Seeking Middle Ground: Reconciling two trajectories for food system relocalization

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

As food systems expand in scale and scope, the sources of their negative externalities are less effectively identified. Globally, this diffusion has resulted in a plethora of paradoxes, as well as a decrease in overall food system resilience to socio-economic and ecological drivers of uncertainty. Relocalizing food production is a potential strategy to address the challenges of conventional food systems. However, relocalization is an umbrella term, with two distinct food production trajectories. One vision for local food system development seeks to holistically integrate human agency with natural agro-ecosystem processes. For example, some activists, scholars and policy makers discuss community-managed organic gardens or agro-ecological farms as critical components of sustainable and just urban food systems. Conversely, several engineers and researchers are seeking to (semi)-separate agricultural activity from an increasingly capricious biosphere, through the development of capital-intensive vertical farming and meat-synthesis technologies. As proponents of both trajectories attempt to construct more localized foodsheds, it is important to consider their potential opportunities, as well as their underlying values and practices, in hopes of enacting broad food system change.

The paradigmatic and practical differences between conventional and alternative food systems have been well-elucidated within geographic literature; however, a growing body of scholarship is adopting a more nuanced approach to discuss the multiplicity of alternative agriculture developments. This thesis contributes to this body of literature, through: (1) comparing the outlooks of two distinct local food trajectories for attaining resilient, just food systems; and (2) assessing their underlying values and paradigms. To accomplish this, a thorough review of the literature on local food systems was carried out, in addition to an analysis of twenty-six interviews with stakeholders involved in local food production projects in China as well as Canada. A further twelve publicly-available interviews were selected for analysis. Interviewees included farm managers, researchers, urban planners, urban designers, and community food program managers.

The results of this study suggest that the two local food production trajectories have conflicting outlooks for realizing food system justice and resilience. Capital-intensive approaches to local food production have huge productive potential and capacity for resilience-building, through disrupting and optimizing energy-capture processes in agricultural systems, while liberating vast tracts of agricultural land. However, several scholars critique current operations for perpetuating the central tenets of conventional food production, including: commodification, global commodity trade, and the further dis-embedding of consumer relationships with producers and nature. In contrast, more ‘traditional’ approaches to local food production often strengthen community relations and offer opportunity for traditional knowledge sharing and environmental virtue development. However, these operations are time and labour dependent, and are fundamentally dependent on a relatively stable biosphere. These findings suggest that both trajectories, if combined, may address the shortcomings of one another.

In terms of underlying paradigms and practices, the results of this study align with an array of literature arguing that local food production projects act in both alternative and conventional ways. Interviewees from both trajectories engaged in multiple forms of economic exchange, and viewed their operations as part of a broader system of local, regional and global, and small to large-scale food production actors. Interviewees from both trajectories differed in their normative commitments to agro-ecosystem management, suggesting that food production is a complex process that cannot be separated from its natural environment, or that food production can be isolated and optimized. To transform conventional food systems, local food production operations must engage with, and work within, broader socio-political institutions. Creating an environment in which local food production projects can experiment with alternative values and practices is critical for their development, in face of increasing socio-economic and ecological uncertainty.

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Chapter 1: Rethinking Industrial Agriculture

1.1 Trends and Definition of Agro-Industrialization

Food production, distribution, processing and retailing practices have undergone rapid changes in scale and scope within the past century. Non-capital-intensive, community-based, family-embedded, and locally-derived production arrangements have been, in large part, integrated into the processes of agricultural industrialization across a global extent (Reardon & Barrett, 2000). In terms of production, practices have shifted from small-scale, agro-ecological farming, to massive, capital-intensive agricultural operations reliant on external energy, nutrient and water inputs (Weis, 2007). Distribution networks have shifted in scope from regional hubs to global webs, linked by unfathomable energy and logistical just-in-time supply chains (Harvey et al., 2002). Food has been modified from a predominantly commons-based resource to a commodity, governed by abstracted market-based exchange in lieu of reciprocal, socially-embedded economies (Vivero-Pol, 2017ab). Concomitantly, food commodities have become embedded within complex financial markets, including futures markets, as well as energy and resource markets, that have far-reaching, complex and unpredictable consequences on food access at a global scale (Clapp, 2014; Johnstone & Mazo, 2010). Though the global industrial food system is by no means all-encompassing, is entrenched to varying degrees across space and is adapted to various social and ecological environments, it is, nevertheless, widely accepted that this system has had far-reaching impacts on the wellbeing of humanity and the integrity of the biosphere (McMichael, 2009; Steffan, et al., 2015). This capital-intensive, global-in-scope, commodified food system will hereafter be referred to as “the industrial food system”, or “industrial agriculture”.

1.2 A Critical Examination of Industrial Food System Processes

1.2.1 The Perceived Benefits of Industrial Agriculture

The proliferation of a global industrial agriculture system has indeed resulted in substantial increases in food quantity and accessibility. OECD data (2017) indicates that over the last fifty years there has been a substantial increase in the yields of all four major global crops: corn, soy, wheat and rice. Along with increasing global yields, the number of individuals classified as 'hungry' worldwide has decreased by over 200 million in the past two decades (FAO, 2015). Science-based crop-management practices; increased mechanization, allowing fewer individuals to farm greater expanses of land; and the selective breeding and engineering of crop varieties have all played a role (Ray et al., 2013). Pingali (2012) goes so far as to suggest that a second Green Revolution is needed, especially in the 'Global South', that promotes better resource-use and crop growth using technology in face of climatic uncertainty.

Proponents of industrial agriculture advocate for an even more profound entrenchment of global food commodity trading to achieve food security. Ridley (2010) notes how different regions of the world have specific climatic advantages and socio-cultural preferences that incentivize producers to grow certain types of agricultural products. Advocates of free market principles described this comparative advantage as 'common sense', to justify the nationalization of local and regional markets and their cooption into the self-regulating market, during the late nineteenth century onwards:

> [the] international division of labour was undoubtedly a progressive creed; and its opponents were often recruited from amongst those whose judgement was vitiated by vested interests or lack of natural intelligence. (Polanyi (1944 [2001], 192)

Applied to food systems, this principle of comparative advantage is posited to optimize global food yield, fostering efficiency and robustness in the international food system. Moreover, areas deficient in food production in any given year can be supplanted by those that produce in excess. Of course, food insecurity remains a challenge, despite the apparent abundance of food resources and integration of national agricultural sectors across the globe. The authors of the Food and Agriculture Organization (FAO) 2015 report on global food security argue that trade in food commodities has been beneficial up to a point, neglecting, in particular, those impoverished individuals that are food insecure and lack the basic financial means to participate in food import economies (FAO, 2015). However, Ridley's (2010) claim does underscore the theoretical potential for global food commodity trading to buffer against global food insecurity. The results of one empirical study, using different models of domestic crop yield potential up to the year

2050 for United Nations' Member Countries, suggest that a significant portion of the world's population will be at risk of food insecurity without the import of international food products (Fader et al., 2013). The 2015 Food and Agricultural Organization (FAO) 2015 report on food insecurity provides a more-balanced account of global food commodity trade, noting that the benefits of trade liberalization are context-specific, and have been beneficial and harmful in different cases. Overall, it is apparent that the globalization of food commodities produced within the industrial agriculture model has had measurable effects on reducing global food insecurity, and can theoretically continue to do so into the future.

In addition to noting industrial agriculture's achievement of increased productivity and food access, proponents of industrial food systems laud the use of technology to advance more ecologically-sound production practices:

> Trajectories of global agricultural development that are directed to greater achievement of the technology improvement and technology transfer frontier would meet 2050 crop demand with *much lower environmental impacts*. (Tilman, et al., 2011, 20263 [emphasis added])

This discourse regarding 'sustainable intensification' is in the weak-sustainability tradition of Julian Simon (2012). This line of argumentation calls for continued technological and innovation and market demand to conserve; to recycle; and to substitute for less eco-friendly technologies, while maintaining those technologies' use-value. Applied to agriculture, human-engineered capital such as advanced mechanical or digital agricultural technologies are suggested to, over time, result in better conservation and reuse of natural capital resources, or replace certain practices and technologies required for agricultural production altogether in the name of 'environmental sustainability'. This position has been critiqued extensively, as it fails to acknowledge that: the economy is a subsystem of a finite biosphere that puts a cap on the theoretical amount of food that can be produced (Daly, 1993); technological solutions result in novel ecological problems, such as pesticide and herbicide resistance (Powles, 2008); and increased use of technology deepens the externalities of agriculture, resulting in biophysical contradictions that further undermine the integrity of the global industrial food system (Weis, 2010).

Despite these critiques, technological innovation has certainly mitigated several of the well-documented, negative, ecological consequences of industrial agriculture practices. For example, better timed and localized application of fertilizer has resulted in the optimization of nutrient delivery based on plant-growth stage, less nutrient waste, decreased temporal crop yield variation, and even slight increases in crop yield (Cassman, Dobermann & Walters, 2002; Fountas, Aggelopoulo & Gemtos, 2016; Yost et al., 2017). Moreover, advanced irrigation technologies such as drip or pivot irrigation allow for targeted and precise watering based on crop need, minimizing water loss to evaporation (Tilman et al., 2002). In terms of soil health and erosion rates, substantial improvement has occurred in agricultural hubs such as the US Mid-west over the past several decades. These improvements have been made through a combination of soil conservation incentives and technology (FAO, 2015). Finally, proponents of agricultural intensification suggest that this process increases yield, while also preventing the continued expansion of agricultural land. However, it is important to distinguish between technology and market-driven intensification. While technical advancements in crop production at a global scale have increased output per unit of land, intensification in crop production to meet market demand has resulted in cropland expansion (Byerlee, Stevenson & Villoria, 2014). Bayerlee et al (2014) go on to recommend continued R & D in agricultural technologies, advanced forest and cropland governance strategies and market certification. For all these reasons, it is optimistically proposed: "...that the world could reasonably set a goal of feeding itself to a higher and higher standard throughout the 21st century without bringing any new land under the plough…" (Ridley, 2010, p. 146).

1.2.2 The Paradox of Industrial Food Systems

While these positive developments have indeed incurred through the industrialization of agriculture, there remain widespread social and ecological challenges unaddressed or exasperated by the industrial food system itself. To begin, it is important to consider that trends in food security differ based on the scale of analysis. Despite an overall positive trend in hunger reduction over the past several decades, 2016 observed an increase of 40 million people classified as ‘chronically undernourished’ from 2015 (FAO, 2017). These changes were partially due to conflict as well as unprecedented drought and flooding events in the African Sahel. Additionally, decreases in undernourishment have substantially diminished since 2010 (FAO, 2017). Second, additional data suggest that the food system is rife with contradiction. Despite global crop yields being at an all-time high, many millions remain hungry or malnourished while many other millions remain obese or overweight (Patel, 2007). This food distribution challenge is compounded through the changing use-value of food, beyond direct human consumption. For example, critics of biofuel advance the controversy inherent in feeding automobiles instead of people (Tenenbaum, 2008). Simultaneously, rising demand for meat products diverts portions of food crop and arable land that could be used for human consumption. Albeit, this argument is multi-faceted, as many livestock crops are fed on non-arable grassland, and remain a symbol of cultural significance in numerous countries (Godfray et al., 2010). Furthermore, a vast proportion of food fails to be used at all. One third of the total amount of food produced for human consumption is wasted, though this total varies between geographic regions (FAO, 2018). More fundamentally, agro-industrialization and the rapid expansion of global agriculture has relied upon, and simultaneously fueled, the degradation of ecological capital at a global scale. Ecological economists have pessimistically forecasted population, food production, industrial productivity, and natural capital depletion scenarios, concluding that current trends of ‘progress’ are unsustainable in the long-term (Meadows et al., 1992; Turner, 2008). The discourse of proponents for sustainable intensification and techno-optimists, within the agricultural sector and beyond, ‘fudges’ limits to growth by deferring them further into the future (Kish & Quilley, 2017).

The arguments that are presented here are generalized and have been critiqued and outlined with greater nuance elsewhere (Fraser et al., 2015; Godfray et al., 2010). The purpose of describing these arguments here, however, is neither to promote nor to refute them, but to note that the industrial food system has resulted in beneficial outcomes in addition to unanticipated and often illogical consequences. Combined with the unnerving precarity and limits to growth of the agro-industrial system, these arguments would suggest that the global food system requires urgent transformation.

1.3 Alternatives?

Clearly, industrial agriculture has influenced global food security and sustainable development in conflicting ways. Furthermore, it is even more clear that industrial agriculture and conventional food systems in general should be reconfigured to address prescient socio-economic inequalities and ecological challenges. No matter these critiques, industrial agriculture's past and present successes can be empirically demonstrated, as outlined above. Thus, this system's central paradigms, such as: centralization, dependence on global networks of input and output markets, competition, domination over nature, specialization, and exploitation (Beaus & Dunlap, 1990), will continue to be both lauded and contested, without adequate advancement on either pro-conventional or anti-conventional sides. This chapter builds on the conclusion of Fraser et al., (2015) who, after outlining several conventional and alternative food system development pathways, note that: "today the intellectual debate on food security risks descending into a policy stalemate – with the hungry paying the highest cost" (84).

A plethora of 'alternative' agricultures have developed across the world in recent years. However, 'alternative' is an umbrella term, referring to a variety of practices and dimensions of perceived alterity. Moreover, there remains little agreement in the literature regarding the generalizability of alterity, that varies according to socio-cultural context and along multiple dimensions. For example, Whatmore (2003) defines alternativeness as an attempt to reverse the logic of bulk commodity production, build trust between producers and consumers, and develop new forms of political and economic food governance. Si, Schumilas and Scott (2015) build on Whatmore's work, defining eight broad features of alternativeness: healthfulness, ecological production methods, local, seasonal, small-scale, increased social ties, social justice and political orientation, and apply these dimensions to the Chinese food system context.

Common to each definition of 'alternative' is a desire to localize food production. Scholars and activists suggest that local food systems decrease the opacity of conventional food production, as the ecological, health-related and social justice externalities of their practices cannot be as easily diffused across space (or time). Numerous studies have also suggested that decentralized and less tightly-connected production networks are more 'resilient': better able to cope with socio-ecological uncertainties (Rotz & Fraser, 2015; Cabell & Oelofse, 2012). The development of robust production and distribution networks within and around urban areas has widely been utilized as a food security strategy in low, middle and high-income countries in the past and present (Mok et al, 2013; Zezza & Tasciotti, 2010).

‘Local’ is also a catchall term, however, varying across multiple dimensions including scale of production, geographic extent, capital-intensity, values, and paradigms, to name a few. This thesis will examine two distinct food production scenarios, based on Quilley’s (2018) typology of local food trajectories, that will be further elucidated in subsequent sections. The first is referred to as ‘Local and Natural’: those forms of production that emphasize the holistic integration of food production within the biosphere (e.g. agroecology, permaculture). These scenarios of food production intonate a more ‘respectful’ relationship between food production and nature, whereby agriculture mimics natural processes and is contained within ecologically-, as opposed to market- or politically-, imposed limits. The second is referred to as ‘Local Prosthetic Ecology’ scenarios: the forms of food production that emphasize a separation of food production from natural ecosystems (e.g. vertical farming, in-vitro protein synthesis). Rather than rely on natural, external inputs to grow food (e.g. the sun), these technologies seek to separate food production from the biosphere through using artificially-generated inputs, such as light; closing water and nutrient loops; and safeguarding production indoors. This strategy represents a radical disruption from cultivation techniques used over the past millennia, amounting to a complete reconfiguration of agriculture and humanity’s footprint on the biosphere (Quilley, 2018; 2012; 2004).

Various critiques of local food system development have been advanced in recent years. These critiques broadly argue that local food systems are not inherently ‘good’. Specifically, these critiques recognize scale as a social construction, not an ontological category, that is therefore governed by relations of power and agency (Bron & Purcell, 2006; Hinrichs, 2000; Allen, 2010; DuPuis & Goodman, 2005). As such, these authors argue that food system localization should be reframed as a means to an end, not an end in itself. However, given the alarming potential of future civilizational collapse scenarios due to energy crisis, climate change, political-economic instability…(Homer-Dixon, et al., 2015), local food production may be both a desirable and necessary developmental direction, toward more resilient food systems. Reconciling the potential socio-economic consequences of promoting local food systems with the urgency of impending socio-ecological uncertainties frames the underlying premise of this thesis.

1.4 Research Gap

Given that there are these two distinct trajectories of local food production development, it is important to examine: a) what are their potential benefits and pitfalls, and b) what opportunities and barriers exist that may impact their ability to transform conventional food production practices. Donella Meadows (1999) examines the specific points at which intervention in a system can result in its transformation. Meadows argues that paradigms: “The shared idea[s] in the minds of society, the great big unstated assumptions” (47) are the strongest points at which to transform a system. While the paradigms that operate between conventional and alternative food systems have been examined in detail (Beus & Dunlap, 1990; Whatmore, 2003; Si et al., 2015), less work has examined how paradigms differ within alternative food systems themselves, including local food production. As such, this thesis sought to examine what specific paradigms operate within Local and Natural and Local Prosthetic Ecology production scenarios, respectively. Understanding the underlying assumptions that exist in either scenario may help bridge political impasses toward the transformation of conventional food systems.

1.5 Structure of Thesis

The major research questions this thesis seeks to address are: 1) what are the outlooks of Local and Natural and Local Prosthetic Ecology food production scenarios for building socio-ecological food system resilience and justice, respectively; 2) what paradigms are shared or differ between either form of local food production; and 3) how might either form of local food production strategy combine to transform conventional food production systems?

To answer these questions, this thesis first examined the socio-ecological literature on local food systems. The explicit comparison of Local and Natural and Local Prosthetic Ecology production strategies has yet to be articulated in food systems literature. Second, this thesis undertook 26 face-to-face and over-the-phone interviews with key individuals in local food organizations in both China and Canada, in addition to analyzing a further 12 publicly-available transcripts of interviews with organizations unable to directly speak with the author.

Canada was selected as a focus because, despite the importance of food production in Canadian cities being well-documented (MacRae & Donahue, 2013), there remains a paucity of studies on urban food system resilience, or the values underpinning local production methods. This work will shed light on the opportunities, and the challenges to be overcome if local food provisioning is to become less of a niche food provisioning strategy in high-income nations such as Canada. China was selected as a main case study due to the current pressures being imposed on its urban food systems, through rapid urbanization and economic growth. As one of the most rapidly developing, growing and urbanizing nations in the world; with a history of intense pollution and food safety scandals; and with a state promoting the consolidation of its majority of small-scale producers, the Chinese food system is undergoing rapid developments (Donaldson & Zhang, 2015; Schneider, 2014). Scholarship continues to examine in detail the development of alternative food networks and ecological urban agriculture in China, including models of local food production, that attempt to address food security and food safety concerns (Shi et al., 2011; Scott et al., 2014). However, less attention has been given to the array of high-tech urban food production operations currently being developed and implemented in large cities such as Beijing and Shanghai (IEDA, 2013). Interviews available on-line were selected to supplement the collected data, as very few Local Prosthetic Ecology operations were available for interviews. These interviews sought to shed light on the paradigms that operate within either local food production strategy. Finally, this thesis commented on future food production scenarios and strategies through the lens of systems transformation and ‘scaling-up’ social innovation.

Chapter 2: Methodology – Emerging Theoretical Frameworks to Measure Global Food System-Related Outcomes

How and to what extent we should reimagine industrial agriculture advances a variety of complex theoretical and empirical research questions? How should food be regulated both economically and politically? What role should technology play in achieving food security and particularly in replacing human labour in agriculture? Across what scale should the bulk of consumed food products be grown and distributed? And how do complex global phenomena, such as climate change and geopolitical and socio-economic landscapes, factor in to how food is produced and distributed? Rather than attempting to answer such profound and fundamental questions, this chapter attempts to highlight burgeoning theoretical frameworks and metrics that can shed light on them. A nuanced theoretical and empirical analysis of industrial agriculture's socio-ecological effects is necessary, in hopes of judging the desirability or transformative outlooks of industrial agriculture's stated principles. To do so, this chapter will draw from theories of complexity science (resilience-thinking, in particular) and political ecology.

2.1 Global Food System Resilience and Complexity Theory

Complexity theory provides a useful framework from which to understand the 'paradoxes' of industrial agriculture, as outlined above. Complexity theory marks a departure from linear, Newtonian views of the world that treat parts of a system in isolation. This theory adopts a modest view regarding human predictive capabilities, acknowledging that systems are open, not isolated, and are influenced by infinite variables that impact their behaviour in innumerable and immeasurable ways (Homer-Dixon, 2011). There are several components to complex systems, and more broadly complexity theory, that must be examined in detail. First, it is important to differentiate between two types of complex systems: non-adaptive, and adaptive. Both types of complex systems acquiesce to natural laws and properties, and function in fundamentally unpredictable ways. However, complex adaptive systems (CAS) evolve, exhibit aggregated behaviour as a sum of their individual parts, and can anticipate change, transforming themselves in response to environmental change (eg. economies, immune systems, or ecosystems), whereas complex systems cannot intentionally respond or adapt to their environment (eg. weather systems) (Levin, 1998). Only CAS will be examined in this paper, as food systems are increasingly recognized as both complex and adaptive (Rotz and Fraser, 2015; Rotz, 2017). Second, it is critical to examine the relationship between CAS and energy. As systems become more complex through establishing multi-system linkages and expanding in scope and extent, their requirement for high-quality energy increases (Homer-Dixon, 2006; Tainter et al., 2003). For example, the Roman Empire relied upon human and livestock labour and, more fundamentally, solar energy to feed human and livestock activity; however, at its peak in power, the Empire grew too large for this relatively low-quality energy source to support itself (Homer-Dixon, 2006). This relationship between system complexity and energy is critical for examining food system resilience, as scholars have continuously demonstrated the inextricable dependency of industrial agriculture on fossil fuels (Weis, 2007; Piesse and Thirtle, 2009). Industrial agricultural systems may be adversely impacted, as it costs greater resources to extract less accessible reserves of oil (Hall, 2014). Third, CAS exhibit properties of non-linearity and emergence. Non-linearity refers to the idea that small changes or perturbations to a system may result in large, unintended consequences: "a fundamental disproportionality between cause and effect" (Homer-Dixon, 2011). An emergent property is an unexpected result, that is unpredictable if examining all parts of a complex system in isolation. The recent increase in chronic undernourishment despite global crop yields exceeding global nutritional requirements is an example of an emergent property with respect to the global industrial food system.

