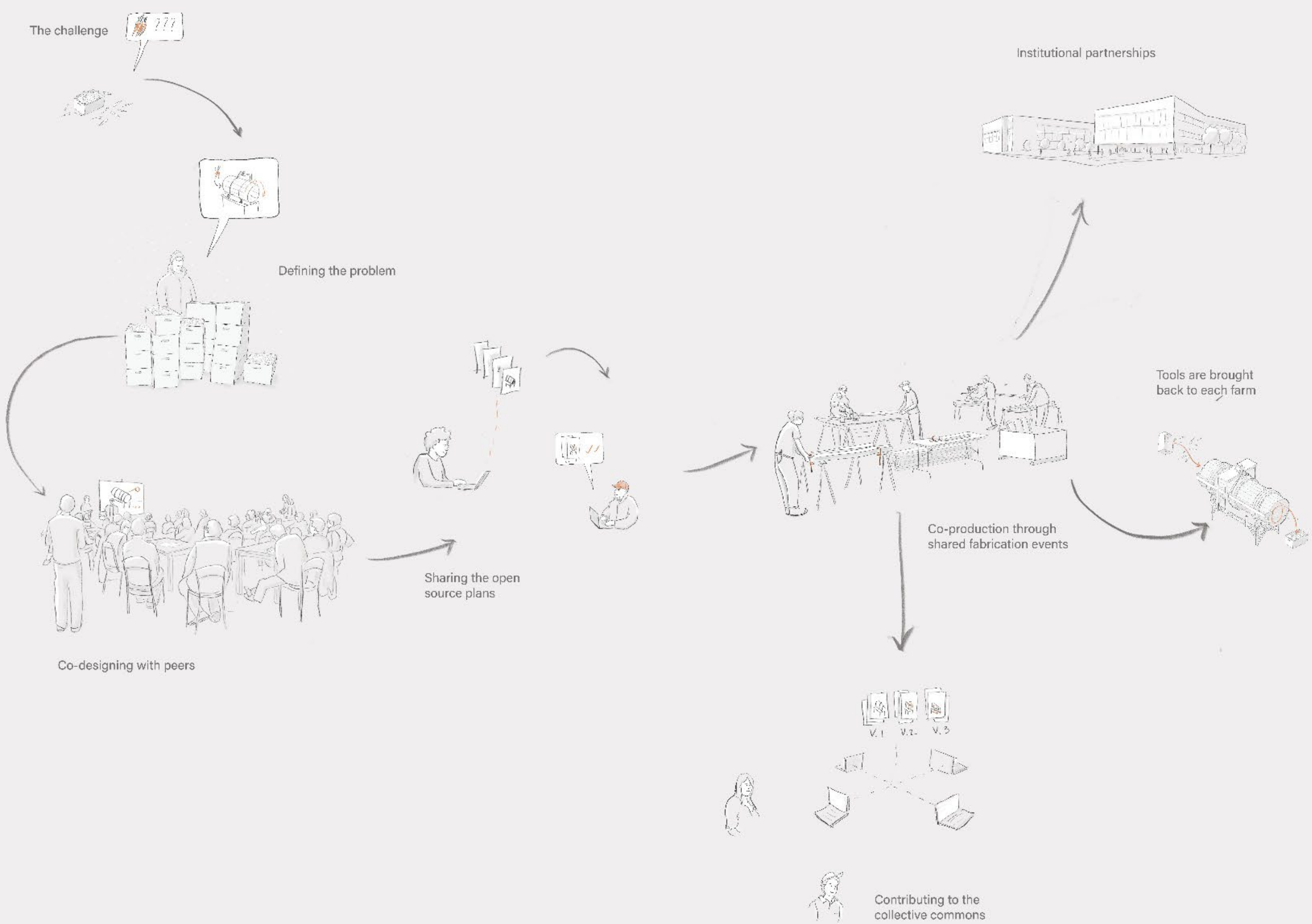


Figure 7.1 Innovation as a linear flow

1) The challenge: How do you wash a thousand pounds of carrots in November? How do you affordably monitor and control temperature in a greenhouse? On just about any day a farmer is confronted with these kinds of challenges. Some have existing solutions. Others require slightly tweaking an existing tool or technique. While others have no clear solution. This leads us to the second key component of this model:

2) The individual: A challenge does not exist as an objective reality. It is challenge, something in need of adapting or changing, if it causes a problem for someone. After attempting to wash carrots by hand on a cold November day, for example, you might begin to consider whether there is better way. The challenge thus emerges in relation to the individual farmer that is sensing their environment and constantly adapting and reconsidering things in function of their objectives. If there is no readily available solution, the farmer is faced with the choice of having to figure it out. This could mean quickly fashioning something out of what is lying around or mulling the problem over and fabricating a more intricate solution.

3) The prototype: In essence the challenge is an opportunity for creative action. Through creative action the individual prototypes a solution - perhaps a tool, a technique, or process. The prototype is a rough approximation how the individual sees the problem. Like the diagram it is an attempt to work out an idea in external form. This is fairly standard design process, but when the prototype begins to shift beyond the individual the process takes on an additional level of complexity and potential.

4) The open exchange: When Serina had finished her greenhouse thermostat prototype, she might have just installed it and moved on to the next item on her to do list. Instead, she brought it to one of the organization's events to show the idea to other members of the network. These kinds of opportunities for cross pollination between members within the network serve as an important inflection point where interesting ideas and working prototypes can move beyond their originator. Events like the *Rendezvous Automnal*, *ExpoChamp*, workshops, and online discussion forums all provide opportunities for members to encounter each other’s ideas.

But it is not good enough for an idea to simply be novel - it must also be useful to people beyond the person who first considered it. Serina's prototype DIY thermostat and microcontroller cost around $100 in comparison to the $2,000 - $7,000 commercial equivalent. So, while it was not new technology, it was an alternative to the unaffordable products on the market and that was of serious interest to other in the group.