As a subsection of complexity theory, resilience-thinking examines the structure of transformation within CAS. Resilience-thinking involves picturing a system as an adaptive cycle: a continuous process of creation and destruction. Renowned ecologist Buzz Holling, alongside Lance Gunderson (2002) theorized these models over time, through observation of ecological systems. The adaptive cycle model demonstrates how systems undergo constant reorganization, rooted in Darwinian principles of selection in face of constant environmental change. As time progresses, a system becomes entrenched and organized around a set of principles and processes (an attractor). The characteristics of a system at this 'frontloop' phase (Figure 1) are as follows: homogenous, inter-connected, path-dependent (less likely to transform its fundamental paradigm and processes) and rich in resources. However, at this later stage the system becomes vulnerable to failure. At a certain point, a small change can result in a drastic and relatively quick reorganization of the system's structure, ultimately manifesting itself into a new set of principles and processes that govern the system within some new environment. Moreover, if this system (eg. the food system) is interconnected across a large spatial scale between multiple sub-systems (eg. oil-energy and water systems), it propagates risk and chance of synchronous failure across all these systems (Homer-Dixon et al., 2015; Hellbing 2013). If this tipping point is reached, then chaos ensues as novelty, innovation and experimentation help to reconfigure the system.

While the adaptive cycle is a useful tool to examine system change, it only does so at a single scale. Thus, a system can be observed as a panarchy: a cross-scale network of interacting adaptive cycles. Panarchy theory builds on the adaptive cycle model, nesting systems within each other across multiple scales (Figure 2); this is useful for conceptualizing the interplay between micro, meso and macro levels of transformation. Panarchy theory contends that at a macro-level, existing patterns of process are reinforced through 'remembrance', while micro-levels introduce and propagate novelty ('revolt') at stages of upper-level vulnerability (Holling and Gunderson, 2002).

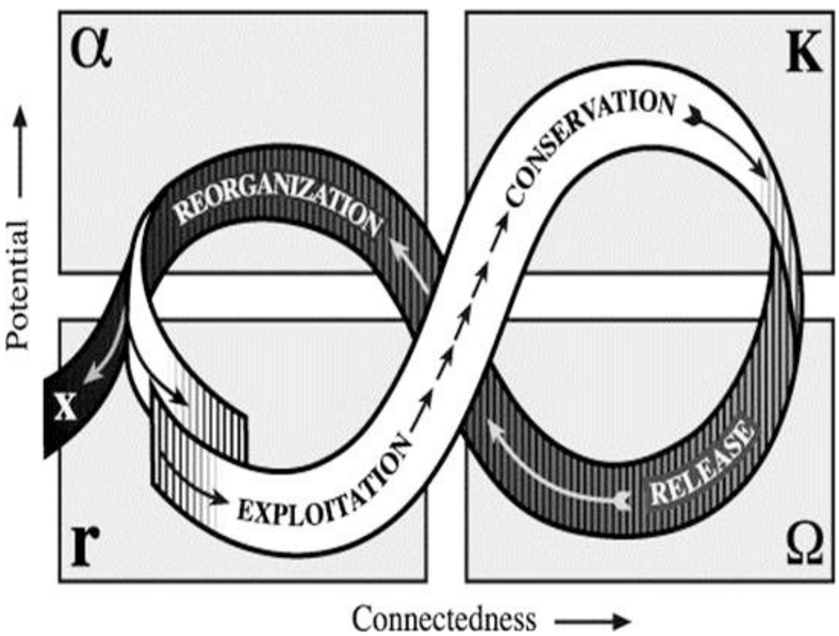

Figure 1. Adaptive cycle. Image taken from Resilience Alliance (https://www.resalliance.org/adaptive-cycle)

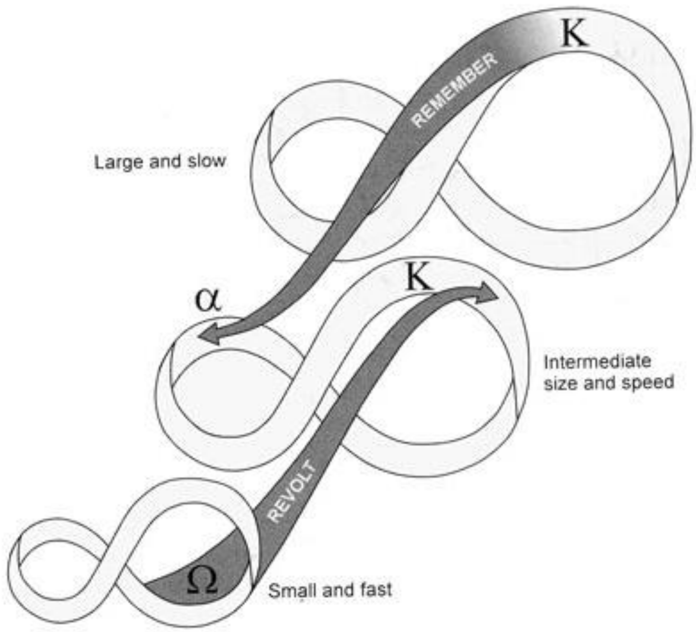

Figure 2. Panarchy Cycle. Image taken from Gunderson and Holling (2002).

Increasingly, researchers advance arguments regarding food systems that posit them in ‘complex’ and ‘resilient’ ways. For example, Fraser (2003) describes the Irish Potato through a panarchy framework, noting the socio-ecological conditions that fostered systemic vulnerability to external perturbations, such as disease. The food system in Ireland at that time had: low biodiversity in terms of type and species of crop, restricted avenues for human access to food, an extraordinary degree of land and economic connectivity, and high abundance in crop biomass. More broadly, increasing consolidation and homogenization of power (as well as crop type and species) within the global food system (Clapp, 2014); the highly intensive structure of agricultural capital, energy and information flows (Harvey et al., 2002; Weis, 2007); and the growth in available crop biomass for human consumption over time suggest the current global food system has entered a conservation (K) phase of growth (Figure 1). In fact, one characteristic of the conservation phase of growth is a decrease in system innovation and a ‘critical slowing down’ before cresting a system’s tipping point (Scheffer et al., 2012). Empirical evidence exists suggesting a decrease in rates of innovation in agricultural technology systems (Grassini et al., 2013). Additionally, Rotz and Fraser (2015) examine the global industrialized food system through a resilience lens, concluding that the very processes lauded by proponents of industrial agriculture, such as mechanization, increased globalization and intensification have in fact contributed to its decrease in resiliency. Finally, the nexus of oil energy, food commodities, agricultural inputs, distribution and retailing, referred to by scholar Tony Weis (2007) as the oil-seed-industrial-livestock-complex, suggest a pattern of increasing hyper-connectivity with heightened risk for systemic collapse (Hellbing, 2013).

Taking the scientific and social-scientific warnings regarding increased climatic and economic disturbances seriously, the current structure of the global food system gives pause for concern. While current macro-trends in food security are positive, there is no reason to suggest these trends should or should not continue into the near nor (especially) into the far future, through the further deepening of industrial processes. Moreover, consumers, politicians and policy-makers stand greater chance of missing key ‘leverage points’ to transform the food system, or may even push it in the direction from which it would benefit the most, as it becomes increasingly opaque through consolidation and globalization (Meadows, 1999). In other words, simple technological ‘fixes’ to food production, processing and storage; policy ‘fixes’ to trade surplus and deficits; and access ‘fixes’ such as food banks or food aid are insufficient to address the plethora of systemic challenges that go into feeding a global population. Moreover, food system inequities in power and food access are systemic consequences of industrial agriculture itself (McMichael, 2005). Complexity theory is a tool to understand why certain system processes, such as those within industrial agriculture models, remain entrenched in popular policy; what factors impede its transformation; and what parts, if changed, are most likely to generate the largest impact.

2.2 A Nuanced Definition of Food System Resilience—Political Ecology Frameworks and Industrial Agriculture

Indicators of resilience are essential to examine how food systems adapt to and possibly mitigate negative socio-ecological change; however, the concept of socio-ecological system resilience have been widely disparaged for failing to adopt a critical social lens. Capturing systemic social issues when applying resilience indicators to socio-ecological systems adds important context, though this practice is often overlooked within the literature (Rotz, 2017; Brown, 2013). For example, as resilience invokes an image of adapting *to* external disturbances, it is often critiqued as a conservative idea. The concept assumes that all individual community members, from local communities to nation states, have equal autonomy and ability to adapt to change, which may not necessarily be true. Moreover, reliance on individual and community-level adaptation to socio-ecological change is suggested to perpetuate neoliberalism and free-market capitalism ideals, such as austerity and individualism (Mackinnon, 2012). However, at the same time, resilience has also been invoked as a counter-hegemonic concept. Radical groups such as Transition Towns and other commons-based community movements operate to transform norms and system parameters into more desirable alternatives (Nelson, 2014; Cretney, 2014). From these critiques, it is clear that resilience is a 'fuzzy' concept, with different meanings for different stakeholders (Cretney, 2014). As such, a more nuanced definition of food system resilience is necessary.

This chapter will build upon Rotz and Fraser's (2015) description of food system resilience: "…the ability of a food system…to address stresses and disturbances while providing stable levels of consistent nutrition to the public" (459). Based on this definition, a resilient food system can be qualified heuristically as: diverse, in term of species-richness and crop function; decentralized across the value chain; and managed autonomously at local levels, where producers have control over their responses to economic and ecological change. These factors are interconnected, as represented in Figure 3. As decision-making autonomy and diversity increase and connectivity decreases, the food system becomes more resilient. While the food systems literature on resilience has normative connotations, it is important to recognize that these recommendations apply only to certain risks, and across different scales. For example, local-level autonomy and decreased international connectivity may be disastrous, if a region is suddenly subject to flooding or drought. Thus, instead of treating food system resilience as some form of 'end goal', this thesis uses it as a useful tool to point out the paradoxes of the current food system. Recognizing these challenges, it is then possible to point out the overlooked or undervalued opportunities for food system transformation.

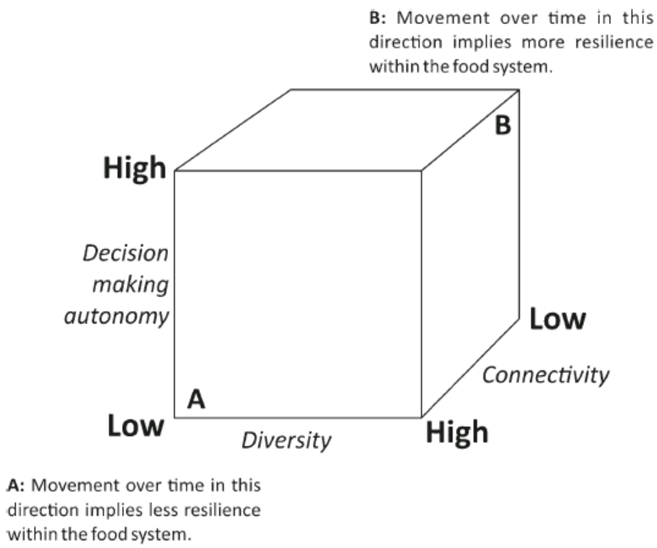

Figure 3. Resilience Space. Image adapted from Rotz and Fraser (2015).

Furthermore, political ecology frameworks can provide necessary socio-political context to this definition of resilience. World-systems and food regime theories have examined how macro-scale power imbalances, created through geopolitical conflict and the commodification of food production, have created unequal food system outcomes. Specifically, historical processes, such as British colonialism and American imperialism have shaped and cultured uneven power dynamics between and within national food agriculture sectors (Friedmann & McMichael, 1988). More recently, scholars posit that corporatization has exacerbated these divides, while increasing the system's overall opaqueness; to consumers, food appears from 'nowhere', while production is continuously squeezed into the jurisdiction of a handful of trans-national corporations (McMichael, 2005). Due to these processes, social and ecological costs of harmful agricultural practices are more easily diffused across space and time (Clapp, 2014). Questions of food sovereignty, including: the right of small-holder producers to fair trade and self-governance over intellectual property, and the right of consumers to adequate quantities of culturally-appropriate and nutritious food, have arisen in response to these changes in power in the food system. As such, agricultural development has moved from measurement through purely quantitative metrics of food security, to more holistic and systemic determinants (Sage, 2014).

It is apparent that Complexity Science and Political Ecology frameworks advocate for similar goals and criticize several of the central tenets of industrial food systems, as outlined in Table 1 below. First, these theories challenge the logic of consolidation and homogeneity, emphasizing the decentralization of productive power, and increasing the diversity of crop type and function. Second, they add more honesty to the discourse surrounding capital-intensity and 'quick-fixes'. Third, these theories challenge the logic of increasingly interconnected, global-in-scale food distribution networks with heightened requirements for high-quality energy. Finally, these theories critique the highly commodified economic foundations on which industrial agriculture rests. To conclude, a resilient global food system ensures adequate supply of food in face of socio-ecological disturbance, while simultaneously guaranteeing greater transparency in processes of agricultural production, distribution, consumption and waste. Attaining a resilient global food system involves fostering ecological and economic diversity in agricultural production arrangements; diffusing agri-management power from national, international and corporate organizations to smaller-scale producers and consumers; and maintaining more dispersed distribution networks, that rely on a larger number of producers but to lesser extents, respectively (Rotz & Fraser, 2015; McMichael, 2005).

Table 1. Political ecology and complexity science critiques of industrial food system processes.

Central Tenets of Industrial Food Systems	**Political Ecology Critique**	**Complexity Science Critique**
Consolidation: environment that rewards scaling-up production methods (get big or get out), resulting in a cost-price squeeze for farmers. This environment also favours monoculture practices: decreased crop type and crop-use diversity	- Accumulation by dispossession of small-scale farming, resulting in decreasing producer power and movements for food sovereignty (McMichael, 2005; McMichael, 2009)	- Increased diversity in crop-use/crop species, livelihood strategy, and in number/type of producer is important to cope with socio-ecological uncertainty (Rotz & Fraser, 2015)
Globalization: Entrenching food commodities into global production and	- Globalization wrests power from individuals and communities,	- Increasing interconnections within the system and between systems enhances risk

distribution networks, linked by necessary financial, energetic and resource markets	displacing consumers physically and psychologically from food products (Feagan, 2007; Ayres & Bosia, 2011; Hendrickson & Heffernan, 2002)	of systemic and synchronous failure (Helbing, 2015) - More intra/inter-system ties across space create more confounding variables, resulting in a greater number of drivers of uncertainty
Commodification: Treating food as a private good to be exchanged in a dis-embedded market	- Dis-embedded (and embedded) markets reinforce inequalities in food access (Hinrichs, 2000) - Fails to treat food as a *right* (Vivero-Pol, 2017a; 2017b)	- Lose accountability through increased abstraction; externalities of production are absent as food is removed from its local socio-ecological context (Clapp, 2015) - Community-based management of food resources develops social capital, community-level resilience and passes down food-growing knowledge (Barthel et al., 2014)
Increasing Capital and Energy-Intensity: More mechanization, automation, use of advanced biotechnology…	- Overlooks accumulated knowledge of producers, with devastating impact on small-scale farmer livelihood and sovereignty (Rosset & Altieri, 2017)	- Blind application of technology results in unanticipated socio-ecological consequences (Weis, 2007) - Streamlined system, with fewer producers/production methods, is more vulnerable to perturbation than a system with built-in ‘redundancy’ (Fraser, 2003) - The embeddedness of oil in supporting industrial food system

		processes is problematic, given recent scholarship regarding peak oil and the increasing cost of extracting dwindling supplies of fossil energy (Hall et al., 2014; Weis, 2007)
Increasing System Opacity: Food 'from nowhere' and decreasing consumer/producer knowledge or awareness regarding food system properties	- As the processes that get food from field to table become more difficult to understand, consumers and producers have decreasing decision-making autonomy or power (Feagan, 2007)	- Opaque systems obscure the potential precarity, or 'critical tipping points' of a system (Scheffer, 2012) - New and changing unknown unknowns: previously unconsidered variables, such as conflict in distant spaces (Johnstone & Mazzo, 2010), result in adverse and unpredictable effects or changes

Chapter 3: Methods

This research has two major objectives: 1) to assess the potential benefits and pitfalls of Local and Natural and Local Prosthetic Ecology trajectories of food production; and 2) to examine the values and practices that underpin either food production trajectory. To accomplish the first objective, I undertook a review of local food system literature that spanned geographic, economic, and sociological studies. Such an approach was important to consider all arguments regarding local food system resilience and justice, comprised of empirical and theoretical studies, and informed through disparate epistemological frameworks. It is important to acknowledge that an overarching commentary on the outlooks of current local food production methods presents a tension, assuming food production operations have general qualities, while drawing from a suite of literature that is locally contextualized and that may not represent a complete catalogue of local food operation types. Recognizing this lack of generalizability, this study did not seek to argue for one production method over the other. Instead, this overview presents a series of *potential* pitfalls and *potential* opportunities, acknowledging that individual operations are uniquely influenced by subjective and situated realities, and thus need not abide by specific values or practices.

To address the second objective, this study employed an exploratory, multiple-case study approach. The case study method is a widely-used qualitative research tool, employed to: "examine a contemporary phenomenon in its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 1981, 98). A case study approach is a useful method to examine the values and practices underpinning current local food production operations, in the context of understanding how those values shape the potential for food system transformation.

Rather than attempt to explain or describe a phenomenon (in this case: local food production values and practices) I opted for an exploratory strategy, to inductively generate a broader understanding of the local food operational landscape from various cases (Baxter & Jack, 2008). Ogawa and Melen (1991) outline the goals and limits of an exploratory case study method:

> …to conduct a fairly comprehensive, open-ended search for relevant information, identify the major themes and patterns associated with the phenomenon of interest, develop or adopt constructs that embrace the patterns, articulate tentative hypotheses about the meanings of the constructs and their relations, and refine questions and/or suggest conceptual perspectives that might serve as fruitful guides for subsequent investigation. (271)

In this study I compared two cases of local food production operations, informed by Quilley's (2018) typology: Local Prosthetic Ecology to Local and Natural. Specifically, I selected operations that used either burgeoning prosthetic ecology technologies (e.g. vertical farms, meat synthesis operations), or that operated according to 'natural', agro-ecological principles (e.g. community gardens, agro-ecological farms, and urban market gardens), to be part of each case.

Counterintuitively, I did not consider localness: the degree to which operations participated in local, as opposed to larger-scale food economies, for selection. This was because Quilley's (2018) local food production trajectory is informed by two other main variables: the use-of agricultural capital, and the normative values of producers regarding the management of agro-ecosystems. Both trajectories assume relocalization as an invariable direction for future system transformation. As such, my overarching research question addresses the current opportunities for technologies of Local Prosthetic Ecology, and Local and Natural production methods, to build more localized production and distribution networks.

I used open-ended questions in semi-structured interviews to understand the motivations, values and practices underpinning individual local food production operations. Semi-structured interviews are useful for the purposes of this study, as they provide a common platform for comparison between cases, while affording enough flexibility to discuss unprecedented themes during the interview (Cohen & Crabtree, 2008). An interview guide was developed prior to commencing interviews (Appendix A).

3.1 Interview Data

A total of thirty-eight interviews were analyzed as part of this study. A majority (N=18) took place in China, eight occurred in Canada, and another twelve publicly-available interviews were selected from around the world (though mostly from Europe and North America). The interviews that I conducted myself took place either face-to-face, at a location of the interviewees choosing, or over the phone. A snowball sampling method was used, whereby I approached contacts via email using an abridged recruitment letter. If interested in participating, I emailed a formal recruitment letter to the prospective interviewee. Following the interview, I would ask the participant if they had any relevant contacts who may be interested in participating in this study. If this was the case, the participant contacted the prospective interviewee themselves. All study materials, including recruitment emails, scripts and interview guides, were approved by the University of Waterloo Office of Research and Ethics. Given that most interviewees expressed a desire to remain anonymous, all quotes are coded and attributed only to the interviewee's title/role in their operation.

3.1.1 Interview Data from China

Between May and July 2017, I conducted eighteen semi-structured interviews with local food stakeholders in China. Interviews with operations involved with Prosthetic Ecology technologies (vertical farming) occurred in three large cities: Nanjing, the capital of Jiangsu Province (located 300 kilometers west of Shanghai); Shanghai; and Beijing. Interviews with Local and Natural operations (peri-urban agri-tourism farms) occurred in Nanjing, and within an ecotourism demonstration zone in Yangling, a small city in Shaanxi province (located 1500 kilometers northwest of Shanghai).

Four Local Prosthetic Ecology operations interviewed in China were private enterprises that developed small and large-scale technologies for intra- and peri-urban food production: from the design of green houses to the planning of large-scale vertical farming districts. Two of these operations were state-owned. An addition five interviews were conducted: one with an urban designer, and four with researchers that specialize in urban farming technologies. A research assistant conducted interviews with my assistance, using the translated interview guide, and transcribed and translated responses during the interview. Most interviews in China (N=16 out of 18) were conducted in Mandarin, Chinese.

3.1.2 Interview Data from Canada

Between August 2017 and March 2018, the author conducted eight interviews with individuals involved in Local Prosthetic Ecology and Local and Natural food production initiatives in Canada. In-person interviews took place in the cities of London, Hamilton, Kitchener, and Waterloo, Ontario. Over-the-phone interviews took place with individuals from Truro, Nova Scotia (a town 1 hour north of Halifax), and Montreal, Quebec.

The three Prosthetic Ecology operations examined in Canada were a large-scale vertical farm, an aquaponics-based operation, and a non-commercial vertical farm. A researcher involved in the design and optimization of light sources for greenhouse production was also interviewed. In terms of Local and Natural operations, two managers from community development initiatives undertook interviews, in addition to two city planners involved in strategic urban agriculture planning.

3.1.3 Interview Data from Publicly-Available Recordings and Transcripts

In addition to interviews conducted by the author with relevant stakeholders, a selection of twelve relevant, publicly-available interviews was selected for analysis. These interviews were selected to supplement data collection: operations with which I was unable to directly interview myself. Additionally, these interviews were selected to assist with data triangulation: comparing themes from multiple data sources to validate findings and observe patterns (Golafshani, 2003).

3.1.4 Interview Questions

Literature on alternative versus conventional agricultural values guided the development of interview questions used in this study. To begin the interview, I asked scoping questions regarding the role of the interviewee, as well as the form and function of the operation. Subsequent interview questions were arranged according to themes that were, in turn, informed by Si et al. (2015) ‘two types of alternativeness’: food features, and relationship among stakeholders. These themes, their associated questions, and rationale for each question are outlined in the table below, with a full list of interview questions in Appendix A:

Table 2. Themes and Justification for Questions Presented in Interviews

Theme	**Interview Questions**	**Rationale**
Scale	Do you believe most food in cities should be grown locally? Why or why not? How do you define 'local'? Does your product (agriculture technology or produce) circulate at predominantly local, regional or global scales? Why have you selected to operate at this scale?	To determine if operations were at all motivated to contribute to local food economies
	What do you picture as the impact of this model of food production on local, regional and global society? How can/can this model be scaled-up? What are the innovation gaps that need to be filled for this production method to become a significant contributor to urban food security? Where are these breakthroughs going to come?	To examine the degree of motivation for operations to challenge dominant food distribution models, and gaps in technology or institutions that need to be addressed for this scaling-up to occur
	How do you define 'agricultural efficiency'? Do you consider your model of agriculture to be 'efficient'? Is efficiency something that is important to you?	To assess the degree to which operations advance bulk commodity production, and desire automation
Food Features and Naturalness	What would you consider to be the main environmental benefits of your method of food production?	To determine the ecological values of operations
	What constitutes 'natural food' to you or to this organization? (prompt: do you think food produced in a lab/without soil is unnatural, as compared to food produced on land? What about food produced without natural sunlight?)	To assess the attitude of producers toward the role of humans in managing agroecosystems
	Do you believe food taste is impacted by the way in which food is grown? (prompt: are there any differences in the taste of food grown using your methods?).	To assess how producers view the quality of produce grown using their production methods

Relationships among Stakeholders	Do you work with other individuals or organizations, for example: businesses, farmers, or universities? What type of work do you do with these other institutions or individuals? Do you work directly with the public, or indirectly? In what ways do you (directly or indirectly) work with the public?	To assess if operations function as private, community or public entities, or somewhere in-between
	What do you consider to be the social benefits of this form of food production (prompt: food security, employment or general social welfare, social justice)? What to you consider to be the social risks with this method of food production? (prompt: are there food safety concerns using this method of production? Are the products accessible to poorer as well as to richer consumers?)	To determine the values of operations regarding their broader role in society
	Do you think it is important for people to know where and how their food is produced? What are the opportunities and challenges to establishing a more transparent food system, using your method of urban food production?	To examine how producers reconnect themselves and consumers to the food system

3.2 Data Analysis

I used a thematic content analysis approach to extract themes from interview transcripts. Thematic content analysis is a flexible analytical method, that "can…work both to reflect reality, and to unpick or unravel the surface of reality" (Braune & Clarke, 2006, 9). The process to extract themes from interview data was grounded in the process developed by Braune & Clarke (2006). First, I familiarized myself with interview data, through transcribing and re-listening to interviews, as well as reading through interview transcriptions. Following this, I manually developed a list of codes (Appendix B) derived from the literature on alternative and conventional agricultural paradigms, as well as from the interview answers. Codes were then grouped under broader themes and used to highlight related extracts of interview data. As appropriate, codes and themes were subsequently refined, streamlined and organized into a spreadsheet in Microsoft Excel throughout the analysis period. Furthermore, I searched for latent themes within the data, that could highlight unexpressed value and practices: “the underlying ideas, assumptions, and conceptualizations – and ideologies…” (Braune & Clarke, 2006, 13).

3.3 Research Limitations

This research has numerous limitations. First, and most importantly, this research is exploratory in nature. Far from attempting to rigorously or empirically categorize local food system organizations, or to make generalizations regarding the values of Local and Natural and Local Prosthetic Ecology operations, this study seeks to highlight the plethora of conflicting paradigms present within the local food movement. However, it is important to note that due to the novelty of the capital-intensive local food organizations/systems/trajectories across the globe, including ‘cultured meat’ and ‘vertical farming’, a relatively large sample size of these forms of operations was examined.

Second, this study is broad in geographic scope, having undertaken interviews in both China and Canada, with secondary source interviews taken from organizations in the United States, the Netherlands, Belgium, Japan and Singapore. The food system contexts vary tremendously between each of these geographical regions. Furthermore, the socio-economic, political and ecological factors that have given rise to these different forms of local food organizations vary significantly between these countries. This study examined studies and undertook interviews within North America, China, Japan and Europe, because these particular regions have had strong roles in the development of Local Prosthetic Ecology technologies. Within Europe, the Netherlands has a long and robust history of indoor agricultural commodity production, partially due to its small size and harsh climate (Viviano, 2017), while North America has observed remarkable recent uptake in various forms of urban agriculture, as a strategy of resilience in face of post-industrial economic change (Colasanti et al., 2012). On the other side of the globe, Japan and China have achieved significant research success with respect to indoor vegetable production systems (Hayashi, 2016).

In-depth comparison of each respect geographic context to one another is beyond the scope of this thesis. This is problematic, as attitudes and values toward local food production vary significantly between different geographic contexts, and this nuance may at times be neglected or misunderstood. I chose to use data from such an array of sources due to the novelty of emerging Local Prosthetic Ecology scenarios of local food production. Had I neglected regions outside of those in which I undertook face-to-face interviews, such as the Netherlands, the United States or Japan, I would have missed on a suite of technological developments that present great socio-ecological resilience potential. Moreover, as stated before, the goal of this project is to highlight the broad array of tensions between Local and Natural and Local Prosthetic Ecology forms of local agriculture, not to categorize them based on operational form, nor on their geographic origin. While the degree of these tensions may differ based on geographic context, this study seeks only to explore the political implications of their existence, or lack thereof, for future food system transformation.

I recognize that the subjective experience of the research assistants, and their identities relative to the interviewee, influenced the answers I received (Turner, 2010; Scott, 2006). Furthermore, as an outsider during my fieldwork in China, I acknowledge that my positionality impacted the engagement of interviewees with interview questions. To address these challenges, I worked with my research assistant before and after every interview to review questions, jot down notes for each question, and verify the accuracy of my notes. Furthermore, the various research assistants translated all interviews following the data collection period.

Chapter 4: Results – Evaluation of Outlooks for Local Food System Trajectories

4.1 The Potential for Local Food Systems

Among the central tenets of critiques of industrial agriculture is a philosophy of going ‘local’: one end of the global-local scalar dipole in food system development discourse. Local food systems often, though not always, challenge: global food commodity networks; environmentally unsustainable practices; the socio-economic logic, or cultural desire, to consolidate; the dis-embedded nature of food commodity trading; and increasing systemic opacity. Some components of ‘local food production systems’ include farmer’s markets, community-shared agriculture and various forms of urban agriculture, among others. These specific examples of local food production operations are widely examined in academia, despite their current limitations. For example, in higher-income nations, the majority (~90%) of food procurement occurs in supermarkets or supercenters, not through alternative procurement strategies (Ver Ploeg et al., 2015). Moreover, in lower and middle-income nations these operations are often negatively-perceived, associated with subsistence agriculture, ‘backward’ development or inefficient urban planning. Schneider, (2014), commenting on the political, economic and social-discourses of peasants in Chinese society, suggests that:

> ….[they] very clearly communicat[e] that whoever the peasants are, they are members of a low-status, low-value, pre-modern group, and their very existence symbolizes a state of underdevelopment and backwardness in Chinese society. (334)

The following sections will briefly outline some of the different types of local food production strategies; examine their outlooks for resilience and food system justice, using human geography-informed social constructivist and complexity-science informed realist perspectives; and compare some of their guiding socio-ecological values.

4.1.1 A Social-Constructivist Spatial-Scale Analysis of Local Food Systems

To begin, 'local' is a scalar concept, and as such merits critical geographical scrutiny. Recent human geography scholarship regarding scale has moved away from 'realist' epistemologies that assume an observable nested-level framework (eg. local, regional and global levels), analyzing scale instead through a social-constructivist approach that is both subjective and dynamic. For example, Marston (2000) articulates scale as a complex concept, established through interrelations between capitalist production, consumption and social reproduction. Marston (2000) critiques the lack of attention given to processes outside of capitalist production and consumption that shape definitions of 'scale', calling for increased attention to "difference in human agents and how power relations outside the relations of capital and labor might also influence scale-making" (238).

Local food systems, often positioned in tension with the global-scale food system in the literature (McMichael, 2009), can be considered an applied manifestation of this line of geographical thinking. Local food systems are suggested to challenge the uneven capitalist production practices in agriculture, by opening markets for small-scale producers; re-negotiating the identity constructs of both consumers and producers, through changing food and land commodity access; and contesting the passivity of consumers within the broader capitalist system, by fostering direct markets of exchange (Sumner et al., 2010; Carolan & Hall, 2016; McClintock, 2010). Local food systems are thus framed, through this social constructivist approach, as positive sites of reaction to industrial agriculture's disproportionate relations of capitalist production, consumption and social reproduction. However, framing local food systems as positive at best, and neutral at worst, ignores their inherent political implications. For example, while local food systems are described as alternative, they are often sheltered within market ideology – farmer's markets and community-shared agriculture, despite their perceived alterity to conventional food production and retailing systems, remain firmly nested within capitalist relations of consumption. The uncritical promotion of agricultural initiatives as 'alternative' is problematic for obscuring the politics of scale in defining 'the local', as well as furthering class differentiation through the monetization of local food markets. For example, Hinrichs (2000), through a case study of locally-sourced banquet meals in Iowa, describes the inaccessibility of these meals to lower-income individuals, while a focus on sub-national scale "…evades direct discussion of the painful restructuring of Iowa agriculture and the differences it has created among farmers…and glosses the variation in how Iowa farmers actually ecologize their farming" (40). Second, participating in 'alternative' but still commodified local food markets may inhibit large-scale food systems transformation: "When voting with our fork, we should remember that the freedom to buy food according to our values does not in and of itself change the power of commodities in our food system" (Holt-Gimenez, 2017, 73).

4.1.2 A Realist Spatial-Scale Analysis of Local Food Systems

Contra social-constructivist approaches, complexity-science examines scale through a realist perspective. Specifically, resilience and panarchy theories treat a system hierarchically, characterized as a set of: "…evolutionary…adaptive cycles that are nested one within the other across space and time" (Gunderson and Holling, 2002, 74). This definition, and its association with *socio*ecological systems, is critiqued for its lack of attention to social dynamics. Skeptical of the normative connotations inherent in socio-ecological resilience literature, Cote & Nightingale (2012) recommend that:

> …the focus of empirical investigations and theoretical development shifts to political and ethical questions as crucial drivers of social-ecological outcomes rather than 'inconvenient' politics that can be simply sorted out through institutional design. (484)

Thus, it is important to recognize that local food production and distribution networks are not necessarily 'more' or 'less' resilient, varying according to local social and ecological dynamics, and to specific parameters or goals of the food system. Simultaneously, however, the current paradoxes and vulnerabilities of the global food system necessitate a deeper understanding of its cross-scale dynamics (Tendall et al., 2015). Given the highly globalized, energy-intensive, and consolidated nature of conventional food value chains, local and regional scales are obvious targets for food system development. Cabell and Oelofse (2012) argue for a more locally-interdependent food production and distribution network, that: "live[s] within the means of the local resource base..." (6). Furthermore, local scales are the most appropriate scale at which to experiment and introduce novelty for larger-scale systems transformation: "A resilience perspective emphasizes an adaptive approach, facilitating different transformative experiments at small scales and allowing cross-learning and new initiatives to emerge" (Folke et al., 2010, 5). The following section will examine each of these claims in greater detail.

Decentralization, redundancy, and decreased energy-intensity

Proponents of local food systems often assume that decentralized, globally-autonomous value chains are more socio-economically diverse, and thus more resilient. Rotz and Fraser (2015) argue that increasing the degree to which producers act autonomously can help prevent the diffusion of problems throughout agricultural systems (e.g. crop disease), and encourage more appropriate, locally-contextualized agricultural practices. Following this argument, consolidation and centralization decrease the decision-making autonomy of independent producers, that are either squeezed out of or vertically-integrated into value chains, resulting in decreased food system resilience:

> When oligopolistic markets and actors exist along the production and supply chain, the chain itself becomes highly vulnerable to perturbation: whether it is weather, price, producer mismanagement, or pestilence. (Rotz & Fraser, 2015, 466)

This claim is readily challenged, however. Market-integration, the geographic expansion of food distribution channels, and agricultural intensification have, in large part, increased the ability of food distribution systems to efficiently cope with widespread variabilities in production (Ridley, 2010). Thus, through a socio-economic resilience lens, debate continues over the appropriate level and scale of 'connectedness' required for networks of producers to deliver adequate quantities of food in face of uncertainties, and at minimal socio-ecological cost.

Some scholars also argue that increasing food system diversity results in greater resilience. However, diversity can be measured in multiple ways, and according to multiple socio-economic and ecological metrics. For example, Fraser (2003) uses the Irish Potato Famine as a case study to argue that losses of land available for subsistence agriculture, widespread inaccessibility to agricultural markets, as well as geographic isolation from food aid channels created a vulnerable food procurement system. Simultaneously, lack in crop-diversity allowed blight to pass through agricultural fields uninhibited. The positive relationship between crop-diversity and the capacity of crop systems to withstand climatic and ecological disturbance is widely supported in the literature (Lin, 2011). These two factors: lack of food procurement channels, and reliance on one or few types and species of crop, resulted in food system collapse in Ireland (Fraser, 2003). Furthermore, this case study suggests that socio-economic and agro-ecosystem diversity are critical components of resilience, which is alarming given the overwhelming reliance of consumers on convenient, affordable, centralized food retailing systems (Reardon & Barrett, 2000; Reardon et al., 2005), and the dominance of highly-specialized, homogenous crop systems (Davis et al., 2012). With respect to food procurement strategies, supermarket retailing systems are extraordinarily robust, however, and not necessarily 'homogenous'. These large retailers supply an incredibly diverse array of products at relatively low-cost, sourcing from producers and distributors from across the world. Similarly, specialization in agro-ecosystem management has resulted in incredible increases in yield and global food security, albeit at the cost of local biodiversity (Tilman et al., 2011). Thus, while the complex, large-scale, food-water-energy nexus that delivers produce to supermarket shelves might present itself as less diverse or resilient (Rotz & Fraser, 2015; Cabell & Oelofse, 2012), it can also be considered more resilient and diverse using different definitions and measures.

Local food systems may also decrease the energy intensity of agricultural production and distribution practices. Some scholars have demonstrated that decreased transportation and refrigeration costs are incurred through reduced food miles, though empirical results are mixed (Mundler & Rumpus, 2012; Coley et al., 2009). More concretely, local and alternative production systems often promote eco-cyclical practices, through reducing chemical and energetic throughputs (Altieri et al., 2012); albeit, at the cost of increased manual labour (Bramberger, 2017).

Cross-scale dynamics

The cross-scale dynamics of local food initiatives is a widely discussed topic in food system resilience literature. How Local and Natural and Local Prosthetic Ecology production methods scale to become mainstream, what tradeoffs occur because of this scaling, and what institutions and scales should be targeted for intervention remain prescient research questions. Drawing from social innovation literature, ‘scaling-up’ refers to the transformation of dominant institutions and resource flows of a system (Westley & Antadze, 2010). Rather than expanding in scope and outreach, an initiative that successfully scales-up changes societal mindsets and practices. The most effective point at which enact these transformations is at the level of paradigms and ideas (Abson et al., 2017; Meadows, 1999). Theories of system-level transformation will be further discussed in chapter 7, including the outlooks for successful scaling-up of local food initiatives. However, it is worth noting here that scholarship increasingly grapples with the paradigmatic differences between conventional and alternative food systems (e.g. Whatmore, 2003; Si et al., 2015).

Alternative food initiatives currently remain, in many ways, ‘alternative’. For example, in the United States organic food sales account for just 4% of total food sales (Greene, 2017). Similarly, current vertical farm operations are projected to remain a niche, high-value commodity in North American food markets[1], while in-vitro meat has yet to enter mainstream markets at all (Specht & Lagally, 2017). One case study in Toronto, Ontario observed the diffusion of local and ‘sustainable’ food-sourcing practices, facilitated through a not-for-profit certification process, into various Ontario University institutions (Friedmann, 2007). However, it is worth noting that while this may be transformational in one respect: changing the flows of produce from farm to universities, it did little to challenge the role of institutions as consumers (rather than producers), nor the commodified landscape of food procurement. Regarding the agroecology movement, recent scholarship has advocated for political networks of small-scale agroecological producers to engage and challenge industrial production methods (Altieri et al., 2012). It is clear from all these examples, that despite the remarkable growth of alternative food sectors, practices, and values over the past several decades in many parts of the world, there remains opportunity for broader, institutional-level change.

Experimentation

Local, small-scale experimentation with novel food production practices and management strategies is critical to determine the alternatives fit for large-scale systemic change. For example, many local food operations experiment with alternative forms of economic exchange.

[1] https://www.verticalfarming.com/

Some scholars posit that direct markets are a means to re-embed economic activity within social networks of trust and kinship, through encouraging face-to-face interactions between consumers and producers and, in some instances, requiring that individuals work collaboratively to manage operations (Feenstra, 2002). Other operations have instead experimented with the (re)treatment of food as an 'impure common resource' governed through a combination of collectively agreed-upon, market-based and government-led management strategies (Vivero-Pol, 2017a). Although local food systems currently abide by a variety of forms of economic governance, experiments with exchanging food as a common or public good (in addition to private good) present a novel food system development pathway (Vivero-Pol, 2017b). Furthermore, local sites of production have widely been used as a strategy to maintain traditions and knowledge surrounding food production, while securing food in face of climatic and political uncertainties (Barthel et al., 2013).

4.2 A Nuanced Typology of Local Food

As briefly alluded to above, 'local food' is an umbrella term, harbouring a variety of production means, distribution schemas, ideologies and values. For example, urban food production is often separated according to location: growing within dense urban areas (intra-urban), or on the urban-rural boundary (peri-urban) (Mougeot, 2000). Of course, local food production can also be differentiated beyond land-use categories, including scale of production, use of capital, as well as form and function. Emerging vertical farm operations can be commercial enterprises, or non-commercial food programs. Similarly, urban gardens such as community gardens grow commercially and non-commercially, as well as at small or large scales. This study examined four specific forms of food production, as part of Local Prosthetic Ecology and Local and Natural local food system trajectories: indoor vertical farming, in-vitro meat synthesis, urban farming, and community gardening. Furthermore, the operations examined in this study, from each respective form of food production, vary in scale and function as outlined in Table 3 (Chapter 5).

Attempting to categorize the different forms of food production thus proves a difficult task, given the multiplicity of current forms and functions. However, drawing from Quilley's (2018) typology of local food initiatives, there are two distinct, and potentially conflicting approaches to long-term food system development. The first strategy, referred to as 'Local Prosthetic Ecologies', seeks to semi-separate the processes of food production from the biosphere through a radical transformation of the basic physiological processes of energy capture for vegetable, fruit and meat production (Quilley, 2004). Rather than subsume further land to capture an ever-greater amount of solar energy, at the cost of natural biophysical systems, this developmental pathway seeks to detach agriculture from nature. To accomplish this goal, proponents of local prosthetic ecologies continue to conceptualize and develop a suite of food production technologies, including: vertical farms, in-vitro meat operations and 3D printing food machines, among others. The goal behind this strategy is to minimize humanity's agricultural footprint on the biosphere, through: a) decreasing the amount of land required for cultivation; b) optimizing the use of inputs (besides land) required to grow food; and c) ratcheting up production levels (Quilley, 2004; Despommier, 2010; Lovelock, 2009).

The second strategy will hereafter be referred to as 'local and natural'. Rooted in permaculture (Holmgren, 2002) and agroecological production philosophies, this strategy's goal is to fully integrate human agricultural activity into the biosphere. To accomplish this goal, proponents of 'local and natural' food production scenarios argue for: a) a greater understanding of the ecological processes of food production, procured through the integration of scientific and indigenous-knowledge; b) the incorporation of food justice into food production and distribution schemes; and c) radical movement away from global, highly-specialized, industrial food production chains toward decentralized, diverse food production arrangements (Wezel et al., 2014; Ferguson & Lovell, 2014; Rosset & Altieri, 2017). With some generalizing, local food organizations can thus be categorized according to these two production strategies: 1) Local, closed-system Prosthetic Ecologies, and 2) Local and Natural. Each category of local food production has its own benefits, but also several potential drawbacks and worldviews, as detailed below.

4.2.1 Benefits of Local Prosthetic Ecologies

Regarding Local Prosthetic Ecology approaches to food production, there is massive opportunity to reduce the environmental consequences of crop production and animal-agriculture, and to positively contribute to global food security in a climatically and economically volatile world.