5) The project

When there is enough interest in a prototype or idea, the network might decide to take it on as a project. For example, in 2015 I was not the only person that had grown tired of washing carrots in the cold. After pitching the idea of a root washer to colleagues it quickly gained interest from others and this catalysed a shared project. The objective of the project is to take a prototype or idea and refine it into something that will be useful for multiple members. A workshop is then organized, and any interested members get together to produce the tool. Each project draws in a handful of members, along with other resources and processes.

6) The institutional memory and collective commons

While there are always new ideas emerging within the network, producing a new tool does not mean starting from scratch. While technologies may differ, the process and resources developed through designing and manufacturing one tool are often applicable to others. This is the function of the organization, which serves to hold the institutional memory and collective commons of the group. These are the indirect, or secondary outputs of shared projects and might include new resources, relationships, material plans, and other artifacts that are produced during the process. The institutional memory and collective commons are both material (e.g.: spreadsheets, plans, parts) and immaterial (e.g.: relationships, processes, techniques).

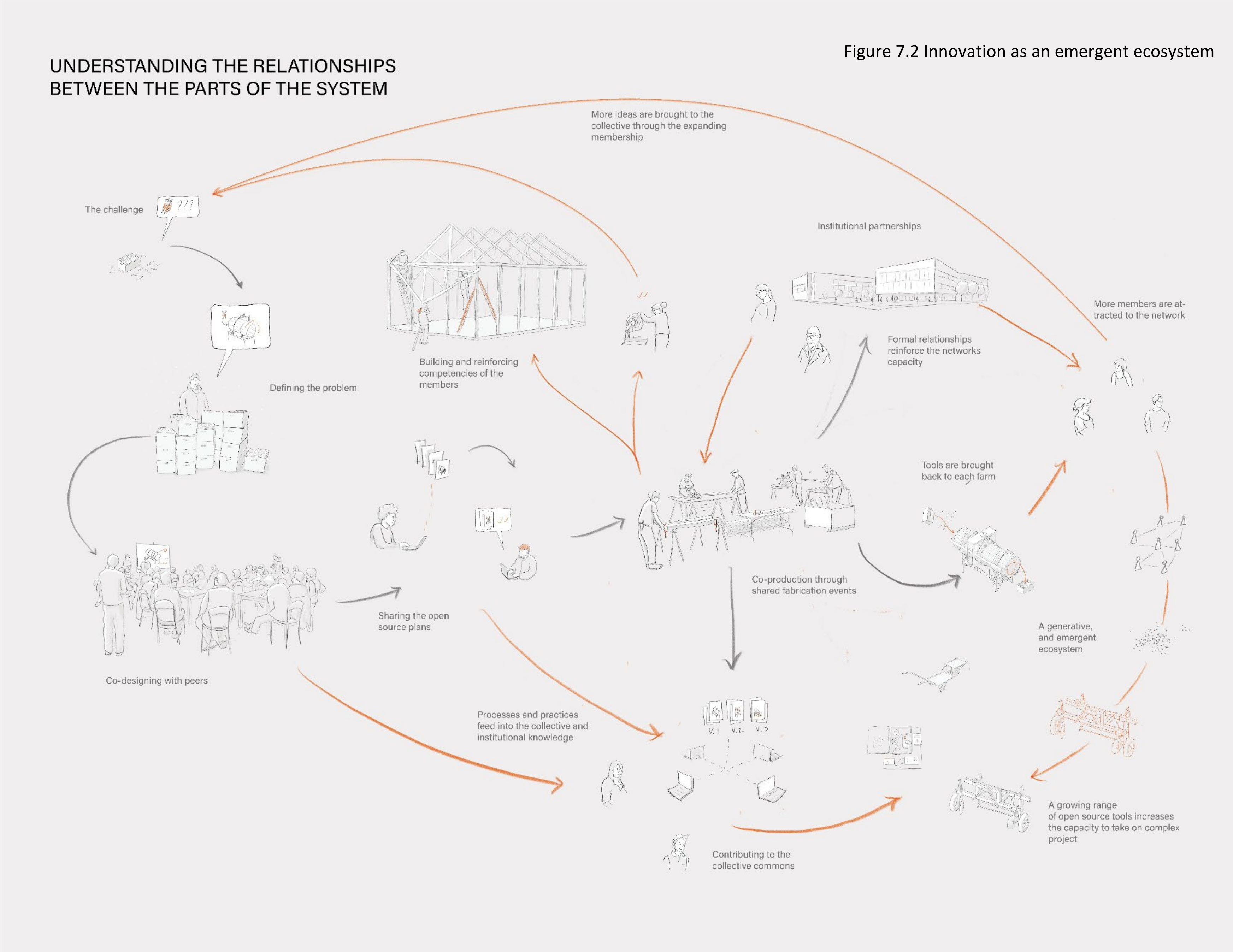
7) The extended network

Beyond the organization and the members, projects draw in resources from outside of the network. This extended network is made up of external partners, such as colleges and technical schools, suppliers, professionals, and government institutions. These resources find their way into the network through different channels. For example, a relationship a member has with a teacher might provide an opportunity to use the infrastructure of their institution for a workshop. This has been the case with the organization's connection with the CÉGEP Victoriaville and the *École professionelle de Saint-Hyacinthe*, both of which have become longstanding partners.