One study examined the economic viability of vertical farms, observing that a thirty-seven-floor vertical farm, located on a 0.25-hectare piece of land, had an overall productive area of 68 hectares: "The crop production alone is roughly 500 times the yield expected from growing these vegetables in an area of 0.25 ha" (Banerjee, 2014). Furthermore, relegating food production to a fraction of its current land area would curtail some of the biosphere's most pressing anthropogenic-induced challenges, such as: deforestation, habitat fragmentation, and agricultural-related greenhouse gas emissions, allowing substantial parts of the biosphere to re-wild and self-regulate. At the same time, this engineered approach to resilience safeguards food production from external climatic variables.

Similar to vertical farming, in-vitro meat synthesis proponents are hoping to match increasing global demands for meat in less ecologically-harmful ways. The definition of in-vitro meat synthesis used in this thesis follows Datar and Betti's (2010, 14) characterization: "[The] culturing [of] muscle-like tissue in a liquid medium, therefore bypassing animal husbandry and slaughter." Proponents of such meat-raising systems posit that they can decrease total amounts of land, water and resource-use in raising meat products. Furthermore, because such systems bypass traditional and industrial animal-slaughter techniques, prominent animal-rights activists such as PETA have endorsed in-vitro meat synthesis[2]. The long-term goal of vertical farming and in-vitro meat systems is to radically alter food distribution chains, producing enough food within and around cities to feed large urban areas, while allowing previous agricultural land to re-wild and self-regulate.

There are many challenges facing the emergence of Local Prosthetic Ecology technologies. The inputs to develop vertical farming operations are currently extremely expensive, including: urban land, physical infrastructure, and electrical costs. Furthermore, only a handful of crops are economically and physically suitable for current operations; staple grains and carbohydrates are uncompetitive and impractical. Thus, despite being a growing market, experts argue that vertical farming will more than likely remain niche for the foreseeable future[3]. In-vitro meat operations face similar hurdles, including added regulatory scrutiny. Ongoing research into vertical farming

[2] https://www.peta.org/features/vitro-meat-contest/
[3] https://www.verticalfarming.com/

and meat synthesis technologies, further resource-saving techniques, adapting energy-use to local environments, and growing on vacant land are just some of the strategies being used to make Local Prosthetic Ecology a more economically and energetically-feasible food production strategy (Despommier, 2010). Furthermore, food production technologies that could disrupt fresh crop, staple crop, or livestock markets or, in the face of market collapse, be more practically and economically-viable than conventional staple crop-production, may yet be developed.

More broadly, the prosthetic ecology local food system trajectory, in all its forms, stands to decrease the potential for humanity to cross at least six of Rockstrom et al.'s (2009) planetary boundaries. Lovelock (2009) illustrates this, outlining his food synthesis science fiction scenario for humanity and for the biosphere:

> What would be synthesized would not be the intricate, natural chemicals we now eat as broccoli, olives, apples, steaks or, more probably, hamburgers and pizzas. Rather, the large new food factories would make simple sugars and amino acids. This would be the feed stock for tissue cultures of meats and vegetables…By doing this on a scale large enough to feed everyone, the land now farmed could be released back to Gaia and used once again for its proper purpose, the regulation of the climate and chemistry of the Earth. The present over-fishing of the oceans could also cease. (133)

More specifically, the optimization of nutrient and water cycling in vertical farming and in-vitro meat synthesis systems would positively impact global freshwater use and biogeochemical nitrogen and phosphorous cycling. Decreased use of agricultural machinery and high-input industrial agricultural practices would simultaneously lessen the greenhouse gas emissions of agriculture, and thus agriculture's impact on climate warming and ocean acidification. Moreover, indoor production is safeguarded from the vagaries of climate change, in all its most potentially-violent forms. Less use of land for agricultural purposes would also decrease humanity's footprint on land system change, restoring vast tracts of wilderness and habitat that could, theoretically, curb losses in biodiversity.

Using a longer sociological, anthropological and historical lens, some scholars have contended that the prosthetic ecology local food system development pathway is the next logical step for agricultural innovation. Quilley (2004; 2011) argues that the evolution of human culture, civilization, population and overall social complexity--defined as the advanced division of socio-economic organization across larger time and spatial scales--has historically been predicated upon increased throughputs of energy and matter. Drawing from the sociological work of Elias (1939 [2000]) and De Vries and Goudsblom (2002), Quilley (2004; 2011) suggests that the ecological crisis is a crisis of human nature. The capacity of humans to transfer knowledge between generations allows us, in a biological or evolutionary sense, to circumvent natural trophic hierarchies:

> The problem of global ecology is, in a very real sense, a problem of human nature…Inter-generational transmission of a social stock of knowledge allows humanity continually to improve its cognitive mapping and understanding of non-human nature. In ecological terms this is extremely disruptive, allowing our species to move into new niches, continually extracting more energy from more nodes in ever more diverse ecosystems. (Quilley, 2011, 69)

Following this argument, our current planetary-scale ecological crisis was not arrived at by choice, and nor was it arrived at by accident; rather, it was the next logical step in the evolution of the anthroposphere. As such, this argument suggests that all the fruitions of modern life, including the development of the welfare state, modern health systems and the notion of human rights, among other benefits, has come at the price of continued degradation of non-human nature: “Given that the anthroposphere is dependent on and expands within a finite and limited biosphere, the relationship between the process of civilization and the biosphere must be defined, ultimately, by a zero-sum game” (Quilley, 2011, 75).

This argument is uncomfortable. It suggests that all the ‘progressive’ advancements made over the course of civilizational development have come at the cost of natural biophysical processes. However, prosthetic ecologies of food production can break this intractable zero-sum relationship. Detached food production systems promise to relieve humanity’s chokehold on ecosystems, while simultaneously maintaining production levels to allow for the continued development of 'civilization'. Such an approach to food system development involves a radical combination of human agency and natural ecosystem functioning to achieve a true measure of long-term sustainability': "In such a scenario humanity would become a part of a new sentient, self-aware, reflexive organ regulating the biosphere" (Quilley, 2011, 84).

4.2.2 Pitfalls to Prosthetic Ecology Scenarios

While the purported benefits of prosthetic ecology trajectories are indeed numerous, there are several potential pitfalls. For example, critical literature on emerging prosthetic ecologies of local food production tends to characterize these current operations as market-oriented, emphasizing profits, efficiency and automation over social, economic and environmental justice concerns (Hallock, 2013). Without being conscious of these political-economic institutional structures, vertical farms and in-vitro meat technologies may be incentivized to perpetuate the tenets of industrial food systems, including globalization, commodification and consolidation, albeit in ecologically-benign forms. Moreover, negative public perceptions of capital-intensive 'lab-grown' meat or LED-light-grown vegetables have been observed in several studies. Public opinion tends to view goods produced in these settings as unpalatable, unnatural or 'yucky', although these perceptions may change rapidly (Leastadius & Caldwell, 2015; Specht et al., 2015). Substantial socio-cultural hurdles currently prevent the development of markets for local, prosthetic ecology food production strategies. Finally, current technologies are nowhere near sufficiently developed as to pose an economic threat to conventional agricultural production chains. Further research, development and public-understanding is needed to make prosthetic ecology technologies: a) competitive in conventional markets, and/or b) available for small or large-scale use, in a multiplicity of economies (e.g. gifting, bartering, or non-monetized exchange).

Additionally, the argument for Local Prosthetic Ecologies is embroiled in debates over limits to growth. Techno-optimists and ecological modernists (e.g. Ridley, 2010; Mol, 2006) would object to any form of 'zero-sum' relationship between the anthroposphere and the biosphere, suggesting that increasing resource efficiencies, the substitution of natural capital as it becomes scarce, and unpredictable technological developments ultimately 'fudge' or overcome natural biophysical limits to growth (Kish & Quilley, 2017). However, developments in complexity science and energy economics over the past several decades have added empirically-based realism to this debate. As society becomes more complex (i.e. solves more of its socio-economic, technological and ecological problems within its current institutional structure and frameworks), it relies upon an ever-greater amount of high-quality energy, with decreasing returns (Tainter et al., 2003; Homer-dixon, 2006). Recent trends in decreasing energy-return-on-investment (EROI) for oil energy sources, decreased rates of innovation in the agricultural sector, and the tightly-coupled food-water-oil nexus all highlight the presence and potential for limits, plateaus, and collapse in the global food system (Hall, 2016; Homer-Dixon et al., 2015; Weis, 2014; Grassini, 2013).

4.2.3 Benefits to Local and Natural Scenarios

Literature on 'local and natural' food production practices has found numerous socio-ecological benefits to these approaches. To begin, such operations are often grassroots in nature, fostering civic engagement and democratic participation in the development and ongoing management of food initiatives (Sumner et al., 2010). More broadly, Carolan and Hale (2016) emphasize that spaces for urban farms and gardens contribute to enhanced community capital (greater social interaction, relationship-building and food knowledge), as well as diverse economies (multiple forms of food exchange, alongside conventional markets). Local and natural scenarios have also been widely-examined as important spaces for the development of food and environmental ethics: "For many, the value of the food grown is found in the process of growing it, in 'getting one's hands dirty,' and of knowing where one's food comes from" (Carolan & Hale, 2016, 540). This process of engaging individuals in food production has been suggested and observed to foster individual environmental virtue development, as well as reconnection to local ecologies (Sandler, 2013; McClintock, 2010). Similarly, local and natural food production spaces are suggested to foster culture and knowledge sharing. For example, agroecological principles seek to blend certain forms of science (e.g. soil science and ecology) with indigenous knowledge (i.e. ethnoecology), fostering a diversity of context-specific, local and natural food production strategies (Rosset & Altieri, 2017). The food sovereignty movement has sought to bring conversations of power into global food system development discourse. Specifically, the food sovereignty movement advocates for adequate quantities of culturally-appropriate food for consumers, as well as for small-scale producers to autonomously choose their own crops and methods with which to grow them: “If we talk about food sovereignty, we talk about rights, and if we do that, we must talk about ways to ensure that those rights are met, across a range of geographies, by everyone, in substantive and meaningful ways” (Patel, 2009, 671).

Local and natural production methods are also suggested to contribute to more resilient cities. For example, community gardens exhibit social self-organization and socio-ecological learning: critical characteristics in the adaptive management of urban food systems in face of crisis (Colding & Barthel, 2013; Barthel et al., 2013). Furthermore, non-capital-intensive urban gardening has traditionally been used as a response to maintain food security in face of socio-ecological uncertainties. Barthel & Isendahl (2013) describe community and household gardens that maintained food caches for soldiers in the early 20th century, simultaneously constructing wartime community through ‘victory garden’ efforts. Similarly, one of the most well-cited examples of successful local and natural food production scenarios is Cuba’s urban agriculture initiatives during the ‘Special Period in Time of Peace’ in the early 1990s. Isolated from international food trading, Cuba adopted an intensive agroecological approach to urban gardening across a range of state, community and enterprise-led initiatives. This program was hugely successful in terms of food security, meeting roughly half of Cuban citizens’ vegetable needs in the year 1996 (Aliteri et al., 1999). There are also many ecological benefits to local and natural food production scenarios. Such systems promote local biodiversity, biological (as opposed to chemical) crop management strategies and enhance urban ecosystem services. Overall, these systems seek to build local ecological capital, allowing for the long-term use of water, land and soil without external additives or inputs (Kremen and Miles, 2010). For these reasons, among others, local and natural food production scenarios have been promoted in the literature, municipal planning and various food movements as a positive model of urban food resource management: “Farms are now highly diversified, producing more than just food, and are also providers of local-scale renewable energy, building materials, and organically-grown medicinal plants, among other things” (Hopkins, 2009).

4.2.4 Pitfalls to Local and Natural Scenarios

Local and natural scenarios of food production also exhibit several potential pitfalls. The first and most widely-argued critique is that non-conventional production methods (i.e. organic, agroecological or small-scale approaches to food production) have lower yields as compared to conventional systems, though these yield gaps vary according to ecological and crop-management contexts and can be further closed through research and development (de Ponti et al., 2012; Seufert et al., 2012). Questions have arisen regarding the political-economic consequences of local and natural scenarios and their vision for urban development:

> To what extent would urban agriculture's smaller-scale farms and fragmented nature be less efficient with respect to water, fertilizer applications, harvesting, and other operations than conventional agriculture, and what are the implications with respect to greater land and energy requirements? Does the need to build houses and industrial operations outweigh the need to produce food near or within cities? (Mok et al., 2013, 38)

Furthermore, while local and natural production strategies such as urban farms and small-scale farming are often lauded for their economic benefits to producers, the specific labour requirements required for large-scale adoption of these forms of food production (e.g. time and energy) are massive. Bramberger (2017), in a study of labour requirements for local, organic horticulture to supply total dietary demands for the city of Guelph, Ontario, argues that such a shift would exacerbate existing labour gaps in Canadian agriculture. Similarly, the precarity of agricultural jobs in alternative agricultural initiatives has increasingly come under scrutiny. Weiler, Otero & Wittman (2016) observed that precarious employment, if present in alternative agricultures, is justified based on the need for 'sustainability transition' or is brushed aside as only present in a minority of farms.

The work of many classical sociological theorists is derived from a common observation: that the shift from subsistence-based, peasant agriculture to massive, capital-intensive agri-business engendered a significant expansion in the global division of labour as well as rapid urbanization (Barnes, 1966; McClintock, 2010; Glaeser, 2014). The shift of labour from rural to urban space, as well as communal or subsistence-based production to capitalist wages, continues to rage in low and middle-income countries worldwide (Akram-Lodhi & Kay, 2010; Donaldson & Zhang 2015). Would a (re)turn to Local and Natural methods of production, with a significant increase in labour requirements, be welcomed by society? Quilley (2004; 2011) argues, persuasively, that it would not. The development of an advanced global division of labour, post-industrial lifestyles and overall increases in social complexity, all of which non-negotiable aspects of modern life, has relied upon simultaneous processes of agricultural industrialization and the movement of rural labour to the city. This implies a tension, between the widespread adoption of 'Local and Natural' production methods: "the more gentle organic/ permaculture vision of food production systems in symbiotic harmony with natural ecosystems" (Quilley, 2011, 82) – and the maintenance of current levels of social complexity, as outlined in section 4.2.2.

Finally, regarding climate change, although local and natural scenarios would necessarily mitigate carbon dioxide emissions through decreasing the transportation/refrigeration distance for food and fostering less fossil-energy intensive practices, they remain fundamentally subject to the vagaries of the natural environment. While some scholars point out that the ingenuity of farmers has, for millennia (before industrialization and the development of high technology), fostered resilient food production systems (Rossett & Altieri, 2017), local and natural scenarios may still be adversely impacted by the alarming and abrupt forecasted climate change scenarios.

4.3 Challenges to Combining Local Food Production Scenarios

While the research outlined above highlights the pitfalls and opportunities for both prosthetic ecology and local and natural approaches to local food system development, it overlooks two elements: a) the political implications of its findings; and b) the nuanced and potentially transformative nature of organizations that hybridize values, practices and assumptions to create novel food system arrangements. For example, not all prosthetic ecology operations need be privately-owned, capitalistic enterprises. Maker and DIY cultures, including a philosophy that seeks to widely and freely disseminate various forms of advanced digital and mechanical technology, combine capital intensity with principles of democratic participation and commons-based management [4,5]. The democratization of local agricultural technologies, including but not

[4] https://www.oreilly.com/pub/au/26
[5] https://www.opensourceecology.org/

limited to hydroponics or aquaponics growing methods, has likewise begun to unfold in dramatic ways (Tas, 2015). Similarly, local and natural production methods need not be ‘less productive’ than conventional production systems, as evidenced by Cuban agro-ecological production, or require the complete return to manual agricultural labour and abandonment of agricultural capital and machinery (Altieri et al., 1999; Altieri & Rossett, 2017). These ‘exceptions’ suggest that both respective local food operations need not abide by certain ‘assumptions’ or ‘norms’ that polarize their production methods, values or capacity for resilience building. Moreover, the extent to which these assumptions and values are commonly held by practitioners within either form of local food production strategy remains less examined within the literature. The following sections survey some of the literature on environmental values and conflicting approaches to agricultural resource management, that may impact how local food system development occurs.

4.3.1 Planet Managers and Fetishers

Eisenberg (1998) offers philosophical caricatures of two opposing environmental groups: ‘Planet Fetishers’ and the ‘Planet Managers’. Eisenberg’s Fetishers, rooted in the philosophies of deep ecologists, green politics, and bioregionalism, advocate for the diminishment of human interference within the biosphere. Pragmatically, planet fetishizing involves a large-scale retraction of the scope of anthropocentric influence over natural capital and processes:

> The name [planet fetisher] acknowledges their tendency to think of nature as a perfect, harmonious whole – perfect and harmonious, that is, when humans keep out. By their lights, humans have no right to a larger role in nature than raccoons…we ought to fade into the woodwork like other residents. In rigorous practice, this would mean reverting to the hunting and gathering that fed us for the first few million years of our hominid career, before agriculture let us breed like mice in a seed bag…In any case, it would mean returning most of the earth to wilderness. (Eisenberg, 1998, 284)

This philosophy has several commendable characteristics, critiquing industrial society and, in its less fundamentalist form, seeking to find “arcadia”: a societal balance of culture and nature. However, Eisenberg (1998) argues that this philosophy has unrealistic expectations regarding the political consequences and feasibility of the withdrawal of anthropocentric influence within the biosphere: “If you are trying to impose a paleolithic worldview on postindustrial people, you are asking for trouble” (285). In contrast, Planet Managers hold science and technology as gospel and utilize them as tools to reconcile the anthroposphere with the limits of the biosphere. Eisenberg (1998) argues that the tools of planet management are indeed useful and can assist with re-establishing the biosphere’s self-regulatory strategies; however, planet managers often ‘fall in-love’ with their tools for management:

> Planet Management…is the silicon version of the judeo-christian ethic of stewardship, which sees the earth as a garden that we are to dress, keep and humanize…What worries me about the Mangers is that they like managing: they have trouble keeping their hands off. Their attitude toward nature is roughly that of aeronautic engineers who have been given a chance to examine a captured enemy aircraft. They want to learn how it works and how to fly it. (Eisenberg, 1998, 286)

These categories of environmentalism are extreme. Moreover, over the past several decades since (and before) Eisenberg’s (1998) publication, either ‘side’ has evolved into much more nuanced forms, that are less fundamentalist than outlined above. However, this caricature is useful as it provides a foundation from which to understand the potential shared or different values of modern environmental (and agricultural) movements, including Prosthetic Ecology and Local and Natural scenarios of food production.

4.3.2 Local Food Movements as Planet Fetishers or Planet Managers

This thesis argues that Local and Natural and Prosthetic Ecology scenarios are rooted within philosophies of Planet Fetisher and Planet Manager, respectively. Local and natural scenarios are characterized as the integration of human activity (in the form of food production) within the biosphere, seeking to minimize agriculture’s negative ecological impacts on the biosphere. Although Local and Natural scenarios differ from Eisenberg’s characterization of Planet Fetishers in that they are less totalizing, seeking not to displace agricultural processes or human agency in natural ecosystems altogether but rather to integrate ecological principles into agricultural landscape management, they share several of the same characteristics. At its core, this scenario of local food production has an impetus to restore balance between human management and natural dynamics in agricultural systems. For example, permaculture philosophies argue that: "with the application of ecologically informed *holistic* planning and design—humans can meet their needs while increasing ecosystem health" (Ferguson & Lovell, 2014, 266, emphasis added). Human management of agricultural systems in these scenarios seeks to mimic ecological processes directly within the biosphere: integrating agricultural activity with natural ecosystems in ecologically-benign ways. Describing the ingenuity of indigenous farming systems that integrate food production into natural landscapes (e.g. forests and prairies), Eisenberg (1998) suggests that ecosystems are untapped reservoirs of agricultural knowledge: "Though the Wild Garden takes us closer to Eden than we, with our numbers and power should dare to go, its tangled depths are rich in tantalizing hints" (431). An example of such projects includes Wes Jackson's (2018) work at the Land Institute, a not-for-profit seeking to: "…grow food in partnership with nature by planting perennial grains in mixtures that can help build and protect soil[6]." Drawing from traditional and scientific knowledge regarding prairie ecosystems, this institute seeks to eradicate human interference within natural agro-ecosystems, effectively making them self-sustaining.

In contrast, prosthetic ecology scenarios seek to semi-separate food production processes from the biosphere, with humans presiding over and controlling all elements within a plant or meat product's development. Such an approach, similar to the Planet Manager thesis, encourages the use of human agency, scientific-worldviews and technology, to manipulate and segregate natural processes. While technology can play a positive, symbiotic role between maintaining social complexity and simultaneously minimizing harm to the biosphere, Eisenberg (1998, 432) maintains that: "Machines will always be a little reckless, changeable, prone to wander off and make trouble. Like goatherds we have to keep an eye on them…judging and adjusting our labile technologies." Technologies of Local Prosthetic Ecology scenarios of food production have immense potential to feed humanity and lessen agriculture's impact on natural ecosystems; their potential abuse and misuse are nonetheless critical to consider for their future development (Hallock, 2013).

[6] https://landinstitute.org/about-us/)

Assuming that Local and Natural and Local Prosthetic Ecology production scenarios are rooted in Planet Fetisher and Planet Manger philosophies leads to the hypothesis that either method of food production also operates according to a distinct set of more nuanced environmental paradigms and practices. To determine the specific paradigms that operate within Local and Natural and Local Prosthetic Ecology food production scenarios, this study undertook a review of literature on local food values as well as a suite of interviews with stakeholders involved in local food production operations. Specific literature on alternative food systems (Beaus & Dunlap, 1990; Whatmore, 2003; Si, et al., 2015) informed key word searches (Appendix C), as well as interview questions.

Chapter 5: Interview Results – Values and Practices in Local Food Production Scenarios

This study examined a suite of local food production forms, spanning a range of technologies, stakeholders and geographic locations. This list of food production strategies is non-exhaustive. Specific food production approaches that would have added greater depth to this study, but that the author did not have the time or means to examine, were 3D food printing technologies and small-scale residential food growing, among others. The specific interviews undertaken and pulled from online are organized into the two tables below as 'Local Prosthetic Ecology or 'Local and Natural' food production strategies. This study chiefly examined intra-urban food production: those forms taking place directly within dense urban areas (Mougeot, 2000), in addition to nine peri-urban ecological agricultural operations. The four main types of intra-urban production examined in this study are vertical farming, community gardening, in-vitro meat synthesis and urban farms or market gardens. The interviews analyzed in this study were conducted with diverse stakeholders: managers, farmers, academics, urban planners, urban designers, technicians and political commentators. Moreover, the genre of each food production

Table 3. Local Food Production Operations Examined in This Study

Food Production Strategy	**Food Production Form**	**Organization Type**	**Basic Organization Function**	**Geographic Location of Interview**	**Source of Data and Number of Interviews**	**Interviewee Code**
Local Prosthetic Ecologies	**Vertical Farming (e.g. indoor vegetable production: aquaponics, hydroponics etc.)**	Commercial Vertical Farm	Grow for commercial use: sell crops to restaurants, retailers and consumers	Canada	Semi-structured interview with author (N=2)	B2, B3
				United States	Publicly-available online interview (N=1)	C10
				Europe	Publicly-available online interview (N=1)	C8

		Non-Commercial Vertical Farm	Grow for donation or for community engagement purposes (may also involve selling commercially, but not-for-profit)	Canada	Publicly-available online interview (N=1); Semi-structured interview with author (N=1)	C7, B7
				China	Semi-structured interview with author (N=2)	A11, A13
		Vertical Farm Technology Researchers and Developers	Build and sell large-scale or small-scale grow-units	Canada	Publicly-available online interview (N=1)	C9
				China	Semi-structured interview with author (N=2)	A12, A14
			Research and development in various vertical farm technologies (e.g. lighting, nutrients and water delivery)	Canada	Semi-structured interview with author (N=1)	B5
				China	Semi-structured interview with author (N=5)	A15, A16, A17, A18, A10
				United States	Publicly-Available Online Interview (N=1)	C2
				Europe	Publicly-Available Online Interview (N=2)	C1, C3
Local Prosthetic Ecologies	**In-Vitro Meat Synthesis**	Commercial In-Vitro Meat Growers	Raise meat for commercial-use	United States	Publicly-available online interview (N=2)	C4, C5
		In-Vitro Meat Technology Developers	Research and development	Europe	Publicly-available online interview (N=2)	C12, C13
Local and Natural	**Community Gardening**	Community Food and Garden Program Facilitator	Grow crops for donation or engage community in growing	Canada	Semi-structured interview with author (N=3)	B1, B4, B6

Local and natural	**Urban Farms and Market Gardens**	Commercial Urban Farm	Grow for commercial use: sell crops to restaurants, retailers and consumers	Singapore	Publicly-available online interview (N=1)	C11
			Grow for commercial-use and provide tourism services	China	Semi-structured interview with author (N=9)	A1, A2, A3, A4, A5, A6, A7, A8, A9
		Non-Commercial Urban Farm	Grow crops for donation or for community engagement purposes (may also involve selling commercially, but not-for-profit)	Canada	Semi-structured interview with author (N=1)	B7

strategy examined in this study varies in function and purpose (from for-profit enterprises to not-for-profit community development programs), and in scale (small to large), as reflected in Table 3. Attempting to develop a typology of local food production strategies was a difficult process. Such a typology risks overlooking the nuances of organizations that blend function and purpose, though this will be discussed further in the following chapter.

The following sections are arranged according to the themes that emerged from analyzing the interview data. As much as possible, the author discerns between the different strategies of local food production and, as appropriate, their specific functions. Themes are arranged across two broad categories: divergent values/practices and shared values/practices. Divergent values and practices are those priorities, definitions or functions over which interviewees expressed disagreement. The two major divergent values observed within this study were regarding how interviewees defined natural food production processes, as well as how interviewees observed and prioritized ‘efficient’ production practices. In contrast, shared values and practices are those priorities or procedures that were common among interviewees. Four major similarities were observed between local and natural and prosthetic ecology scenarios: (1) Both forms expressed mixed resource management strategies, governed as either commercial enterprises or commons-managed operations; (2) both emphasized the importance of building relationships between consumers and producers; connecting consumers with food; and increasing food system traceability and transparency, in both passive and active ways; (3) all operations emphasized a desire to build closed social or ecological-loops; and (4) nearly all initiatives (except 3 out of 38) agreed that localization was insufficient to create food secure urban areas, citing economic and political institutional factors that inhibit their desire or ability to 'scale-up' and affect broader institutional changes (Westley & Antadze, 2010).

To ensure confidentiality, codes were assigned to interviewees; as such, quotes remain anonymous. However, to add necessary context and voice I distinguish between interviews from Canada, China and publicly-available sources. Quotes attributed to interviewees labelled with an "A" are from interviews that took place in China, while those that are labelled with a "B" are from Canada, and "C" from publicly-available sources (see table 4 below). Additionally, "(x)" refers to the specific interview number.

Table 4. Guide to Interviewee Codes used for Quotes

Code for Quotes	**Interview Origin**
A(x)	China
B(x)	Canada
C(x)	Publicly-available interview sources

5.0.1 Case study source contexts

As outlined in section 3.3 "Research Limitations", an in-depth comparison of the cross-cultural context for each selection of case studies is beyond the scope of this thesis. The intention of this work is to highlight the suite of tensions within and between operations from each local food system trajectory, using an exploratory case study approach. The goal of this thesis is *not* to rigorously categorize operations based on their values, practices or geographic context. Without commenting on these case-by-case nuances, it is nonetheless important to briefly highlight the history and status of local food production within both Canada and China.

In Canada, local food production has a long and conflicted history. Economic growth in post-war North America spurred the penetration of urban development into peri-urban farmland, generating concerns regarding the availability of local farmland, as well as a plethora of arable land reserve policies (Newman, Powell & Wittman, 2015). Due to pressure imposed by both urban developers and local food advocates, an assortment of small to large-scale food production operations farm on land within otherwise suburban developments: a phenomenon defined as 'agriburbia' (Newman, Powell & Wittman, 2015). In terms of food production within city limits, urban agriculture has recently been adopted in large-force by an array of municipalities. Albeit, this adoption has largely been for socio-ecological and economic benefits other than food security (MacRae & Donahue, 2013). For all these social, political and economic reasons, local food production is an increasingly important topic in Canadian food system development circles.

Regarding the Chinese context, local food has a distinct history from the North American context. China's agricultural sector remains dominated by small-holders despite the state, in combination with the private sector, pursuing an intensive, 'modernized', consolidation process within most agricultural industries (Schneider, 2017). This agricultural modernization paradigm and policy framework, in the Chinese context, seeks to "increase the output of high-quality products based on green and innovative production" (Ministry of Agriculture and Rural Affairs, 2017). Simultaneously, however, the state continues to pursue the development of robust, regional networks of fresh food distribution. Policies such as the Vegetable Basket Program bolster regional supply chains, through introducing agricultural technology to smallholder producers, intensively monitoring local production and distribution chains, and allocating food sufficiency targets to municipalities (Gu, 2009). Furthermore, outside the state and private sector, alternative networks of food exchange such as community-shared agriculture are continuing to rise in prominence (Si, Scott & Schumilas, 2015). Regarding urban agriculture, strict land use and rural-urban integration policies have reinforced a more capital-intensive approach to growing food in the city, often at the cost of more informal or small-scale food production endeavors (Horowitz & Liu, 2016). Moreover, local prosthetic ecology technologies have strong support in Chinese research and political institutions (Hayashi, 2016). For all these reasons it is apparent that local food system development in China, especially in urban areas, has a unique and contentious future.

5.1 Divergent Values and Practices

5.1.1 Naturalness

Interviewees cited two main definitions of 'natural' food, both of which are predicated on the processes of production and their associated impacts on taste and quality. Those associated with Local and Natural production operations emphasized a systems-thinking-based definition of natural food. They contended that: a) science can never provide a complete scientific understanding of agro-ecosystem processes, and b) attempts to remove agricultural processes from their natural environment, results in a loss of the 'sacredness' surrounding food. The following quote from an urban farm manager, Interviewee B7, expresses this idea eloquently: "I'm very passionate about growing in dirt…To me, when you take it out of that ecosystem approach and put it into one that's more controlled by humans…Where's the miracle of life: the part we don't fully understand?" All community garden, urban farm and agritourism operations emphasized agro-ecological production principles as a requisite for 'natural' food. Three representatives from these operations were doubtful regarding the potential for indoor growing systems, that they claimed reduce the complex interactions between soil, organisms in the soil and the physiological components of plants.

Predictably, local Prosthetic Ecology operations emphasized a reductionist interpretation of natural food. These interviewees were more optimistic regarding the capacity of humans to manipulate and understand intricate agricultural processes: "…The light we provide [to plants] isn't really different from sun. We're just only giving them the parts of the light spectrum that they need" (Interviewee B2). Individuals from these operations remarked that how food grows influences its commercial value and demand, in addition to its quality and taste. Thus, three vertical farm operations in this study actively sought organic or heirloom varieties of seed, attempting to make their production processes as 'natural' and as 'transparent' as possible:

> I don't think food produced without soil/light is unnatural. I produce very high quality food without soil and it has the same nutritional benefits, plus others. I mean I personally

> use organic and open-pollinated seeds... But that's just because it's something I believe in. (Interviewee B3)

Vertical farm and in-vitro meat synthesis interviewees were also optimistic that the perceived 'unnaturalness' of novel growing methods would be overshadowed by the freshness and health-benefits of locally-grown, nutritionally-manipulated plant and meat products:

> The clean meat industry is well aware that it might face initial resistance from consumers, so producers are trying to be transparent about their process. At scale the process will look something like a beer brewery. (Interviewee C14)

The extent to which interviewees accepted 'unnatural' products varied between and among different forms of food production. Moreover, this continuum of acceptance differed between geographic contexts. For example, Chinese interviewees from Local and Natural operations expressed a deeper distrust of food produced unnaturally, arguing that: "humans should not interfere with natural laws and processes" (Interviewee A19). This is likely due to widespread distrust in the Chinese food system, as well as the recent development of alternative food networks in China that emphasize healthfulness and trust (Scott et al., 2014; Si et al., 2015). However, it is beyond the scope of this thesis to delve into cross-cultural comparisons of food system values. All interviewees from Local Prosthetic Ecology operations noted the tradeoffs between natural and unnatural food, arguing that artificial growing processes may be necessary depending on climate, commodity markets and socio-cultural demand for food products.

5.1.2 Efficiency

All interviews examined in this study defined efficiency in similar ways: decreasing the ratio of inputs to outputs; however, specific inputs and outputs varied among this study's participants. For example, interviewees from Local Prosthetic Ecology operations highlighted multiple measures to enhance 'productivity'. Vertical farms emphasized optimizing the delivery of nutrients, water and light to plants, in addition to achieving labour efficiency through automating harvesting procedures:

> Lettuce is going from seed to point-of-sale in seventeen days; it is something restaurants would pick up every day, if not every other day… If there was something that could harvest it for me, that would be great. It would save me 20 hours a week. (Interviewee B3)

In-vitro meat synthesis operations emphasized fine-tuning the nutritional components of meat, in addition to minimizing the inputs, such as land, water and capital required to grow meat. Individuals from agritourism and non-commercial vertical farms highlighted multifunctionality (e.g. tourism, agricultural education, food processing) as something that is economically efficient, generating additional surplus at little cost. Similarly, Local and Natural production operations such as community garden and urban farm operations emphasized the importance of productivity and minimizing the use of inputs. Interviewee B1, working at a community food and garden facilitation program, observed that efficiency is an important but often overlooked component of local food system conversations:

> It's hard for me, because I'm so pro a local food system but I feel like efficiency is kind of a bad word in local food conversations... but I question: is the farmer using efficient practices? are they using resources wisely? how are they transporting food around?

Local and Natural food production operation interviewees added that, besides ratios of inputs to outputs, a definition of 'efficiency' should capture the broader, long-term impacts and externalities of production. An urban planner involved in the development of an urban agriculture plan argued for this greater comprehensiveness:

> I think comprehensively [efficiency] has to be long-term, and it also has to, in order to be meaningful (when we talk about resiliency/sustainability), have environmental and social considerations. (Interviewee B7)

Similarly, three individuals from agritourism firms suggested that the definition of efficiency should be more cognizant of product quality, in addition to quantity.

5.2 Shared Values and Practices

5.2.1 Mixed Resource Management Strategies

As observed in Table 3, Local and Natural and Local Prosthetic Ecology scenarios of food production have several different functions. For example, vertical farms examined in this study are a mix of commercial enterprises: growing crops for restaurants and retailers or selling individual growing units (small or large-scale) to prospective growers. Furthermore, several vertical farms examined in this study did not engage in conventional markets, instead distributing their produce as food aid in their communities. Similarly, four (N=4) vertical farms grew for the market but functioned as not-for-profit enterprises. In-vitro meat synthesis operations were all commercial enterprises, seeking to compete within global meat industries. However, one interviewee alluded to the potential for such technologies to be distributed for smaller-scale, or at-home use. Overall, Local Prosthetic Ecology scenarios largely function as private operations, with a few emergent projects experimenting with alternative food distribution channels. Two non-commercial vertical farms examined in China were initiated by municipal and national authorities, rather than through private enterprise or community members.

The author observed similar findings with respect to Local and Natural scenarios of food production. Most (10 out of 14) local and natural food production operations were commercial enterprises. This larger number was due to the abundance of interviews that took place with peri-urban ecological agritourism farms in China. Two operations examined in this study were not-for-profit enterprises, consisting of a market garden and a community garden. Additionally, two urban planners involved in the development of an urban agriculture strategy were interviewed. This specific agricultural plan predominantly highlights urban farms and gardens (Local and Natural scenarios), although it suggests that in the future more technologies of Prosthetic Ecology food production scenarios, such as hydroponics or aquaponics, could be adopted in city planning. One urban planner highlighted that they were seeking to retract the scope of management for community gardens from the city to the community, in an effort to make the garden more self-sustaining. Additionally, the two not-for-profit Local and Natural operations examined in this study grew food to sell at markets to sustain their operations, in addition to distributing ‘unsellable’ food to volunteers and workers on the farm. Overall, Local and Natural scenarios of food production exhibit highly hybridized privatized and club-based management strategies with some (decreasing) public assistance, discussed more in Chapter 6.

5.2.2 Closed-Loops

Across all forms of local food production examined in this study, creating closed-loop socio-ecological systems was an important component of 'efficiency'. Interviewees from vertical farm operations, especially those using aquaponic growing methods, outlined the importance of water and nutrient reuse and recycling systems. Similarly, several individuals from agritourism farms (N=4) stressed the ecological benefits of closed-loop nutrient and water systems. Community garden, urban farm and non-commercial vertical farm organizations highlighted their closed-looped ecological practices, in addition to their contribution to the strength of local socio-economic networks between consumers and producers.

5.2.3 Barriers to scaling-up: "local is part of the food security puzzle"

Interviewees expressed mixed perceptions regarding the potential for local forms of food production to fundamentally transform the structure and outcomes of conventional food systems. For example, individuals defined the extent of 'local' in multiple ways, specifically regarding the 'most effective' political-economic structures and levels of food production, distribution and consumption, as well as the outlooks for local food producers to provide for growing urban populations.

5.2.3.1 Socio-Economic Barriers: Self-sufficiency, comparative advantage and gourmet localism

All except three interviewees stressed that local food production was insufficient to meet the food needs of urban areas. Those three exceptions were emphatic that complete self-sufficiency was an important direction for food system transformation and change, whereby urban food needs are met from local food production environments. Conversely, all other respondents noted that local food system development was a noble, but insufficient goal. This majority of respondents stressed that the local area in which food is grown impacts its taste, quality and freshness. This argument suggests that food should be grown and traded to maintain its best possible quality. Interviewee B3, from a vertical farming operation, adopted this approach:

> I think everyone should grow their own food. I think, if I got put out of business because everyone was growing their own food I'd be okay with it... But at the same time, I understand that we live in a very globalized world…and we have developed tastes for things that don't grow here.

Similarly, respondents highlighted comparative advantage as a guiding principle for local food system development. This approach argues that food should be grown in the areas in which it grows most efficiently, and be traded with regions that specialize in other products. A vertical farm researcher from China echoed these arguments:

> Different kinds of foods have different features. Those not suitable for long-distant transportation or preservation are mainly grown locally. Also, Chinese really care about the taste of food, and they think different foods belong to different places. (Interviewee A16)

This contrasts with self-sufficiency approaches, that seek to meet food needs within a specific geographic boundary, and with minimized trade. Commentators on indoor food production strategies used similar logic. Interviewees posited that certain non-perishable items, such as staple crops and root vegetables, are not an economically-viable option for greenhouse or Vertical Farm production, whereas leafy greens and other quick growing, high value crops are. Overall, most (34 out of 38) interviewees argued that, to maintain food security (sufficient quantities of culturally-appropriate, nutritious food), food commodities should be traded between regions, and should be grown using the methods with which they grow best, rather than aim for predominantly local self-sufficiency.

With respect to Local and Natural food production scenarios, all community gardens (N=3) and most urban markets (N=6) examined in this study were actively attempting to localize their inputs (e.g. water, soil and nutrients) and consumer-base. The community gardens, in addition to the Canadian and Singaporean urban market examined in this study, sought to make their products more accessible, producing and providing land (often at no or reduced cost) for marginalized groups within their own and neighbouring communities. All Local and Natural operations sourced labour from local groups, including providing employment and/or opportunities for volunteer-work, in exchange for access to food and food-growing knowledge.

Regarding Local Prosthetic Ecology operations, the non-commercial vertical farms examined in this study also focused on providing for local communities: especially those groups in remote areas with poor access to year-round fruits and vegetables. One planned vertical farm in China was designed for the specific district in which it was located, while another was advancing a more radical agenda to completely supply a new town with its fresh produce. Likewise, the two Canadian commercial vertical farms examined in this study were catering primarily to the neighbourhood, districts and cities in which they operate. However, only one was actively attempting to build local distribution networks, while the other was focused on expanding across the country and abroad. The former commercial farm had a specific strategy to localize its production inputs, from nutrients to water, in one, large closed-loop system. In terms of labour inputs, all vertical farm organizations were attempting to minimize the use of manual labour, and placed little emphasis on hiring local workers or technicians.

5.2.3.2 Scale of food production

All interviewees argued that consumers should have some knowledge of food growing, or grow food themselves. However, most interviewees (N=33) suggested that small-scale growing by individuals is insufficient to meet urban food demands, and that the bulk of food production should (and will) be left to professionals (e.g. farmers or food-growing technicians). These interviewees stressed that their local food production strategies were all “part of the [food security] puzzle” (Interviewee A12). One vertical farming researcher observed that their direction of research changed from small to large-scale operations, due to funding constraints for the former. Only (4 of 38) interviewees--two vertical farm researchers and two agritourism farmers--argued that small-scale, individual or family-level urban food production, could be sufficiently-productive to feed urban populations. Additionally, Interviewee B7, working at a not-for-profit urban farm, highlighted the need for their operation to compete within conventional urban food markets: “I have a great deal of respect for farmers, but if we had less monocropping, smaller-scale vegetable growing…it would be really great. Is [small-scale growing] a viable livelihood? I don’t know.” This interviewee was part of an organization whose mission was to explore this question, and teach others how to make a livelihood out of small-scale urban production.

With respect to in-vitro meat companies, there was more optimism regarding the potential for this technology to disrupt conventional meat-raising systems. One in-vitro researcher was optimistic of the market and ecological-based efficiencies of lab-grown meat:

> Our research shows that cultured meat could be part of the solution to feeding the world’s growing population and at the same time cutting emissions and saving both energy and water. Simply put, cultured meat is, potentially, a much more efficient and environmentally-friendly way of putting meat on the table. (Interviewee C14)

However, the in-vitro meat companies examined in this study were not necessarily motivated to go ‘local’ or to produce at smaller scales; rather, they were motivated to scale-up and out, through competing in conventional global meat markets. As technology becomes cheaper, however, the shift may be to smaller-scales: “Potentially, you can do this in your kitchen. You can grow your own meat” (Interviewee C13).

5.2.3.3 Political Barriers

The food production operations examined in this study highlighted several political challenges to their development. The multitude of stakeholders involved in urban food production development--agricultural and non-agricultural related firms, farmers, city planners, citizens and academics--all play an integral role in the development of local food production strategies. Interviewees described the inter-personal conflicts that shape efforts to develop local food production strategies in and around cities. For example, in the broader scheme of city planning, local food production remains one, among many, political priorities. One city planner, when describing their city’s urban agriculture development plan, highlighted urban agriculture’s current niche status as a city development priority:

> There are 60-70 people that love [urban agriculture] and want to go with it. There are a few people who see it as potential for the city to completely reorganize the way it's doing things. But the city is not going to reorganize itself on the response of so few people; it's not, politically speaking, how things happen. (Interviewee B4)

Local Prosthetic Ecology operations echoed these sentiments. A designer for a vertical farm operation in a city in China described a lackluster, reluctant government partner. This partner's hesitancy was delaying the farm's development. Similarly, those agritourism farms in China expressed a desire for their government to pursue greater promotional efforts into educating the public regarding the benefits of organic, ecologically-grown food, thereby establishing a market for their goods.

5.2.4 Relationship Building and Food System Traceability

All interviewees highlighted the importance of building a traceable, transparent food system for consumers. A 'transparent' or 'traceable' food system is a system in which consumers have access to information regarding the food they are consuming, necessarily involving trust and relationship-building (with producers and products). Opinions about the processes through which a transparent food system is achieved, however, differed between interviewees, integrating consumers in more or less passive and active ways.