7.3.3 Step 2: Understanding the relationship between the parts

The process outlined in the previous section is linear: an individual is confronted with a challenge and creates a prototype to solve it. She then shares it with others in the network and it becomes a shared project. The shared project contributes to the collective commons and draws external partners into the network. In this section we turn to a revised version of the diagram, reconceptualizing it as a dynamic system rather than a linear flow. More precisely, this diagram proposes an ecosystem model, where the parts do not function in isolation but work collectively as a dynamic whole. In other words, it is not a one-way process that follows a set trajectory. At each stage there are feedback mechanisms and interactions between the different parts, a process that can catalyse a ripple through system. Following this added conceptual layer, we will further analyse this proposition through examples from the field work and design explorations.

Figure 7.2 Innovation as an emergent ecosystem



The challenge as a catalyst for individual creativity action

> "In real-world practice, problems do not present themselves to the practitioner as givens. They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain. In order to convert a problematic situation to a problem, a practitioner must do a certain kind of work. He must make sense of an uncertain situation that initially makes no sense." (Schön, 2017, p.40)

As we return to this question of the challenge and the role it plays within this dynamic system, Schon's distinction between 'problem solving' and 'problem setting' are useful guides. In his research exploring the intuitive knowledge of practitioners, Schon suggests that creative responses to problems often arrive when there is no obvious technique on which to turn to. The same can be said in the context of farming when the farmer is confronted with a challenge in which there is no readily available tool. While Schon is speaking of a technique, a series of protocols which can be followed in a sequential order, a technology is itself an of assemblage of techniques which can be reliably used to get a predictable result.

Without a tool or a readily obvious technology, without a solution on hand, we are forced to consider the problem. Here is where the distinction between problem solving and problem setting is helpful. Problem solving, suggests Schon, works on assumptions and existing protocols. It is a way of enacting solutions which approximate things we know. Problem setting, on the other hand, questions the problem at a deeper level. The problem, as Schon states, is not a 'given.' When neither the problem nor the solution are givens, we are forced to enter new territory. "Technical Rationality," says Schon (1989), "depends on agreement about ends. When ends are fixed and clear, then the decision to act can present itself as an instrumental problem. But when ends are confused and conflicting, there is as yet no 'problem' to solve" (pg. 41).

Because members of the CAPÉ are working within a sector that has not seen the same level of technological development as the conventional agricultural industry, they have less readily available solutions. For every problem there are untold responses and thus the problem is a matter of perspective. So, they are obliged to consider the problem from many angles, performing this 'problem setting.' It is the individual, along with their specific capacities and background which informs how they approach the *problem of problem setting*. This is the difference between 'solving a problem' and understanding the complexity of situation. The problem, then, is contingent on how the individual sees it and when there is no clearcut solution they must begin to activate their creative skill and intuition.

Thus, the encounter with a challenge is the point of origin for the innovation process we are discussing here. It is the individual that senses the potential of a possible change or alternative to the challenge at hand, setting in motion an orientation towards their environment that sees it adaptable and amenable to change. If a given technical protocol cannot be easily enacted, the 'technical rationality' that Schon speaks of, there are, even in the smallest challenges, possibilities for an alternative way of seeing things. The individual plays a small but important role in bringing this alternative into being.

If the problem is a subjective perception of the individual that encounters it, so too is the solution. This is a simple premise, but one which must be taken up seriously. It implies that a technology is, at its core, a reflection of how its designer sees the problem. In this sense, we might consider how the lack of available technologies opens the space for divergent problem setting. As a farmer encounters challenges, they may of course draw from what they have seen before, but they are also drawing from their own idiosyncratic experience and background. Each individual brings a unique view to every challenge.

We see this in the different prototypes developed by the network. Serina's early version of the Otomate reflected her scientific background - where she had learned to build programs to model forest ecologies - and her DIY hobbyist passion. In other words, seemingly unrelated knowledge and experiences can be brought together to produce novel solutions. This is further illustrated by the later prototypes of the Otomate where Henri, Mathew, and Francois, each contributed very different skills and resources to the second iteration of the tool. Those idiosyncrasies are reflected in the Otomate. In Francois's electrical engineering background, Henri's programming skills, and Mathew's deep knowledge of supply chain procurement.

Addressing a particular challenge on the farm would seem to be local response which does not have impact outside of that setting. Yet, in responding to these kinds of problems the individual is outlining a fundamental issue with the current system - in which no solution exists - and further makes a small contribution towards identifying this problem in a way that aligns with their values, priorities, and needs. The result of this effort is a tool, an approximation of the challenge, a prototype which now is the set protocol for addressing this challenge in the future.

7.3.4 The prototype and the open exchange of ideas

In this way the prototype is an amalgamation of the ideas and approaches of those who produce it. It tells us about how they see the problem and reflects their creative capacities. It is the creativity of individuals within the network that drive innovation. Yet this observation creates something of a catch 22. Is the success of the CAPÉ's tools due to a few highly creative individuals or the model? Without people like Serina or Andrew would the whole thing cease to work? A system which is reliant on handful of high performers serves very little value as a reproducible model.

As we move beyond the creativity of the individual on their own farm, we see the importance of open exchange and cross pollination within the network. At events and online, members are in constant conversation with one another about challenges, tools, techniques, and ideas that they are individually working on. If the encounter with problem is a possibility for activating creativity, engaging in these kinds of open collaborative spaces provides opportunity for members to sense the broader creativity of the network. An event like *Rendezvous* is a chance to observe how peers work, glean ideas and approaches, and strengthen relationships.

The stakes in these settings are often low and there is in informal conviviality that leads to interesting exchange and sharing between peers. One illustration of this is the '*bons coups, mauvais coups*' presentation I observed during dinner at the 2023 *Rendezvous.* Over the course of the meal members would share both a *mauvais coups*, or 'fail', from the season and a '*bons coups,*' success. Most of these revolved around a technique, processes, or tool that someone came up with and an example where things went sideways. But in all cases the reception was the same: positive. A good idea was met with the same enthusiasm as a blunder.