More passive methods to achieve food system transparency include giving consumers greater access to production information, without the direct involvement of consumers in food production practices. Methods to achieve this include more labelling, certification, or the ability to scan product information onto consumer mobile devices: "From printing the code to the final meat packing, each piece of meat can be traced. We're doing this right now" (Interviewee A4). In commercial vertical farming operations, emphasis was placed on maintaining openness regarding production practices: displaying production methods on websites (including what nutrients/water sources are used), as well as allowing the public into growing facilities. The extent of public interactions within these settings is limited, however, given biosecurity and current intellectual property concerns. Interviewees suggest that benefits to achieving a traceable food system through passive rather than active means include greater consumer convenience, quality-assurance and market-demand for safer or higher-quality products.

Between passive and active methods to achieve food system transparency is building stronger consumer-producer relationships. Such approaches seek to engage consumers with producers, without the consumer having to grow food at a large scale themselves. This approach was not mentioned by any of the interviewees in this study; however, it is well outlined in literature on the benefits of alternative food distribution models, such as farmers markets and community-shared agriculture systems (Hinrichs, 2000; Si et al., 2014).

Active methods to achieve food system transparency involve the direct involvement of consumers in food production processes, with the hopes of building relationships with others and with the food they are consuming. Direct consumer involvement in food growing is posited to promote greater knowledge and power regarding what inputs and growing processes are used. Concomitantly, all interviewees stressed that experiential knowledge gained through growing food is important for reconnecting individuals with the food system, and for understanding the socio-ecological challenges of growing food. The ways to involve consumers, however, varied across multiple forms of local food production. Certain companies are working to develop plant and meat-growing systems for at-home or institutional (e.g. school or hospital) use. Other operations emphasize community participation in food growing, through programs such as community gardens or non-commercial urban farms.

All Local and Natural and Local Prosthetic Ecology operations highlighted the degree to which food-growing creates unique opportunities for socialization and relationship-building. One interviewee, managing two community garden programs, noted the diversity of people that access their gardens:

> It’s amazing; there are twelve different families of immigrants in such a small space, all growing different things. And it’s not even necessarily with us promoting diversity. It just seems to happen that way in certain gardens, based on the neighbourhood. (Interviewee B6)

Interviewees from vertical farm operations had similar insights, noting the novelty of their food production methods and their ability to draw conversation. When speaking of a research park in which a vertical farm was to be located, one urban designer noted that:

> [It] was pretty quiet when we visited...it is inward looking. Nobody talks to each other; everyone does their own thing. I think [the vertical farm] creates interesting places for people to socialize and mingle. It's a kind of new experience. (Interviewee A11)

Interviewees also noted that actively participating in growing food in urban areas allows for the sharing and development of food culture. The diversity of growers in settings such as community gardens, or urban farms allows for hands-on experience and knowledge sharing, while also serving to re-introduce farming culture and know-how to urbanites. Similarly, several vertical farms, mostly non-commercial, were actively attempting to (re)engage members of the public with food growing, albeit through novel, capital-intensive practices. These organizations argued that food growing at small-scales is an important component to maintaining healthy urban lifestyles. More broadly, interviewees considered the degree to which consumers understand and are included within production processes. For example, one vertical farming researcher, commenting on lab-grown meat and indoor plants, noted that non-traditional approaches to raising meat, fruits and vegetables risk consumers losing touch with and respect for their food: "The problem that we've had with going to a centralized food system is that we've lost respect for food…The problem with the petri dish systems is that you've [also] lost that relationship" (Interviewee B5).

5.2.5 Shared Risks

Risks were similar across the different forms of local food production examined in this study, spanning cultural, economic and political domains.

Social Acceptance: Vertical farm, in-vitro meat producer, community garden and urban farm organizations highlighted social acceptance as a major factor impeding their growth. Vertical farms and in-vitro meat producers that took part in this study identified 'ick' or 'yuck' factors as customer deterrents: the fact that their products are grown unnaturally or in laboratory settings. Similarly, community garden and non-commercial urban market operations highlighted community participation as a significant barrier to the success of their programs. These organizations were actively attempting to make market gardens, community gardens and community food programs self-sustaining, in terms of funding as well as management.

Economic: Several operations (N=19) including vertical farms, in-vitro meat production organizations, agritourism farms and urban markets, are seeking to compete within conventional food commodity markets: supplying retailers, restaurants and directly to consumers. Vertical farms and in-vitro meat operations were seeking to lower their prices through the further development of their production technologies; two such organizations have currently committed to keeping their products cheaper than organic but more expensive than conventional products. While accessibility to the means of production for vertical farming or meat synthesis remain prohibitively expensive, several partnerships have formed between government and private sector organizations, to provide high-tech growth facilities to communities situated within poor food-growing climates, such as Northern Canada. Moreover, several business models include the development of grow-at-home technologies. In terms of broader risks, one vertical farm technology researcher highlighted that there is a potential trap for corporatization in the burgeoning vertical farm industry. Agritourism farms were similarly attempting to secure a market for their goods. Two of these organizations stressed that it was difficult to find a market for their more expensive, ecologically-produced goods.

With respect to community garden and urban farm operations, interviewees identified several economic barriers to their function. For example, many food-growing programs were in direct competition with developers for land. However, interviewees were developing strategies to overcome these challenges, such as slotting agriculture into other land use categories (e.g. recreational or forested land), or working in partnership with private land owners. Additionally, many non-commercial community food programs were selling their products to retailers, restaurants and directly to consumers, to sustain their operations. As such, these groups faced market competition from numerous sources, even those similar with purpose and social function:

We have to do a marketing push. Then there's this [other organization] that says they'll deliver local produce to your door. That's where I get defensive; I want those customers, and we have the same demographics... But at the same time, I understand that they are part of the solution more than part of the problem…it's not a competition, we're all in it together. (Interviewee B7)

Chapter 6: Discussion

6.1 Two Strategies with Conflicting Outlooks?

The comparison of Local and Natural to Local Prosthetic Ecology scenarios of food production made in Chapter 3 are summarized in the table below. It is important to note that not all benefits nor drawbacks listed here apply to the multiplicity of forms of each respective food production method. For example, though several Local and Natural projects are community-based, grassroot endeavors, some are run by private or state actors. Likewise, although vertical farming operations are largely concentrated in the private sector, several emerging projects reflect public-private partnerships, social entrepreneurship, or civic-led initiatives. The key takeaway from this table is that both trajectories of local food production have several unique opportunities and potential drawbacks.

Table 5. Summary of Benefits and Drawbacks to Local Food Production Trajectories

	Benefits	Drawbacks
Local and Natural (e.g. community gardens, agro-ecological farms, urban market gardens	- Often at the grassroots-level, these projects build community capital - Positive space for environmental education and development - Knowledge-sharing, especially around traditional food growing practices and cultures - Limited but nonetheless possible source of nutrition and potential food security strategy - Tool for urban beautification and contribution to local biodiversity and ecosystem services	- Labour intensive - Variable performance in future yield and population scenarios - Land-intensive: difficult to prioritize with other competing land uses and developments, especially in urban areas - Remains exposed and vulnerable to vagaries of climate change
Local Prosthetic Ecology (e.g. vertical farms, in-vitro meat synthesis operations)	- Decreased use of agricultural inputs (especially land) - Optimization of inputs for plant yield and nutrition - Massive productive potential	- Currently operates in a highly corporatized, commodified framework - Huge current startup costs and capital-intensity

	- Ultimate engineered-approach to food system resilience, safeguarding yield from pests, climate and other shocks - With respect to livestock, avoids cruel conditions of raising and slaughtering - Overall, reconcile population and civilizational requirements for food energy with limits of finite biosphere	- Lack of acceptance by general public - Advances new, unexplored questions regarding the socio-economic impacts of mechanization, high-automation, and the further disembedding of individuals from food and, more broadly, nature

I argue that each method of food production alone is limited, but that together each strategy may address the shortcomings of the other. The productive potential, protection from ecological uncertainties, and capacity for automation afforded by Prosthetic Ecology technologies serve to address the substantial labour and land-use requirements, as well as the vulnerability to climate change, of Local and Natural food production strategies. Similarly, the contribution of Local and Natural operations to ecological education, traditional knowledge sharing, as well as urban-ecosystem services, addresses several of the potential drawbacks of Prosthetic Ecology strategies. These drawbacks include the further dis-embedding of individuals from the food system, and the potential socio-economic consequences of high automation. A synergistic relationship between either scenario of local food production in urban areas could be envisioned, where most caloric needs are met by large-scale vertical farms and meat-synthesis plants, and broader socio-economic and ecological outcomes are achieved through a variety of agro-ecological projects (for an in-depth discussion of such urban planning scenarios see Quilley, 2018). The following sections will compare the underlying paradigms that operate within each local food system trajectory. Understanding the underlying values and practices that shape each food production method is critical, to highlight the outlooks, opportunities and barriers for these operations to transform conventional food production systems (Abson et al., 2016).

6.2 Conventional-Alternative, Prosthetic Ecology-Natural Paradigms

The following analysis draws from alternative agriculture scholarship (Whatmore, 2004; Beaus & Dunlap, 1990; Si et al., 2015), as well as theories in economic sociology regarding metabolic rift, alienation and embeddedness (McClintock, 2010). Scholars and activists juxtapose local food systems to global commodity chains that are commodified; large-scale; removed from their social, economic and ecological context; and highly exploitative of nature. Examining how and to what extent these paradigms are represented in local food production operations is a critical strategy to leverage large-scale systems transformation:

> Sustainability science needs to engage with the deep, or ultimate, causes of unsustainability and consider interventions that address the emergent *intent* and *design* of systems of interest…" (Abson et al., 2016, 37)

The following sections discuss the broader significance of the value and practice-based themes discovered through interview analysis, and how they compare between Local and Natural and Local Prosthetic Ecology scenarios of food production.

6.2.1 Food as an excludable commodity, exclusive club good or public right?

This analysis draws from commons-based resource management (Ostrom, 1990 [2015]) scholarship, and specifically the work of Colding et al. (2014) and Webster (2007) on economic realms and goods in urban areas. Following neoclassical economic theory, goods describe how and to whom resources are distributed and managed: a function of how accessible resources are (excludable), and whether they degrade over time with use (rivalrous). The degree to which goods are excludable or rivalrous depends on a variety of factors, including:

> …the physical characteristics of a good or service, available production technology, the scale and scope of activity, and other aspects of the production system including storage and distribution. (Polski & Ostrom, 1999, 20)

Webster (2007) distinguishes between public, private, club and common goods (Table 6). Public goods are those that are non-excludable (individuals cannot be prevented from using a resource) and non-rivalrous (continuous use of the resource does not degrade it over time), whereas private goods are those that are excludable and rivalrous. Club goods are excludable and rivalrous. Common goods, in contrast, are non-excludable and rivalrous.

Table 6. Multiple Types and Characteristics of Economic Goods.

	Excludable	Non-Excludable
Rivalrous	Private Good (e.g. land in a fenced backyard)	Common Good (e.g. public land for guerrilla gardening)
Non-Rivalrous	Club Good (e.g. land in a gated community)	Public Good (e.g. food aid)

Table adapted from Webster (2007).

Concerns over the degradation of common environmental goods have prompted numerous debates over sustainable resource governance strategies. Whereas Hardin's tragedy of the commons (1978) theory advocated for privatization and state intervention to regulate the usage of common environmental goods, later scholars (e.g. Ostrom, 1990) have argued that community-level responses to resource management challenges are an overlooked, but effective strategy for socio-economic and ecological sustainability. The three arenas through which to manage resources: privately, through the state, and collectively, will hereafter be referred to as 'realms'. Specifically, the term realm refers to the actors and institutions involved in the management of a resource. For example, urban land can be managed as a public realm (e.g. parks), private realm (e.g. backyards), or club realm (e.g. gated communities).

The interaction between realms and goods is complicated. One good can be managed within multiple 'realms' (e.g. community gardens run by the state, private developers, or a closed-community), and the actors within one realm can, to a certain degree, manage a good in multiple ways (i.e. make it more or less excludable and rivalrous). Some scholars have recently begun to challenge the conventional economic management of food commodities, arguing that its sole treatment as a private good, managed in public or private realms, should be reconsidered (Vivero-Pol, 2017a).

Most operations examined in this study (N=36) treated food as a private or club good, that was exchanged through private transactions, or within a select community. Specifically, these food projects sold their products within conventional markets, through food retailers or restaurants, to maintain their operations. One urban market and one community garden examined in this study did partake in alternative forms of economic exchange (e.g. gifting 'unsellable' produce or bartering), albeit as a secondary activity, and mostly with those who were part of their organization (or club), as opposed to the broader public. Similarly, those community gardens examined in this study operated on an individual plot basis (N=2), in which overall garden management occurs as a community but garden plots are privately-maintained. Finally, three local food initiatives led through the public realm (one vertical farm contracted by the Chinese state, and two municipally-funded community garden and urban market initiatives in Canada), treated food as a club good: excluding members outside the area in which the project was located.

Four food production operations examined in this study governed their products as a non-excludable commodity. These included two 'food aid' operations, in the form of aquaponics food banks that treated food as a hybridized public-club good. One of these operations required proof of nearby-residence to qualify for food donations while the other required proof-of-need, limiting the access of individuals to their services and thus making their services excludable. However, in this case excludability is a function of the scale of analysis. As a single food aid operation within a network of other food aid organizations, individuals may not be excluded from accessing their services. Moreover, increasingly self-sufficient food aid operations, such as aquaponics food banks, challenge the rivalry of traditional food donation models. These traditional food donation networks are reliant upon seasonal, discretionary and often low-quality charitable food surplus gifting, whereas more self-sufficient food production and distribution endeavors guarantee a steadier flow of high-quality product. Given large community demand and a relatively constant supply of produce, these operations resemble public good provisioning systems (Vitiello et al., 2015). The third operation that treated food as a non-excludable good was a community food project in Canada. The programs run by this operation were available to all community members: "I definitely think [we] take a role in educating the community as a whole...We don't just do outreach to schools where most kids live with low-incomes" (Interviewee B1). This operation was catering to 'community' in a broad sense while simultaneously operating within a bounded city, reflecting a hybrid public-club management strategy. Similarly, one upcoming Chinese vertical farm spearheaded by a large municipality is intended for public enjoyment and education, while its products are to be sold to retailers and restaurants. This situation reflects the treatment of food knowledge and beautified urban space as a public good, alongside edible food products as private goods.

Scholars and activists have widely disparaged the treatment of food as a pure-private-good, with its negative impacts on food security, consumer power and socio-ecological well-being within the food system. Local food production operations, under an umbrella of alternative agriculture, may combat this dominant privatization narrative as the appropriate scale and venue through which to hybridize public, private and commons (or club)-based management strategies (Vivero-Pol, 2017ab). For most operations examined in this study (N=34), food produced within public, private and collective realms was largely treated as club or private goods, in which food is excludable, while four operations treated food as a hybridized public-club good.

These results suggest that local food production projects operate within multiple resource management frameworks. While most operations examined in this study treated food as a private or club commodity to be traded and exchanged selectively, there are burgeoning movements (in both Local and Natural and Local Prosthetic Ecology scenarios), that reflect the practice of treating food as a non-excludable right. This finding aligns with literature reflecting the hybridity and fluidity of values in alternative agricultures (Dupuis & Goodman, 2005). With respect to Local Prosthetic Ecology scenarios, the findings of this study contradict totalizing claims that technologies such as vertical farms solely: "…encourage urban restructuring around elite consumption, and…reproduce and advance capitalist agriculture and the corporate food regime" (Hallock, 2013, 31). While many examples of vertical farming or meat synthesis projects examined in this study did pursue the commodification of urban agricultural goods and space, others operated under radically different management practices. Moreover, given the massive productive potential of vertical farm and meat synthesis operations, food production can theoretically become non-rivalrous in the long-term. Similarly, Local and Natural scenarios did not operate solely according to a single form of economic exchange or management strategy. For example, the community gardens and urban market gardens examined in this study remained embedded in the logic of private property and participation in conventional agricultural markets. At the same time, however, these operations were managed within multiple realms and partook in alternative forms of economic exchange. These findings align with literature on the hybridity of local food operations, that exhibit a range of alterity (Hinrichs, 2000; Holt-Giménez, 2011). The extent to which this hybridity of alternative-conventional values facilitates or hinders system transformation is a topic of further discussion, examined in Chapter 7.

6.2.2 Trade, self-sufficiency, and 'appropriate' food system scales

Beaus and Dupuis (1990) suggest that food production and distribution networks are rooted in 'centralized and 'decentralized' paradigms. The former argues for increased specialization, the deepening of global food commodity exchange, and the scaling-up of production practices to achieve "cheap and abundant food" (Beaus & Dupuis, 1990, 601). This prescription for food system development engenders an intricate, complex network of trade relationships between large-scale producers, distributors and retailers across a global extent. Conversely, proponents of a decentralized food system argue that centralized systems are vulnerable to socio-ecological disruption, and wrestle autonomy from small-scale producers and communities to large-scale corporations and government stakeholders. Alternative food production operations seek, broadly, to challenge "the logic of bulk commodity production" (Whatmore et al., 2003, 89). Building robust, local, smaller-scale foodsheds would enhance the livelihood of producers and food insecure communities, contribute to local social and ecological resilience, and positively impact food security and nutrition (Burgin, 2018; Desmarais & Wittman, 2014; Cabell & Oelofse, 2012). Debates in policy and academic circles question the potential for domestic self-sufficiency, specific definitions and realistic outcomes of 'localization', and appropriate scales for production.

6.2.2.1 Trade or Self-Sufficiency?

The drive for relocalization and self-sufficiency have manifest in a variety of discursive trends and developmental consequences. Exponents of conventional food distribution pathways have argued, through theory and computer simulation, that the international trade of specialized food commodities is a vital strategy for international food security given future climatic and population scenarios (Ridley, 2010; Fader et al., 2013). In addition to food security, food trading contributes to changing local tastes and demand for agricultural products grown elsewhere. In contrast, scholars advocating for more localized production-distribution pathways highlight the power imbalances that have resulted through the globalization of food distribution chains, contributing to a consolidated 'corporate food regime' (McMichael, 2009). Scholars and activists position local food production systems in tension with global networks, suggesting that 'going small' empowers local economies and communities, all the while contributing to local biodiversity in agricultural systems (Feenstra, 1997; Wittman, 2009; Rosset & Altieri, 2017).

Recent scholarship has sought to bridge dichotomous local-global food distribution debates. Some studies are advocating for a finer-grained spatial analysis, calling neither for local nor global trade networks, but regionalized foodsheds that are somewhere in-between (Kissinger et al., 2018; Schipanski et al., 2016). Other studies argue for the rethinking of food trade and food security at a national-scale. Bioregionalism, a movement that calls for constructing forms of political association (and foodsheds) according to natural, biophysical boundaries, rearticulates food security as a regional priority, as opposed to national (Cato, 2013). Other scholars have sought to change the generalized language of the debate. Clapp (2017) calls for a more nuanced conceptualization of food self-sufficiency that is: "…more about a country's domestic capacity for food production than it is about a rejection of food trade" (95). Individuals within the more political associations of food system relocalization, such as the food sovereignty movement, have advanced arguments for a more place-specific definition of food sovereignty that is less about food supply management and more about community autonomy and self-determination (Desmarais & Wittman, 2014). Simultaneously, these individuals have grappled with the cross-scalar nature of their political engagement, and the opportunities (and challenges) that come with advocating for local struggles in provincial, regional, national and international arenas. Common among this set of literature is a recognition of the fluidity of food commodity production and distribution flows across multiple scales, and the need to engage multiple stakeholders, beyond just the local, to promote local food systems (Desmarais & Wittman, 2014).

All interviewees that took part in this study highlighted that their operations were part of a larger food production puzzle that is local, regional and global in scope. Nearly all interviews except for (N=3) were skeptical regarding the potential for complete local self-sufficiency. The three exceptions suggested that their production methods, including two grow-at-home vertical farming units and one agroecological farm, could sufficiently produce enough food for urban citizens. No interviewees expressed a desire to radically shift the balance of food provisioning, from broader to more localized networks. Moreover, the in-vitro meat synthesis operations examined in this study highlighted a drive to integrate into global markets; these operations may not currently classify themselves as 'local'. However, it is important to highlight that currently these operations cater to local niche restaurants, and over time as technologies democratize and cheapen, markets for smaller-scale units may develop. For example, 3D food printing, a technology that can take computer design blueprints and generate three-dimensional food products using edible 'inks', is steadily becoming more decentralized and applicable for small-scale use (Lipson & Kurman, 2013). Overall, the operations examined in this study recognize the benefits of both local and global scales of production, while reflecting an "as much as possible" (Interviewee B1) approach to building more local and regional food sheds.

This thesis did not examine operations involved in the food sovereignty movement, although they have had a profound role in engaging global communities in local food struggles. Although these operations are themselves not fundamentally "anti-global" (Wittman, 2009), they advocate in local and international arenas for: "…reducing global food trade and reorienting food systems around local production grounded in agro-ecological principles" (Clapp, 2017, 207). In other words, these organizations are highly political, engaging in advocacy for local food systems across multiple scales: municipal to international (Desmarais & Wittman, 2014). This political engagement for the construction of local food sheds contrasts with the operations examined in this study, from both Local and Natural and Local Prosthetic Ecology trajectories, that take a less political approach to local food system development. It is apparent that local food operations reflect, across multiple production methods, a continuum of desire and action to localize food production practices.

6.2.2.2 Scales of Production

In most upper-income and several middle-income countries farm size has increased, and farm numbers have decreased over the past six decades (Lowder et al., 2016). In the tradition of neo-classical economics, some scholars argue that mechanization, specialization and bulk commodity production are more economically efficient and productive (in terms of yield and labour requirements) than smaller-scale production systems (Ridley, 2010). Detractors of conventional food production systems argue that reversing this farm-size trend is important to develop more just and resilient food systems. Rooted in the tradition of ‘small is beautiful’, this movement to ‘scale-down’ argues against the logic of gigantism, through pursuing smaller-scale economies. Schumacher (1973) advocates against economic activity that values goods more than people, and consumption more than creative activity. Furthermore, he maintains that producers have lost pride and fulfilment in their work through increasing scales of production for greater profits, while emphasis on quantity over quality increases wasteful consumption.

Scholarship in human geography has widely discussed a ‘quality-turn’, or ‘post-productivist’ era in agricultural production practices, that stresses similar economic arguments as those presented above. Alternative production schemes are suggested to emphasize qualitative over quantitative food system outcomes, prompting numerous sectoral developments, including: “…direct marketing, short food supply chains, local food systems, and the renewed legitimization of artisanal food practices and regional cuisines” (Goodman, 2003, 2).

A critical body of literature has emerged over the past several decades that is skeptical of this productivist, post-productivist discourse. For example, Born and Purcell (2006) caution against the local trap; local food systems, like food systems at all scales, do not automatically guarantee positive outcomes such as food justice and resilience, or an anti-productivist set of practices. Following this argument, some scholars have highlighted that organic and community-shared alternative agriculture projects lose touch with their anti-conventional paradigmatic roots, through pursuing increased production scales and profits over alternative goals (De Lind, 2010). Likewise, post-productivist or quality-turn scholarship has been extensively critiqued for its lack of attention regarding class relations (‘higher quality’ products are often more expensive), and for reinforcing weaker models of sustainability transition (Potter & Tilzey, 2008). However, these studies assume that emphasis of ‘quality’ over ‘quantity’ is inherently a positive development and conflate market with technological-intensification.

Another body of literature is seeking to move beyond productive, post-productive scale debates altogether. These scholars maintain that local food systems are rooted in a multiplicity of economies and social relations, that require farmers to be flexible and hybridize their practices, including the scales at which they produce. As such, scaling-up production does not automatically result in ‘local’ production operations losing their core values. Furthermore, scaling-up local food systems may even be required for economic and social viability, as well as large-scale systemic change (Mount, 2012; Nost, 2014). Climate change and ecological doomsday pundits continue to examine future global food production and population scenarios, including the yield potential of various production methods, and their input to output efficiencies (de Ponti, et al., 2012).

This study examined a suite of local food production projects that operated at small and large scales. All interviewees except for two were skeptical of the potential for small-scale growing at the household or farm level, using Local and Natural or Local Prosthetic Ecology methods, to significantly contribute to food security. Even those organizations that developed technology for, or were involved in small-scale growing, expressed this cynicism. These operations suggested that it is important for food be grown at smaller-scales, such as at the individual consumer-level, but for reasons other than food security such as environmental education and relationship building. Overall, the operations examined in this study sought to simultaneously realize greater food system transparency and close socio-ecological loops, while contributing to consumer budgets, tastes and convenience.

All interviewees suggested that ‘efficiency’ is an important metric to consider, when measuring production outcomes. Moreover, all operations examined in this study defined agricultural efficiency in similar ways: the ratio of inputs to agricultural outputs. Although this was a common definition across all interviewees, specific inputs and outputs differed. For example, some interviewees suggested that efficiency should be measured using various crop yield per land area metrics, while others stressed profits and the minimization of production and consumption waste. All Local Prosthetic Ecology projects deferred to this highly productivist interpretation of efficiency; however, interviewees from Local and Natural operations questioned if agricultural practices could be considered efficient if they have unintended socio-ecological consequences. This suggests that productivity and efficiency remain important considerations for all operations, contradicting strict dichotomies between ‘productive’ and ‘post-productive’ food production practices. However, Local and Natural scenarios of food production recognize the tradeoffs that come with streamlining and making food production more ‘efficient’.

6.2.2.3 A continuum: local → global, small→large scale

The results gathered for this thesis suggest that local food operations function along a continuum, in their desire to 'decentralize' or to 'centralize' food production and distribution systems. Overall, no operation examined in this study was fundamentally 'anti-global' or 'post-productivist' in their underlying values and approaches to food production. Both Local and Natural and Local Prosthetic Ecology operations reflected a space 'in-between', valuing local distribution pathways and global trade networks, in addition to efficient practices and broader metrics for production outcomes. These findings align with Mount (2012) and Nost (2014) arguments, that local producers operate across multiple scales and with multiple practices to cater to different consumer and client needs:

> …while [consumers and producers] are shaped by the failures of conventional food systems, they are also exposed to the benefits—including price, variety and convenience. As a result, [local food systems] are often expected to deliver hybrid results, while maintaining an alternative identity, in a context where the conventional and alternative constantly adapt. (Mount, 2012, 117)

While the Local Prosthetic Ecology scenarios of food production examined in this study were highly motivated to increase productivity (as a function of land, labour and yield), they also highlighted their potential to increase food quality. For example, interviewees noted that technologies of Prosthetic Ecology allow for greater control, manipulation and optimization of nutrients and chemical components for plant and meat growth. In this case, increased productivity need not come at the expense of decreased product health or 'quality'. Of course, quality is a subjective judgment: the way in which food is grown, regardless of its physical components post-production, impacts its reception by consumers (e.g. Specht et al., 2015). Local and Natural operations also operated in both productivist and post-productive spaces. These Local and Natural projects reflected a greater alignment with 'quality-turn' literature on food production systems, and their associated focus on other food production outcomes besides just 'efficiency'. Moreover, desires to scale-up these operations were motivated by factors other than solely profit or yield maximization, such as greater community outreach, educational impact, and broader networks of relationship-building. While Prosthetic Ecology projects did emphasize multiple socio-ecological outcomes as driving factors for their operations, besides just productivity, these operations should be cognizant of the potential consequences of scaling-up and out as the sector grows in the following decades (addressed in the following section).

6.2.3 Embeddedness and Metabolic 'Rifts'

A central motivation for food system localization is to reattach significance to the relationships between and among individuals, communities, food and nature itself. Theories of metabolic rift and embeddedness shed on light on the processes through which these relationships strengthen and deteriorate over time. To begin, scholars have posited that conventional agricultural processes generate a material 'rift' between food systems and natural ecosystems. As the processes of capital accumulation occur at a rate beyond that of natural ecosystem restoration, natural resource bases are undermined; subsequently, capital accumulation processes shift across space (Clark & York, 2008). Applied to agricultural systems, as food production processes outpace their natural biophysical yields, the system must undergo a series of overrides (e.g. the introduction of synthetic fertilizer, water inputs and genetic manipulation) to maintain its function. This has resulted in a series of biophysical contradictions that undermine the system's long-term sustainability (Weis, 2010).

Scholars have also examined metabolic rift through a socio-economic lens: what McClintock (2010) calls 'social rift'. These scholars contend that the treatment of land and food as fictitious commodities, traded according to abstracted, asocial monetary values, has resulted in the scaling-up of agricultural practices and a rise in wage labour in agriculture. Highly 'productive', input-intensive, specialized systems displace small-scale farmers, and distance producers from their labour. McClintock (2010) argues that local, informal urban agriculture is, in a Polanyian sense, a counter-movement against the consequences of industrial agricultural processes: "amount[ing] to a wresting away of food production and consumption from the market via the valorization of unquantifiable socio-cultural values and relations traditionally inherent in food" (200).

This concept of 'social rift' is derived from Polanyi (1944 [2001]) and later Granovetter's (1985) work on 'embeddedness'. These scholars critique the rational-choice theories of neoclassical economics, arguing instead that economic exchange is mediated within a complex web of social relations, rather than an individualistic vacuum. Case studies of some of the various forms of local food production, such as community gardens, community shared agriculture (CSA's) and farmer's markets, posit that these venues reattach social significance to food in an otherwise disembedded, globalized food commodity market. For example, Kingsley & Townsend (2006), among other scholars, observed the capacity of community food production endeavours to build social bonds and support networks between community members. Similarly, direct markets of exchange build trust between consumers and producers; this transparency is required for social acceptance and economic success of local food production endeavours (Cleveland et al., 2014). While direct exchange markets and community-based food production endeavours do not automatically guarantee transparency, trust, or the eradication of existing power asymmetries, they nevertheless harbour potential to achieve these goals (Winter, 2003; Hinrichs, 2000; Allen, 2009). Regarding producers, scholars and farmers including Wendell Berry and Wes Jackson advocate for a rekindling of the relationship between producers and their land and labour:

> The technology of infinity (however that might be defined) would be vast and exclusive…It might at first seem that enormous power would lie in the hands of the 'couple of telefarm operators' who would be feeding a million people; but it seems more likely that they, too, would be the absolute slaves of their machinery. (Berry, 1968, 78)

Through using technologies 'appropriately' and reflexively, producers attach greater importance to their labour and its broader social and ecological impacts.

This economic conceptualization of 'social rift' and embeddedness is here expanded to include the relationship between individuals and, in its most broad sense, nature. Marx and Marxist-inspired scholars argue that individuals, alongside material goods, are separated from their biophysical resource bases through the processes of capitalist modernization (McClintock, 2010). Applied to food systems, as food and land are commodified, producers and consumers are physically and emotionally separated from the food system: "an internalized rift in our cognitive and experiential understanding of ourselves as functional organisms existing as a part of a larger ecosystem" (McClintock, 2010, 201). McClintock (2010) goes on to argue that agriculture is a vehicle through which to restore the relationship between urban dwellers and the broader environment: “By physically labouring the soil, sowing seeds, cultivating, harvesting and preparing food, [urban agriculture] mends individual rift by reengaging individuals with their own metabolism of the natural environment” (202). With respect to raising livestock, Budiansky (1992) uses the evolutionary and biological history of animal domestication to make two arguments: 1) that raising livestock is beneficial to both humans and animals, in evolutionary terms; and 2) that consumers and producers have become disconnected from this relationship, through conventional livestock farming processes. Specifically, Budiansky (1992) suggests that today, with respect to food and nature, we lack: “genuine understanding, which used to come from actual experience of the natural world” (2), and later that “we have an urge to turn animals into either things or into people” (3).

Agrarian literature has widely explored technical and philosophical questions regarding how producers manage their land and grow food within wider ecological webs. Some scholars suggest that conventional food production practices are exploitative. Reductionist approaches to ecosystem management, that treat nature as a ‘tool’ to be manipulated and controlled by humans, are widely disparaged in critical literature on conventional farming systems (Vitek & Jackson, 1996) and bioengineering practices (Shiva, 1997). Such systems overlook the complexities of natural, ecological processes. Alternative production systems are often described as ‘ecological’ (Si, et al., 2015). These systems attempt to mimic natural processes, integrating agricultural production within wider ecological webs, and lessening the footprint of agriculture on local ecosystems. However, some environmental philosophers have taken more ‘pragmatic’ approaches to philosophizing food production systems. For example, notwithstanding that genetic engineering is ‘unnatural’ and has had several negative socio-economic consequences, Brand (2009) argues that it is still a useful technology for feeding growing urban populations in future climatic scenarios. While this is an arguable claim, such pragmatic approaches to food production development highlight tradeoffs between naturalness and other food production outcomes.

6.2.3.1 Closing and opening rifts:

All the operations examined in this thesis sought to 'close' ecological rifts: the material disconnect between food production practices and local biophysical environments, albeit through different means. All vertical farms sought to localize and close resource loops, while adapting to local demands for specific products and climatic conditions. Although in-vitro meat operations did not highlight a desire to localize inputs, their practices would necessarily be 'close-looped' as a few cells combined within a growth medium can create an effectively infinite quantity of meat[7]. Similarly, most Local and Natural operations actively sought out local inputs for their operations, especially soil amendments and seeds. It is apparent that local food productions, in their multiple forms, have potential and desire to address the material rift between agricultural production and biophysical systems.

With respect to closing socio-economic rifts: the disconnects between producers and their labour, and producers and consumers, Local and Natural and Local Prosthetic Ecology scenarios have differing potential. While both forms of operations seek, broadly, to encourage more direct markets of exchange and more transparent food systems, they do so through different means. 'Natural' forms appear to foster more interactive spaces of engagement, as Prosthetic Ecology approaches examined in this study were currently limited in their openness due to patents and biosecurity concerns, as well as prohibitive start-up costs. However, Prosthetic Ecology operations did seek to educate consumers regarding their production practices, due to the novelty of their practices and the lack of current consumer acceptance (Specht et al., 2015). Moreover, operations from Prosthetic Ecology scenarios were highly motivated to integrate automation and mechanization within their production practices. These laboratory-like food production spaces are highly compatible with artificial intelligence and robotic advancements. Further research is needed to comment upon the potential socio-cultural and economic impacts of these labour-saving technologies in agricultural practices.

Regarding the rift between individuals and 'nature', the starkest differences between Local and Natural and Local Prosthetic Ecology are apparent. Interviewees from Local and Natural operations highlighted the irreducible complexities of food growing as something intrinsically

[7] Publicly-available interview with CEO of in-vitro meat synthesis company

meaningful. These interviewees suggested that removing production from soil or exposure to natural sunlight, or using synthetic inputs, overlooks the known and unknown benefits of growing in natural conditions. Furthermore, through seeking to mimic natural biophysical processes, these operations attempt to reconnect producers and consumers with their local ecosystems. The reductionist approach of Local Prosthetic Ecology operations to food production, in contrast, seeks to remove food production from its 'natural' environment. Interviewees from these operations argued that they can mimic natural conditions enough to sufficiently produce high quality products. Some interviewees went further, arguing that removing production systems from natural conditions *allows* for the optimization of plant and meat-growing. While a highly reduced scientific understanding of food production processes does, on one hand, connect individuals to the food system, it may fail to foster this 'intrinsic' connection between individuals and nature, as suggested by one vertical farm researcher. Interviewees argued that the perceived 'unnaturalness' of their production methods is one consequence that can be overlooked, if assessing all other benefits. Overall, these findings suggest that Local Prosthetic Ecology projects operate according to a more 'pragmatic' approach to food production (Brand, 2009). These operations note that their production methods may be 'less natural', but that their supplementary benefits: high yields, nutrition, closed-looped production systems, override these concerns.

It is important to recognize that the reidentification of 'self' with 'nature' is a modern concept, contingent upon historical, violent processes of individuation and capitalist modernization. An individual's sense of disconnect or alienation from the natural world can be attributed to:

> The Great Transformation…the progressive disembedding of economic life, individualization and the enthronement of state/market as the predominant axis of integration… that was reflected in the tropes of classical sociology as it confronted the disruptive maelstrom of modernization. (Kish & Quilley, 2017, 310)

In other words, the "I" identification created over the past several centuries, and all its progressive benefits: democracy, human rights…is predicated upon a willful-disconnection with nature and the adoption of ecologically-destructive political and economic institutions (Quilley, 2013). As a result, a loss of individuation created through a rapid, uncontrolled, ratcheting back of social complexity might result in a more ecologically-benign and ‘ecologically-connected’ society, but at the cost of these non-negotiable social benefits. For these reasons, while the Local and Natural trajectory of food production may indeed foster a greater connection between self and nature, its complete adoption would trade ‘self’ for ‘we’, with all its potential associated social consequences. This conclusion commends itself to a more ‘pragmatic’ approach to food system development, that combines Local and Natural operations (a conscious re-identification with nature), with the highly specialized, unnatural, but hyper-productive fruits of Local Prosthetic Ecology technologies (a conscious semi-separation from nature).

Chapter 7: Conclusions

This study began by reviewing the political ecology and complexity science literature on conventional agricultural systems. Despite using radically different epistemological frameworks to examine food system outcomes and cross-scale dynamics, these bodies of literature share several of the same conclusions. Broadly, they contend that conventional food production processes: the commodification of food, consolidation across the food supply chain, advanced energy and information intensity, and increased overall system opacity, fundamentally undermine the ability of the food system to respond to drivers of uncertainty, while contributing to a plethora of paradoxes and injustices. Notwithstanding that 'conventional' agricultural systems have resulted in substantial yield increases and has indeed alleviated food insecurity across much of the world, these theories put their long-term desirability and sustainability to task.

In response, a suite of alternative food networks has emerged across high, middle and low-income countries. Common among these networks is an emphasis on *localized* production and distribution chains. In this study, I examined two distinct local food production trajectories, informed by Quilley's (2018) working paper on relocalization. One of these trajectories is referred to as 'Local and Natural': an umbrella term for the variety of production methods that seek to integrate agriculture within natural ecosystems and local economies, thereby mimicking natural biophysical processes and minimizing the impact of production on local socio-ecological environments. The second long-term trajectory is referred to as 'Local Prosthetic Ecology': a catchall term for the science-fiction scenarios of food production that seek to further separate agricultural processes from the biosphere. Through this thesis, I sought to contribute to the rich body of literature on local food systems, by: a) building upon a more nuanced typology of local food production methods; b) examining the outlooks of either strategy for fostering food system resilience and justice; and c) analyzing the values and practices within either form of food production. While a plethora of scholarship has examined the 'alternativeness' of local food initiatives, few studies have compared Local and Natural to Local Prosthetic Ecology projects. Understanding either scenarios' outlooks and values is critical to determine their synergies and (un)common ground, for future urban planning and conventional food system transformation.

7.1 A Review of the Literature: Complementarity and Contradiction in Diverse Local Production Methods

To examine the potential pitfalls and opportunities of each food production trajectory, I undertook a review of the geographical, sociological and economic literature on local food systems. The findings of the literature review suggest that each trajectory for local food production has unique capabilities to address the socio-economic and ecological contradictions of conventional food systems. Broadly, Prosthetic Ecology operations stand to reconcile future levels of population and social complexity with the limits of a finite biosphere. Semi-detaching agricultural production from natural ecosystems safeguards food crops from climatic uncertainties and releases a large portion of the biosphere to self-regulate, all the while maintaining extraordinary levels of productivity with opportunity for automation. However, some scholarship has critiqued these systems for perpetuating the precepts of conventional food systems, including: the commodification of food, the deepening of globalized commodity chains, scaling-up production practices, as well as the further dis-embedding of consumers and producers from the food system. Conversely, Local and Natural scenarios of food production are lauded for their potential to contribute to local social, community and ecological capitals. These operations often increase biodiversity in local agricultural and urban ecosystems, build social networks around food, contribute to the autonomy of small-scale producers, utilize alternative networks of economic exchange, and re-embed individuals within the food system and, more broadly, nature. However, present forms of Local and Natural production operations are critiqued for their labour and land-use inefficiency, fundamental reliance on a stable biosphere, as well as their lack of critical attention to power dynamics or their own potential lack of alterity.

These findings highlight the complementarity of each form of food production. On their own, each trajectory might be limited in its ability to build a more resilient and just agro-ecosystem; however, their combination may create a scenario in which the shortcomings of one are addressed by the other. Local and Natural operations stand to materially integrate food production into local socio-ecological environments, and cognitively re-connect individuals within local agro-ecosystems, while Local Prosthetic Ecology methods of food production can grow the caloric requirements of dense, large urban areas at a steady volume, irrespective of socio-ecological variables. Put together, these two local food production scenarios can re-embed individuals within the food system, while contributing to urban food security and the maintenance of current levels of social complexity.

The second part of my project involved a comparison of the values and practices of both forms of food production. Operations from Local and Natural and Local Prosthetic Ecology trajectories shared several management strategies as well as motivations. All operations engaged in multiple forms of economic exchange; participated in a variety of local to global trade relationships; and expressed a desire to increase or maintain current scales of production. Concurrently, all operations examined in this study sought to re-embed food production within local biological, social and economic environments. This spectrum of practices and values aligns with recent literature on the hybridity of local food systems, arguing that producers operate reflexively according to consumer-demand and broader socio-economic and ecological dynamics.

Where either scenario of food production differed substantially, was in their commitment to specific agro-ecosystem management practices. Vertical farming and in-vitro meat synthesis projects highlighted a highly productivist, reductionist approach to agro-ecosystem management. Conversely, Local and Natural operations stressed the irreducible complexity of food growing, arguing that the various metrics of efficiency are important, but insufficient criteria to judge a production method. These differences also underscore a fundamental normative debate between producers: one side emphasizing the intrinsic value of food, as part of nature and society, and the other a highly pragmatic approach, willing to weaken these socio-natural connections in the narrow pursuit of various metrics of efficiency.

This study hypothesized that both strategies reflect distinct normative commitments to how nature, or agro-ecosystems, ought to be managed, drawing from Eisenberg's (1998) distinction between Planet Managers and Planet Fetishers, as well as critical geographic literature on each respective food production trajectory. Local Prosthetic Ecology operations in this study, as 'Planet Managers', viewed food production through a highly productivist and reductionist lens: that food production could be separated from the natural environment, streamlined and optimized in yield and nutritional content. Local and Natural food production operations as Planet

Fetishers, in contrast, viewed production through a more idyllic and irreducible perspective, where food production is sacred and an end in and of itself.

7.2 Political Barriers and the Role of Public Institutions

Recognizing the paradigmatic similarities and differences between each trajectory of local food production, it is now important to consider how they may challenge conventional food production systems. Social innovation and systems transformation theories can shed light on the processes and potential pitfalls for these ‘alternative’, local food production methods to propagate in scope and political influence. Westley and Antadze (2010) examine systems transformation through a distinction between scaling out and scaling up. Scaling out refers to the success of groups in organizing, propagating in number, and impacting more individuals, whereas scaling up refers to the process whereby groups challenge and transform dominant political, economic and social institutions, policies and resource flows.