This is not to say that there is no competition or obvious desire to be seen as competent. Nonetheless, it highlights how these informal, open exchanges seed an environment of levity that is at once inviting and inspiring. The same is true at the workshops, where members share personal projects that they are working on, and through the online forums, where there is an endless stream of discussion threads on just about any topic imaginable.

The result of all of this can be observed in those moments when an idea slips over from a casual conversation to an inspiration. Whether at an in person or online space, the creative potential of a participant can be activated at any time. This, again, is directly reflected in tools like the *Otomate*. It was at one of these events that Henri became interested in Serina's prototype. He began dabbling in programming and developed his own model over the course of a season. His prototype in turn interested more people and soon members like Mathew and Francois saw opportunities for their own particular interests and skills to be of use. In this way, the free exchange of ideas creates an atmosphere of radical possibility. On the one hand, on their own farm each member is confronted with challenges and constantly coming up with novel prototypes to address them. At the same time, they are also participating in shared spaces where they are observing what others are doing, and through this process refining and adapting their own work. So, while there are certainly individuals that stand out for the high level of skill they bring to the group, there is a base level of encouragement and collaboration which creates a convivial atmosphere where members feel comfortable to participate and bring their own creative impulses to the network. In this open environment, in the best case someone might take your idea and improve it; in the worst case, you might get a good laugh.

7.3.5 The Project as formation

Formal projects provide further opportunities for members to engage in this kind of convivial and dynamic environment. In fact, the indirect benefits of projects are perhaps more significant than the development of the tools that they are organized around. We can see evidence of this through the impact of the project on individuals, the collective commons and institutional memory. But we also see this in the partnerships and connections created through the extended network.

We have seen how the open exchange at events and online brings out the different creative potential of individuals in the network. In the same vein, shared projects harness the diverse skills of members, as well as contribute to building up the competencies and capacities of participants. Take for example participation in a root washer fabrication workshop. Manufacturing the tool requires an understanding of metalwork, woodwork, and basic electronics. Because participants all have varying degrees of comfort and experience with the necessary fabrication tools, the organization has built in training modules to ensure everyone is well equipped for the workshop.

Recalling the 2015 root washer workshop, I remember the dramatic difference between the start and end of the day. The group included people who had never used a lot of the tools, like an electric circular saw, along with members with a high level of ease and skill around power tools. As the day continued and participants found their groove, it was hard to spot who was picking up a tool up for the first time. This observation holds true in the range of workshops the organization has led, whether soldering circuit boards for the *Otomate*, or the complex welding joints for a tool like the *dechaumeuse*.

But it is not just technical skills that participants acquire through participation in projects. Successfully pulling off one of these tool events requires a great deal of planning, preparation, and coordination. For each project a working group is formed to plan and organize the event. This group tackles all of preparation together, from redesigning technical plans, to sourcing parts and setting up the physical workspace. Working groups are typically comprised of someone that has participated in a previous build of the same tool, as well individuals that are interested or motivated for different reasons. In 2022, the working group for the root washer was made up of the *Autoconstruction* coordinator, a farmer that had built the previous tool, another farmer that was organizing a parallel workshop, two farmers that were interested in building the tool, and a student that wanted to learn more about the organization.

Together this group met on a bi-weekly basis, with each tackling different aspects of the project coordination and planning. An updated price list for steel and wood was required; someone had to contact the CÉGEP Victoriaville; hardware and electronic components had to be sourced; and a survey on participation interest had to be created and shared through the network's listserv. As with the more technical skills acquired through fabrication workshops, through participation in organizing and planning entire projects members gain additional skills around planning, management, and technical design. What's more, and this also true of fabrication workshops, members practice the cultural and social competencies of cooperation and collaboration that are central to the organization.

With each of these feedback mechanisms, one starts to grasp the impact of this accumulated skill development on the different parts of the ecosystem. The competencies and problem-solving skills that participants acquire through workshops are applicable to their everyday work. The next time a member encounters a challenge that might require welding, they now have the skill and comfort to tackle it. In other words, as more members participate in workshops, the collective competency and creative potential of the network expands. As members increase their experience, they are more likely to contribute novel prototypes which may then go on to become future collective projects. Members might also apply their new skills towards furthering an existing prototype - this is how Henri was able to go from participant with no programming experience, to redesigning and coordinating the last three iterations of the Otomate.

So, while each member brings their own unique perspective to problems, as they gain experience and observe the work of the peers in this environment, they begin to take on more complex challenges in their day-to-day work. Challenges become opportunities to practice creativity and the practical skills learned from workshops and projects equip them with the necessary skills and confidence. Thus, rather than becoming overly reliant on single individuals with high levels of competencies, the network is constantly fostering the creative capacity of all the members. As we have seen in the case of the *Otomate*, activating a single individual in the network can have dramatic impact on the whole.

7.3.5 The commons as a generative resource

In addition to feeding into the development of individuals within the ecosystem, the project contributes to both the institutional memory of the network and the collective commons. Institutional memory is best understood as the practices, values, processes, and relationships that are core to the organization. On the one hand, as either project coordinators or participants, members carry forward some of this institutional memory through ongoing practice and participation in the network. But it is the CAPÉ, as a formal organizational entity, which serves as the steward of this memory. The role of the organization is to ensure that learnings from past events, whether new approaches, best practices, or important relationships, are maintained over time.

A way to distinguish between how individual members and the organization hold this institutional memory is to consider them as implicit and explicit knowledge. The skills and knowledge of individuals are often implicit, acquired through practice and often activated intuitively. The aim of the organization, on the other hand, is to make the processes and practices explicit in order for them to be reproduced. The organization fosters this through its culture of cooperation, openness and through the events and online forums that facilitate practicing and transferring these values. But, more concretely, over time the organization has worked toward formalizing processes and capturing the 'learnings' of each event in order to better facilitate future projects.

While the primary objective of the project is the production of a particular tool, at each stage of the process ideas, new approaches, design changes, alternative sources, and relationships emerge. These learnings are made explicit through the range of artifacts and immaterial knowledge left as traces of the process. They are the secondary outputs of the project, and because they feed into a shared resource, they make up what we can understand as a shared commons.

Broadly defined, a commons is a collective resource that is governed by a group through shared agreements (Bollier et Helfrich, 2015). In the case of the CAPÉ we can understand the knowledge produced through the ongoing workshops and events as commons. One obvious example would be the open-source technical plans which users can readily access online. It also includes the less obvious resources, such as budgets, contacts, suppliers and even the layout of a shop space. These elements play a critical role in the reproducibility of a tool. To put it simply, to avoid reinventing the wheel one needs both *le savoir et le savoir faire* – the knowledge and the knowhow.

The evolution of tools like the root washer demonstrate how this collective commons advances the development of the technology over time. Despite the fact that there are always different people involved in projects, the learnings are available from the previous iteration of the tool because there is some continuity between coordination teams, and therefore the members can draw from those insights as they prepare for the latest version. The utility of this commons goes beyond specific tools. In many cases, immaterial artifacts, such as spreadsheet budgets, inventory calculators, and relationships with distributors, can be applicable to other tools. So, an improvement in the process for one tool can lead to an improvement in the process for all the tools.

We can see that the group, in addition to developing and refining technical artifacts in each project, is simultaneously building its institutional memory and organizational commons. Each project is itself an opportunity to prototype and refine the organizational practices. At the conclusion of a project, the commons have been updated. The collective intelligence of the network is expanding, both in terms of institutional memory and the individual members.

7.3.6 The extended network as an extension of the ecosystem

As we elaborate the interaction between the different parts of this ecosystem, we see how feedback loops are always increasing the generative potential of the network. An individual shapes the system while simultaneously being shaped by it; the project draws on the institutional memory while refining it and the individual capacity of members. In this way, the parts of the system are continually reconstituted through a mutual process of cocreation. From the individual contributor to the organization itself, we observe an ongoing learning process. But is this innovative process restricted to the network? If not, what are the boundaries of this ecosystem?

The success of the organization's tools have led to growing awareness of their work, attracting more farmers to the network who want to participate in workshops and more partnerships with institutions and organizations. Tool success and the size of the network and its partners form a reinforcing feedback loop. Early partnerships with technical schools dramatically improved the networks capacity to take on more challenging projects. For example, the *dechaumeuse* project in 2017 marked a significant milestone for the organization in both complexity of the technology and organizational capacity. This project was made possible through a relationship with a professor from technical school, which in turn facilitated both technical support and use of the school's workshop space.

Just as the creative capacity of a single member can lead to a whole new range of technologies, these kinds of relationships with external actors can spark collaborations that have an outsized impact on the evolution of the network. One dramatic illustration of this is how those formal partnerships with technical schools have contributed to the organizations increase in recognition from public institutions and policy makers. As a result, the CAPÉ has been able to qualify the tool building workshops as trainings, opening up opportunities for the tools to be eligible for government grants. These two parallel processes evolved quite organically.

In the first case, in an effort to encourage shared leadership roles and increase the coordination support for workshops, the CAPÉ began remunerating members that were willing to help organize projects. In order to cover this cost, they began charging a participation fee to members that were joining just as participants. Because of the formalized partnerships with schools like the CÉGEP Victoriaville, these workshops could be considered training programs, so the participation fee can be reimbursed to members through a government training initiative. This makes a compelling case for participating in a workshop as either an organizer or participant.

The second impact of institutional partnerships is that organization's tools are eligible for government subsidies aimed at encouraging uptake of technologies that increase farm productivity. Around the third iteration of the *Otomate,* the organization was able to have the technology qualify for a specific program of the MAPAQ. While the cost of the tool is already substantially lower than the market equivalent, this new development has further encouraged farmers in the province to adopt the CAPÉ's tool rather than a competitor's technology. The organization has since been able to qualify other tools in this program, including a row-cover roll up machine, and the root washer.

Because the organization does not have rigid boundaries, there are opportunities for it to draw in new members and actors who, in turn, participate in shaping the whole. As with the self-reinforcing system that emerges through the skill building of members, we can observe a similar process at these higher levels, where there is ongoing feedback between the different parts. In parallel to the uptake of technologies providing a quantitative metric for the success of the network, the transfer of the process of innovation itself points to the deeper potential of this methodology. Adopting a new tool will have an impact on the individual farm, whereas adopting a practice and an orientation towards creativity can impact the entire network.

So, the increase in the number of tools produced might be understood as an increase in the capacity of the network itself. An increase in participant membership means the organization has a larger pool of resources to draw from when it comes to sourcing ideas and organizing workshops. As we have seen, each workshop also serves to train and build competencies of the participants, which suggests that the network is increasing in size as well as competency and ability. This 'network effect' catalyzes a virtuous cycle where participation in workshops increases skills, which in turn increases the likelihood for more novel technologies to emerge within the group, which increases the number of workshops, which attracts more members.

As more actors are brought into the network there is a corresponding increase in the diversity of problems faced by members and possible opportunities to tackle these problems. Thus, innovative practices and innovative technological output are mutually constituted through ongoing entanglement. Without concrete problems and needs to address there would be no incentive to gather. It is through assembling together to develop a tool that the network reproduces innovative social practices which in turn support the ecosystem, building the collective capacity to undertake new and greater challenges.