How do new technological or socio-cultural arrangements ‘scale up’, and fundamentally transform systems? Meadows’ (1999) seminal paper on system leverage points provides one lens through which to understand these ‘scaling up’ dynamics. In this paper, she contends that there are intervening points that are more or less impactful, if seeking to transform a system. At the top of the list, as the most impactful intervention point, are ‘paradigms’: those mindsets and values that dominate the current system. Meadows goes on to describe how to change and transcend paradigms:

> In a nutshell, you keep pointing at the anomalies and failures in the old paradigm, you keep coming yourself, and loudly and with assurance from the new one, you insert people with the new paradigm in places of public visibility and power. You don’t waste time with reactionaries; rather you work with active change agents and with the vast middle ground of people who are open-minded. (Meadows, 1999)

This argument is comprised of three important considerations. The first, is that the flaws of the previous paradigm must be constantly and critically examined. The second, is that new paradigms must be publicly-adopted and supported by public institutions. Finally, to work to advance and critique paradigms, individuals must be motivated and open-minded to consider new, unexplored avenues for change. Using Meadow's (1999) framework, if local food systems hope to fundamentally transform food production they must: a) continuously work to critique conventional production frameworks; b) insert themselves in the public view and within public institutions; and c) work with open-minded individuals across the local food production spectrum. Each of these three considerations will be examined in greater detail below, following the results of this study.

7.2.1 Scaling-up?

As described in section 7.1, the local food projects examined in this study actively pursued the central precepts of conventional food systems to different degrees, reflecting a range of alternative practices and values. While this hybridity in local food operation management and values "…cannot be interpreted as problematic in and of itself" (Mount, 2012), it may provide a challenge to transforming conventional food systems. For example, all operations examined in this study, including authorities from a municipality in Canada and China, did not view local food production scenarios as a method to "reorganize" (Interviewee B4) cities, or as a priority for urban development. Only one community food and garden operation was actively lobbying and attempting to engage in policy change to support community-level food security solutions. However, even this interviewee expressed that their organization remained reliant on funds that were competitive to secure, and further fiscal transfers from the state.

All operations examined in this study expressed similar goals, seeking to alleviate the socio-ecological impacts of conventional food systems (ie. close material and cognitive rifts between food production processes, individuals and nature), through practices and values reflecting a continuum of alterity. Of course, there are other forms of local food production unexamined in this study that do more political engagement in pursuit of changing conventional paradigms. However, these results highlight a tension between the potential of operations to transform dominant institutions and resource flows, and the hybridity of their values and practices.

Westley and Antadze (2010) argue that, to the extent conventional paradigms are maintained, and whose problems are addressed with band-aid solutions (i.e. those interventions that do not address the roots of the problem), systems will continue to lack resilience. Social innovations, including those novel practices that challenge conventional beliefs and attitudes, reflect a deeper commitment to resilience:

> The capacity of any society to create a steady flow of social innovations, particularly those which re-engage vulnerable populations, is an important contributor to overall social and ecological resilience. (Westley & Antadze, 2010, 3)

Applied to food systems, this argument suggests that hybridity in values and practices of food producers may be insufficient to guarantee the long-term socio-ecological health of the food system. For example, as individuals are continuously excluded from the procurement of local foods (inherent in the treatment of food as a private or club good) or lack the opportunity to engage in food production processes (e.g. do not have access to agricultural capital or intellectual property), the food system loses a diversity of actors. Furthermore, from a food system justice perspective, the exclusion of anyone from food procurement is itself a major issue. This presents a wicked challenge. On one end, social innovation theorists would caution against the permeation of underlying 'conventional' agendas into 'alternative' projects, that may thwart systemic-level interventions in the food system. Similarly, hybridity of values and practices in food production operations may reflect a more conservative approach to address the contradictions of conventional food systems.

Moving into the future, how Local Prosthetic Ecology and Local and Natural operations elect to govern themselves, within what realms they are managed and how they seek to re-embed within local communities, economies and ecologies will play an important role in shaping their ability to transform conventional food paradigms. Creating experimental spaces for local, alternative operations that reflect non-conventional management practices, and engaging across multiple scales as well as stakeholders (e.g. private, public and community), are critical strategies for building environments conducive to social innovation (Westley et al., 2014).

7.2.2 Public Institutions and Public Goods

This study includes only one interview with an operation run through the public realm: a Chinese vertical farm being constructed within a municipal district, commissioned by the local government. However, there is a wide array of public food production projects that were not part of this study, but which would have added further insight. For example, schools and hospitals are increasingly adopting local food production into curricula as well as their public health policies. Based on the abundant literature of school and hospital gardens, these food production spaces are largely used for education (ecological, healthy-eating, or business-related skills), personal-development, and well-being, rather than large-scale food production for the broader public. Food in these settings is distributed to 'the public': students, patients, staff or other transient members of these communities; albeit, as Colding et al. (2014) argue, these public realms treat food as 'club goods', where individuals unaffiliated with the school or hospital may lack access to food produced in these settings. The potential for public institutions to transform conventional food production and distribution models, with their large labour force, research capabilities, and capacity for food production experimentation, has yet to be realized (Quilley, 2018).

The municipal authorities that participated in this study are engaging with local food production projects, run by private or community entities, in a way that serves to 'slot them' into existing municipal structures, without fundamentally altering city planning. Furthermore, these interviewees noted that municipalities have a passive role in local food production experiments, providing resources and expertise for community groups and private stakeholders to pursue these ventures. Interviewees cited government involvement in local food production projects as too politically risky, or an inefficient use of land, time and energy.

Outside the public realm, several private and community-led operations in this study experimented with alternative forms of economic exchange (e.g. gifting, or public-provisioning). This suggests that the treatment of food as a common or public good is a burgeoning operational model, especially across Local Prosthetic Ecology scenarios of food production.

7.2.3 Open Mindedness

> How do you give nature room to work and still get on with the business of being a human? And if part of the business of being a human is to work with nature, how do you do that when you don't know exactly how she works or…what she wants? (Eisenberg, 1998, 291)

This quote illustrates a seemingly intractable tension of resource management. Are 'civilization' in a broad as well as, admittedly Eurocentric, vein, and 'nature' incompatible? And what worldviews operate to determine the appropriate tools and strategies required for natural resource management? In previous sections, Eisenberg's description of 'Planet Fetisher and 'Planet Manager' were used to distinguish between two distinct agro-ecosystem management philosophies. This study examined the values and practices of 'Local and Natural' and 'Prosthetic Ecology' approaches to local food production, to assess if each trajectory is rooted in each respective philosophy. To a certain degree, the results of this study support this association.

Soilless, artificial, reductionist approaches to food production are indeed 'unnatural', and agroecological, soil-based growing methods are certainly labour and time-intensive (i.e. 'less efficient'). As such, Prosthetic Ecology food production methods may be less able to address 'cognitive rifts' between individuals and nature or producers and their labour (McClintock, 2010), while Local and Natural scenarios may not produce sufficient quantities of food for a growing global population, at current levels of social interconnectedness and complexity, and in an increasingly uncertain world (Quilley, 2011). However, both scenarios harbour similar goals and outlooks for local food system development. For example, both share a desire to close socio-ecological rifts between individuals and the food system, and can be managed under multiple, often contradictory values and models of economic exchange. Thus, there are tradeoffs regarding either approach, taken alone, that need be acknowledged if hoping to create a more sustainable food system development pathway in the long term. However, there also extensive similarities between each trajectory that can be leveraged to create a more synergistic, resilient, just food system. Current planetary-scale social, economic and ecological crises bring added urgency to this debate:

> In the short run, it seems likely that civilization is heading for a period of contraction if not collapse. But if humanity does manage to come through the present century with a complex, science-based civilization intact, the future may open up a new symbiotic relationship between humanity and the biosphere. (Quilley, 2011, 84)

7.3 Future Directions – Big to Small Pictures of Food System Transformation

It is almost a truism to claim that the biosphere is on the precipice of calamitous environmental change. The planetary boundaries model created by Rockstrom et al. (2009) and elaborated by Steffan et al. (2015), suggest that three planetary-scale ecological thresholds have already been crossed, including: biospheric integrity at the level of genetic diversity, as well as biogeochemical flows of nitrogen and phosphorous. It is also almost a truism to point the finger at unfettered economic growth, the market and modernism, broadly, as the proximal causes of both socio-economic and ecological angst. Schumacher (1973) suggests that neoclassical economic principles of comparative advantage, specialization and economies of scale, form the groundwater in the well from which "poverty, frustration, alienation, despair, breakdown, crime, escapism, stress, congestion, ugliness and spiritual death…" (80) are drawn. Naomi Klein (2014) advances a similar critique of consumerism and austerity, and their role in precipitating climate change:

> Indeed, the three policy pillars of the neoliberal age—privatization of the public sphere, deregulation of the corporate sector, and the lowering of income and corporate taxes, paid for with cuts to public spending—are each incompatible with many of the actions we must take to bring our emissions to safe levels. (72)

While these critiques successfully highlight the pathological relationship between modern political-economic institutions and the biosphere, they hold two significant oversights. The first, is that they fail to consider the socio-economic 'goods' accrued through the processes of modernization, such as: a decrease in inter-personal violence through internalized self-restraint (Elias, 1939 [2000]); the 'freedom' and individual rights that come with loosening communal social ties (Tönnies, 1935 [1999]); an advanced division of labour and the development of more collaborative, as opposed to ascriptive, forms of social solidarity (Durkheim, 1893 [1984]); and overall increases in various metrics of 'development', from life expectancy to overall quality of life (Pinker, 2018). Albeit, these benefits of 'the market' and state-formation have come at the cost of violence, colonialism, displacement and brutal social cleavage (Polanyi, 1944 [2001]). More fundamentally, the normative commitments engendered through these critiques of modern political-economic institutions either overlook limits to growth or fail to consider the political implications of 'degrowth'. For example, politicizing solutions to the socio-economic and ecological contradictions of capitalism through a negotiation between the state and the market, assumes that economic growth is a pre-condition for sustainability. This prevents the development of alternative, unexplored political-economic arrangements that are rooted in low or no-growth logic (Quilley, 2012). Furthermore, given the social benefits accrued through economic growth and the, admittedly violent, processes of state formation, a rapid 'de-growth' of the economy, while probably good for the biosphere, would simultaneously entail a rapid loss of social complexity:

> …progressive forms of state, culture and society along with scientific rationality all depend very directly upon the progressive (growth) economy, which in turn depends upon the high and expanding energy/resource flows and pollution sinks provided by the biosphere. (Kish & Quilley, 2017, 306)

So, with some generalization, we are at a crossroads. Using energy and complexity-science lenses, any kind of 'delaying' tactics through the pursuit of weak measures of sustainability, such as: increasing resource efficiencies or substituting resources as they become scarce (Simon, 2012), serves to postpone the inevitable. Energy economists argue that 'growth', no matter its improved efficiencies, comes at increased energetic cost; without raising the quality of their base-energy sources, systems risk inevitable collapse (Tainter et al., 2003; Homer-Dixon, 2006). Similarly, complexity scientists argue that the rate of innovation and human problem-solving can never keep with the pace of problems (Homer-Dixon, 2000). On the other side of the coin, any kind of literal or figurative 'return' to pre-modern forms of society would likely require 'regressive' socio-political change (Quilley, 2013). So how do we throw away modern political-economic systems and all their associated ecological 'bads' while preserving their social 'goods'? Moreover, if the answer is not more growth, then what are the feasible (i.e. non-socially-regressive) de-growth alternatives?

Throughout this thesis, I have attempted to outline how wicked tensions between growth and de-growth apply to industrial, conventional agricultural systems and their proposed alternatives: Local and Natural and Local Prosthetic Ecology scenarios of food production (Quilley, 2018). Food has a unique place within the de-growth agenda. Agriculture alone continues to have massive, negative ecological impacts (Rockstrom et al., 2009), as well as socio-economic contradictions and paradoxes (Patel, 2007; McMichael, 2009). At the same time, an advanced global division of labour has relied upon a widespread conversion to non-agricultural labour and increased abundance of cheap food, notwithstanding that a large portion of the world's farmers are still small-scale (< 2 ha) and produce roughly 30-34% of the global food supply (Ricciardi et al., 2018). Simultaneously, this process has been fueled by an abundance of cheap oil (Weis, 2015). The movement to relocalize food systems, born from the lack of resilience and justice of conventional food systems, has emerged across high, middle and low-income countries.

The Place of Food in De-Growth Debates

Central to the evaluation of each respective local food system trajectory are questions regarding energy, labour and normative commitments to the management of agro-ecosystems. How does the energy-return-on-investment (EROI) of capital-intensive, indoor production systems stack-up against conventional food production systems, or more labour-intensive, 'Local and Natural' food production methods? Related to this question, how do the labour requirements of both Local Prosthetic Ecology and Local and Natural scenarios of food production differ, and what are the potential implications of this difference? Finally, how do both local food production scenarios differ in their commitment to agro-ecosystem management values, and how might these differences affect the relationship between and among individuals and nature? These questions are arguably unanswerable. However, the research undertaken for this thesis has advanced some tentative conclusions, that may inform future theorizing and exploration of either respective food system trajectory.

Regarding energy, the appeal of Local Prosthetic Ecology technologies is that they can theoretically, in the long-term, radically transform the basic processes of energy capture for agricultural systems. In this scenario, rather than rely on unsustainable tracts of land and vast quantities of oil to grow food to support economic and population growth, food provisioning is relegated upwards using passive energetic systems (Despommier, 2010; Quilley, 2004; 2011). Concomitantly, food production is optimized in terms of yield and nutrition, through necessary infrastructural developments and monitoring technologies. Of course, prosthetic ecology technologies are nowhere near this imagined technical endpoint; however, this process of trophic detachment (Quilley, 2004) comprises their inexorable direction. With food rendered effectively non-rivalrous, current and future demands for food can be met, at a fraction of the energetic or ecological cost.

In terms of labour, the outlook for Local Prosthetic Ecology technologies and Local and Natural production methods appears more mixed. Durkheim (1893 [1984]), outlining the relationship between surplus, specialization and the division of labour, argues that there are two forms of social solidarity. One form of solidarity he calls mechanical, whereby social bonds are generated through a strong, shared sense of 'we' identity. The other form of solidarity is a product of 'difference', what he calls organic solidarity: social bonds are created through the mutual-interdependency of individuals specialized at certain societal functions. Durkheim (1893 [1984]) argues that the advanced division of labour favours organic forms of solidarity:

> Why does the individual, while becoming more autonomous, depend more upon society? How can he be at once more individual and more solidary? Certainly, these two movements, contradictory as they appear, develop in parallel fashion. (37)

Following this argument, a return to Local and Natural methods of production, in which the bulk of citizenry is necessarily engaged in agricultural activities, would be associated with a loss of functional diversity within society. Thus, subsequent forms of solidarity would likely favour mechanical characteristics, such as repressiveness, homogeneity in the form of social bonds, and lack of individual freedom.

It is important to note, however, that Durkheim cautioned against the perversion of the division of labour. If individuals become too atomized, solidarity is lost: "If the division of labour does not produce solidarity…it is because the relations of the organs are not regulated, because they are in a state of anomy" (368). Thus, a pathological scenario in which highly-specialized, automated, food-growing factories replace more mutual, embedded forms of food production and exchange, could be envisioned.

There are multiple lenses through which to critique either trajectory of local food production if either are blindly or unreflexively pursued, as I have attempted to do here. However, there is no lens quite as compelling than that of science fiction. Several writers have tackled these critiques of food production scenarios, through dystopian portrayals of unfettered capitalism and the rapid but unwelcome return of society to pre-industrial lifestyles. Margaret Atwood, in her Maddaddam trilogy, paints a vivid, dreary picture of corporatized Local Prosthetic Ecology scenarios, if left unchecked:

> What they were looking at was a large bulblike object that seemed to be covered with stippled whitish-yellow skin. Out of it came twenty thick fleshy tubes, and at the end of each tube another bulb was growing…
>
> "Those are chickens," said Crake. "Chicken parts. Just the breasts, on this one. They've got ones that specialize in drumsticks too, twelve to a growth unit."
>
> "But there aren't any heads..."
>
> "That's the head in the middle," said the woman. "There's a mouth opening at the top, they dump nutrients in there. No eyes or beak or anything, they don't need those." (Atwood, 2003)

Representing the ultimate manifestation of a neo-productivist, unnatural agricultural paradigm, this scenario of Prosthetic Ecology highlights the potential consequences of a completely corporatized, profit-driven strategy to food system development. In this scenario, producers, consumers and society-writ-large have completely lost respect for food and, more broadly, nature.

In contrast, a suite of science fiction writers has examined a world in which Local and Natural scenarios of food production are necessarily pursued, following peak-oil or nuclear Armageddon-induced political-economic upheaval. This scenario of food production is far less idyllic than those portrayed by proponents of Local and Natural operations, especially when adopted out of necessity. Drawing from Kunstler's (2009) The Long Emergency series, Quilley (2013) suggests post-industrial civilization, created through rapid collapse, is not so romantic:

> In his novel, *A World Made by Hand*, Kunstler (2009) is surprisingly honest. He doesn't shy away from what the politics of such a newly agrarian society might look like. Without 'fossil fuel energy slaves' most of the population become peasants and old social hierarchies, including gender inequalities, reassert themselves. (8)

Both these fictional accounts suggest the *worst of 'what could be'*. However unlikely (or likely) the engineering of meat machines or a rapid collapse in global energy systems, these portrayals caution us against going too far down the figurative 'Planet Management' or 'Planet Fetisher' rabbit-hole, calling for a controlled transition into new food production regimes. There are challenges, as highlighted through this thesis, that may dissuade local food production stakeholders from the pursuit of the *better of 'what could be'*. These challenges include the tension between hybridity in alternative versus conventional values, and systems-level transformation; a currently limited institutional environment through which to scale-up local food production innovation, especially within public realms and with respect to public goods; and fundamental normative differences regarding the management of agro-ecosystem resources. Overcoming these challenges is possible, but requires that we relinquish our own hubris, accept a degree of discomfort and practice conflict-management. As Meadows (1999) concludes:

> You have to work hard at [system transformation], whether that means rigorously analyzing a system or rigorously casting off your own paradigms and throwing yourself into the humility of Not Knowing. (49)

Let us get on with the business of Not Knowing.

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Appendix A: Interview Guide

Scoping/orienting questions:

1) Do you believe most food in cities should be grown locally? Why or why not?
2) What is the main consumer base of your organization?
3) Have you heard of the term 'resilience' before? Is this a term that is used by your organization? (prompt: resilience, in this case, is defined as the ability of the food system to 'resist risk', for example: giving a reliable supply of food to poorer people with unstable jobs, or being able to produce enough food to feed society, despite a changing climate).
4) Do you believe your organization can assist broader society meet its food needs, when considering unanticipated environmental, economic or political changes (prompt: climate change, financial uncertainty, or policy change)? Is this something that is important to your organization?
5) Does your product (agriculture technology or produce) circulate at predominantly local, regional or global scales? Why have you selected to operate at this scale?
6) What physical inputs are required to maintain your operations (eg. Fertilizers, building materials, seeds etc.)? From where do they originate?
7) Do you work with other individuals or organizations, for example: businesses, farmers, or universities? What type of work do you do with these other institutions or individuals?

Interviewee Perceptions:

Environment

8) What would you consider to be the environmental benefits of your method of food production?
9) How do you define 'agricultural efficiency'? Do you consider your model of agriculture to be 'efficient'? Is efficiency something that is important to you?
10) Considering conventional agriculture as a contributor to climate change and environmental degradation, do you believe urban food production is a potential solution to these issues?
11) How do you believe your method of food production impacts the urban environment? (prompt: do you see it as contributing to greening the urban environment? How?)

Social

12) What do you consider to be the social benefits of this form of food production (prompt: food security, employment or general social welfare, social justice?)
13) What to you consider to be the social risks with this method of food production? (prompt: are there food safety concerns using this method of production? Are the products accessible to poorer as well as to richer consumers?)
14) Do you think it is important for people to know where and how their food is produced? What are the opportunities and challenges to establishing a more transparent food system, using your method of urban food production?

Scale and Innovation

15) What do you picture as the impact of this model of food production on local, regional and global society? How can/can this model be scaled-up?
16) Considering the narrative of "increasing food production to feed 9 billion in 2050", do you think urban food production can do this? What is the role of technology in accomplishing this goal?
17) ***For high-tech specifically****:* what are the innovation gaps that need to be filled for this technology to became a significant contributor to urban food security? Where are these breakthroughs going to come? (prompt: what do you see as the most exciting or novel technologies currently emerging?)

Naturalness

18) What constitutes 'natural food' to you or to this organization? (prompt: do you think food produced in a lab/without soil is unnatural, as compared to food produced on land? What about food produced without natural sunlight?)
19) Do you believe food taste is impacted by the way in which food is grown? (prompt: are there any differences in the taste of food grown using your methods?).

Appendix B: Themes and Codes

Theme	**Codes**
Scale of Production and Distribution	-Comparative efficiency -Where food grows impacts its taste and quality - Local can't sufficiently provide for urban areas - Local can sufficiently provide for urban areas
Naturalness	-'Natural' is an obscure, or poorly-defined term -Production replicates natural ecosystem processes -Anything with natural chemical building blocks is natural
Food System Transparency and Relationship Building	- More intensive labelling - Biosecurity or intellectual property concerns - Encourage consumer participation - Encourage at-home gardening - Use production method as conversation starter or beautification project in urban areas - Share culture around food growing
Closing Input-Output Loops	- Attempt to localize inputs and consumer-base - Education around food production and waste
Efficiency	- Raw productive yield - Yield per unit of land - Yield as a function of labour - Productivity is one among many metrics to measure food system outcomes

Appendix C: Keyword Searches for Publicly-Available Interviews

Keyword for Production Method	**Synonymous Terms**
Vertical Farming	- Building-Integrated Agriculture (e.g. Specht et al., 2015) - Protected Agriculture - Plant Lab - Plant Factory
In-Vitro Meat Synthesis	- Clean Meat - Cultured Meat - Meat Synthesis - Lab Meat