Thus, each aspect of this process is self-reinforcing, with individuals drawing on established protocols and bringing in their own approaches, and the organization itself engaging in an ongoing reflexive process of refining and elaborating its approach. Simply put, this is an emergent process, where the system is both shaped by and shapes participants. "All creation is collective, emergent and relational;" says Escobar, "it involves historically and epistemically situated persons (never autonomous individuals), " (2018, p. xvi). The system which has emerged through the organization's collective work is a close approximation to what Escobar means when he calls for an 'autonomous design.' Autonomy, in the tradition which Escobar is invoking, is not about atomized individuals carrying out their own private lives, but the capacity of the smallest actor to shape and be shaped by the world.

CHAPITRE 8 Conclusion

8.1 Building the social infrastructure: situating the CAPÉ within broader movements

In the previous analysis chapter, I sketched out the salient features of the CAPÉ's approach to the design and development of technology. But it would be impossible to interrogate this process without understanding the origins of the organization itself. Just as scholars of grassroots innovation have pointed to seeds of the contemporary maker movement in early appropriate technology movements, the longstanding practices like the *corvée* and the early interactions between CEGEP students were the original germ of what would later become the CAPÉ. While gaps in the market can catalyse the emergence of grassroots innovation, the values and priorities of those communities are what shape the kinds of technologies they develop. What we see in the CAPÉ is a merger of the historical practices of rural Quebec farming communities, such as cooperatives, sharing and gathering, with the contemporary practices of the maker movement and modes of organizing.

As Andrew implied in our one of our conversations, the groups approach came about through a 'totally natural' proclivity to collaborate. What might seem natural to farmers that have come up in a culture of cooperation and sharing would likely seem foreign to many that had not spent years practicing this alongside peers. Sennett (2012) reminds us that cooperation is a skill that is learned, and the surest way to acquire a new skill is through practice. Thus, as the CAPÉ evolved from the first generation of back to the land idealists, to curious students seeking additional resources, and into established educational programs and organizations, the movement has been practicing, refining, and adapting their models of cooperation. We can see how these practices are embedded in the network's different programs and initiatives - such as the early direct to consumer CSA model, listservs, annual gatherings, and informal corvees. This culture of cooperation has been fostered through consistent opportunities for members to get together to share, support and exchange with one another. This historic context reveals why, when it came to addressing the lack of affordable and accessible technologies, members 'naturally' adopted a collaborative orientation. By the time the *Autoconstruction group* emerged within the CAPÉ, the network had long established these practices.

Giotitsas (2018) makes a similar observation on how the frames in which grassroots agricultural innovation networks emerge influences the organizations themselves. Contrasting the examples of l'Atelier Paysan from France and Farmhack in the United States, he notes how the French network, with its strong socialized system and state support, has led to a much more robust organization in comparison to its American counterpart. The U.S based Farmhack, where there is more emphasis on entrepreneurialism, quickly developed an online platform and garnered positive media attention and support. Despite this, Farmhack has not sustained the same level of participation and growth as the L'Atelier Paysan. This is not to suggest that one approach is necessarily superior to the other, but to highlight that, as with the CAPÉ, the social and political context in which these organizations have emerged have played a significant role in how they approached developing their networks, infrastructure, and technologies.

The lack of coordination and formal support for Farmhack has led to the organization focusing primarily on the online tool library. It is also worth noting that many of the original members of Farmhack have shifted their focus to a new organization called GOAT, which has a stronger emphasis on digital infrastructure and open data projects (Bronson, 2022). L'Atelier Paysan on the other hand, which emphasizes hardware and physical infrastructure, continues to build on the success of their in-person ateliers and has taken a more critical stance on digital technologies in agriculture (Clerc et Jarrige, 2020).

There are strong parallels to be made between the CAPÉ's approach and that taken by L'Atelier Paysan. While Farmhack initially worked on organizing events and in person meet ups, over time the focus went towards building a central website that provided open access to tool plans. Despite the fact that the platform is a wiki format and allows anyone to modify and edit the tool designs, this emphasis on the technological infrastructure does not seem to have fostered the same level of social interaction as L'AP or the CAPÉ.

The emphasis on building social conditions for innovation has been called *infrastructuring* by participatory design scholars (Ehn *et al.*, 2014). In contrast to focusing on novel technologies and artifacts, with infrastructuring the focus is on long term investments of strengthening relations in the network and developing collaborative processes. Before the CAPÉ began developing tools and technology, its members were practicing their own models of cooperation and collaboration through the early listservs, corvées, annual retreats, etc. The CAPÉ's approach to solving the lack of affordable tools has evolved directly from this lineage of cooperation. While the concept of infrastructuring used by participatory design scholars has not been adopted by the group, in comparison to the more technologically focused Farmhack we can see how it is an essential component of the CAPÉ's form of innovation.

It is hard to untangle the socially innovative practices of the CAPÉ from the projects in which they emerge. If the organization were to simply focus on social innovation without connecting the practices to concrete initiatives, it stands to reason that there would be a great deal less participation. Like the problems that spark creativity on the farm, the collective projects are based on real needs. It is through addressing these needs that the organization creates opportunities to practice collaboration. As Sennett (2012) points out, cooperation is a skill and as such is best learned through solving real problems. Like L'AP, the CAPÉ is managing to balance fostering social infrastructure through informal events like *corvées* and formal events like the *Rendezvous automnal* and *ExpoChamp BIO*, while providing tangible technologies for their membership. Jégou (2008) makes a similar observation in his call for everyday life projects as important sites for socially innovative behaviors.

It is not enough to simply get a bunch of people in a room to brainstorm good ideas. Speaking of the well-intentioned design thinking and social innovation that are influencing current management practices, Manzini cautions against what he calls 'post-it-note design,' process heavy group exercises that do not lead to real world change. Similarly, critics point to issues of social innovation hype, where implementation and real-world applicability of novel ideas can fall short (Ehn *et al.*, 2014). While these more meta-design processes can foster collaboration, without an emphasis on concrete issues they can waste resources and lead to disillusionment of participants.

At the end of the day, networks like the CAPÉ need to address challenges that often call for tangible tools and technology, and digital tools have played an important role in coordination and organizing. But as the group begins developing more digital technological infrastructure, it will be important continue the socially engaged activities. It is important to build both technological and social infrastructure. Having the perfect web platform does not guarantee an engaged community, and likewise it is ineffective to try to drum up social innovation without a practical challenge to address. In the case of the CAPÉ's model, the two seem to arise simultaneously through the interactions that happen when people are faced with a challenge and have developed the skills to work with one another to tackle it.

8.2 Feedback loops, creativity, and our capacity to act in and on the world

> "Breakdowns are moments in which the habitual mode of being in the world is interrupted. When a breakdown happens our customary practices and the role of our tools in maintaining them are exposed and new design solutions appear and are created." (Escobar, 2018, p. 113)

On the farm where I work the well has never had enough pressure to irrigate the fields. The solution to this problem, developed by one of my early farming mentors, was to place a reservoir at the highest point on the land. The well has enough pressure to pump up to this point and can slowly fill the reservoir over the course of a day. To irrigate, a gas pump draws water from the reservoir and directs it to the fields throughout the farm. Because the reservoir takes a long time to fill the well is always left on. This creates a problem. Sometimes the reservoir fills to the point where it overflows, which causes flooding and is a waste of water. A simple solution to this problem, put forward by a former colleague some years after the reservoir was installed, was to add a float valve, like you would find behind a toilet. This device shuts off the water once it reaches an adequate height. It was a simple solution to the overfilling problem, but the valve itself led to a different kind of spillover effect. After many years, the force of water pressing up on the float valve caused a wracking effect on the reservoir structure, eventually causing the walls to collapse.

A broken reservoir meant no irrigation. But not having a float valve meant the constant risk of water overflowing. In discussions with colleagues, it was clear we needed to install a new float valve but had to find a way to avoid the pressure on the structure. After a few days of puzzling the situation over I resolved to build a small scaffold that could hold the float valve above the reservoir to avoid contact and strain on the walls of the structure. Over coffee I sketched up a quick drawing, and while salvaging parts from around the farm another colleague volunteered to help with the construction. I explained my idea, showed my drawing, and we set to work building a very simple scaffold.

The sketch quickly became a point of departure as we modified the design in function of the parts we found and ideas and challenges we encountered along the way. By the end of the afternoon, the scaffold was built. I attached the water line and the float valve and opened the inlet. It worked. I felt an involuntary smile sweep over my face and a familiar feeling of contentment. This feeling was like that initial sense of awe and intrigue that I first felt when participating in the root washer event. I encountered a problem, imagined an alternative, and using what was on hand was able to realize this vision.

By all accounts this is an entirely unremarkable experience, and, in many ways, it is one which I have become almost habituated to as a farmer constantly having to address an endless stream of small crises each day. And yet, as I have tried to put my finger on the specificity of the process emerging in grassroots innovation networks, it strikes me that these kinds of daily challenges, which lack ready-made solutions, are small opportunities to practice an intuitive form of creativity. So, while these bricolage solutions themselves may not be all that compelling to a casual observer, there is something significant in the instinct, or perhaps the permission, farmers give themselves to solve these little problems. It is not without reason that we say, ‘necessity is the mother of creativity’. This instinct, or capacity, which I am speaking of is a direct result of the constraints most farmers encounter daily.

The process which I have described would be readily familiar to most designers. Let’s again recall Manzini who says: “when confronted with new problems, human beings tend to use their innate creativity and design capacity to invent and realize something new: they innovate” (2015 pg. 9). Scholars of grassroots innovation note that innovation often emerges in areas where traditional markets and industry have overlooked communities or have simply decided they are not worth investing in (Gupta, 2020 ; Smith et Stirling, 2016).

The CAPÉ, Farmhack and L’Atelier Paysan are each a good case study of this kind of market oversight. Given much of the industry has chosen not to produce technology for smaller-scale, sustainable agriculture, farmers, through necessity, have had to develop their own tools. In other words, by not having a ready-made tool on hand, these groups have had to activate their own creativity to imagine the kinds of tools they would need. Like most farmers that engage in these networks, I can track my own creative path - the development of skills, approach to addressing a problem, and collaborative work methods - through the various challenges I have encountered on the farm and through the organizational workshops I have participated in with the CAPÉ.

Perhaps this is what Escobar has means by autonomous design, a kind of direct action in response to breakdowns, in which design is necessary, intuitive, and immediate. "Every tool or technology is ontological,” Says Escobar, “in the sense that, however humbly or minutely, it inaugurates a set of rituals, ways of doing and modes of being" (2018, page 110). As I reflect on my capacity to respond to the problems on the farm in relation to a network of peers who are responding to broader systemic crises cooperatively, I am conscious of how much my own approach has been formed through participation in this network.

And yet, when confronted with challenges, how often do we opt for the tools which already exist at hand and what ‘set of rituals’ cascades from these decisions? How do these ready-made, pre-established tools, and ways of responding inhibit our own inquisitive nature? From an individual perspective, I am confronted with somewhat mundane issues daily and the choice: I either employ an existing solution or actively engage my own capacities in an attempt to solve the challenge. In both cases there is no guarantee that I will resolve the problem altogether. But as the ubiquity of ready-made solutions expands, two things happen. First, I increasingly disengage from having to solve the problem myself and I stop practicing this skill. Second, the environment begins to reflect the logic of the tool, conforming to the efficiency and needs of the technology, and establishing a feedback loop.

We see this in the landscapes of industrial agriculture which have evolved in sync with modern innovation. The values of the people designing the tools sets the frame for the problem to be solved. Enmeshed in a system of competition and thin margins conventional farmers have been caught in viscous cycle of adopting the latest tools in order to stay afloat. In turn, these technologies reproduce the logic of efficiency, optimization, and increase productivity, shaping the environment and further entrenching this dependency loop.

Speaking of this recursive capacity of design Escobar (2018) puts it this way- "in designing tools, we design the conditions of our existence and, in turn the conditions of our designing" (p. 4). Escobar is getting at our interdependence with our environments, both built and natural, what STS scholars describe as a 'socio-technical entanglement'. Still agency exists, both in those moments when we experience so called breakdowns, and in the small challenges we encounter daily where we practice creativity. Observing the systems of innovation emerging in groups like the CAPÉ, we see how practicing creative action as an individual and within a network shape not only tools but the world in which we enact these processes. Thus, we find ourselves in ongoing process of confronting both local and systemic problems, grounded in the knowledge that what happens on small-scale is a reflection of the whole. Again, to recall Ehn's words:

> "Practice is both action and reflection. But practice is also a social activity; it is produced in cooperation with others. However, this production of the world and our understanding of it takes place in an already existing world. The world is also a product of former practice. Hence, as a part of practice, knowledge has to be understood socially - as producing or reproducing social process and structures as well as being a product of it" (Ehn, 1993).

8.3 A big organism evolving together: towards a *terroir technologique*

> "What we practice at the small scale sets the patterns for the whole system." (brown, 2017, pg.53)

While industrial agriculture has been an ongoing concern for environmental movements and sustainable farming advocates for years, more recently the understanding of the negative impacts of industrial farming and its role in climate change has found its way into broader society. It is within this changing socio-technical landscape that digital agriculture and AG 4.0 has emerged as an industry-led alternative to the current unsustainable practices of the industry itself. This embracing of sustainability and environmentalism rhetoric by an industry rebranded as AG 4.0 poses new challenges for longstanding grassroots farming movements and networks like the CAPÉ who have been actively developing alternative tools and technology to support their forms of agriculture.

The tension is captured in the opening vignette of this thesis, where, at a grassroots organic farming technology exposition, the growing presence of industry and start-ups is a trend which is likely to continue. Clearly the CAPÉ will need to negotiate how to interact with emerging innovations and technologies that offer certain advantages while posing challenges and possible ethical dilemmas. What I have attempted here is to tease apart the inherent differences between grassroots farming innovation networks and the more conventional innovation patterns of AG 4.0. Even as these disruptive digital agricultural technologies have dialed into language of sustainability and environmentalism, an exploration of the values that have been embedded in those tools, and thus the kind of worlds they will subsequently shape, are telling.

Let’s reflect on the crucial contribution from critical theory of technology: Technologies reflect and reproduce the worlds we inhabit – thus technology, by in large, reflects the values of dominant social groups. Or said another way, technologies tend to come from a small minority of society and thus represent only a portion of the values, ways of knowing and being in this world. We open the question of the possibility for alternative futures when we challenge the linear, determinate view of technology. If we are not headed toward an inevitable future, where to? To take up the orientation of design is to not only to imagine but to enact worlds. Far from an abstraction, or a top-down approach to changing the system, this vision of autonomous design is radical because it implicates us directly in the cocreation as individuals intimately connected to each other and our environments.

Thus, while networks like the CAPE wrestle with technologies like automation or implementing digital platforms for collaboration, the more fundamental differences, as I have argued here, can be tracked through the processes of innovation used by these networks. The processes are in turn a reflection of the many individuals and the direct relationships they have with their environments. Like industrial agriculture, AG 4.0 is based on abstraction and the same kind of cartesian logic of separating things in to the quantifiable. In contrast, grassroots innovation networks confound this drive for efficiency and optimization by prioritizing democratic processes of participation and access. These grassroots networks are complex organizations made up of a tenuous assemblage of individuals, each of which has its own idiosyncrasies and understanding of the worlds they inhabit. When I asked Jean what he has noticed after visiting so many of the CAPÉ farms across Quebec he spoke to this complex diversity and his sentiment is worth quoting at length:

> "My visits reinforce the idea that each farm is like its own country. The farms might even be neighbours, but on each it is like an entirely different world. Even if they share the same soil, or climate sometimes. It is really the choice made by the farmers, in terms of technologies, ways of working, their own values, personal histories, so many factors. So, the farm is really a unique organism. The reason I say this, is that because I like to travel and see other parts of the world, when I arrive in a country, with new languages, new culture, new social etiquette, there are many unique factors between them. And there are certainly commonalities as well, as on farms, but there are so many variations, which is why I really don't like to think about imposing a single model of agriculture. But at the same time, even as each farm is different or unique, it is as though these three hundred or, so farms are really just one farm... in my head I see it as though all these farms are linked, like a big organism, that is evolving together"

As Jean said this it felt as though he had interceded my own train of thought. It was one of those strange moments when someone is able to articulate something you have been trying with difficulty to intuit – his words giving shape to an idea that was still forming somewhere in my own mind: different countries, worlds, organisms, teeming with their own diversity, entangled in a web of relations, coming together to form these tenuous artifacts that collectively point to another path forward. Moving between the scales of the individual, the network, the system - the image is that of an emergent, if not precarious reality being born, a collective world building, at once greater than the sum of its many parts.

As practices spread through regions, members become creative nodes within ecosystems. The site-specific responses of a farmer to her own environment contributes to the development of a technology that reflects her context. Thus, even as the tools spread through the network, the novel practices acquired by members encourage the potential for divergence and diversity that mirrors natural ecologies. It is fitting, perhaps, to draw a parallel to the food that emanates from regions and the celebration of *terroir* - the complexity of taste and character that comes from a place - and the possibility for a technology that is a reflection of the diversity of the environment and communities in which it is embedded. A *terroir technologique* - instead of deterritorialized technologies that reproduce their logics on the communities and landscapes, tools that emerge through entangled social and environmental ecologies.

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