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A Frame Analysis of Agriculture 4.0 in International Agrifood
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Abstract (English)

This thesis critically examines how Agriculture 4.0 is framed within global food security and food sovereignty debates. While ‘smart farming’ innovations are often presented as technical solutions to food insecurity, they carry contested implications for agricultural development, the autonomy of peasant communities, and global power relations. Drawing on Critical Discourse Analysis and Frame Theory, this thesis analyzes how four organizations (FAO, CGIAR, ETC Group, FIAN) conceptualize and frame Agriculture 4.0 in relation to food security. Particular attention is given to the underlying dichotomies and paradigms mobilized in these frames, as well as to tensions between dominant discourses of food security and justice-based alternatives. By examining the relationship between different understanding of Agriculture 4.0, this thesis identifies contested sociotechnical imaginaries of the future of technology in food systems and whose interests these visions might serve. The findings suggest that utopian imaginaries of Agriculture 4.0 support growing involvement of philanthrocapitalism in agrifood systems, while their dystopian opposition reflect broader binaries and methods of resistance in agrifood discourses. Likewise, the emergence of a protopian imaginary presents a potential break from deeply ingrained dichotomies. This thesis illuminates points of contention in agrifood perspectives on the international stage and ultimately contributes to ongoing debates on food systems transformation.

Keywords: Food Security, Food Sovereignty, Agriculture 4.0, Smart Farming, Food Regimes, Sociotechnical Imaginary, International Policy Arena, Protopia, Utopia, Dystopia

Abstract (Deutsch)

In dieser Masterarbeit wird kritisch untersucht, wie Landwirtschaft 4.0 in globalen Debatten zu Ernährungssicherheit und Ernährungssouveränität gerahmt und verhandelt wird. Während Innovationen des „Smart Farming“ häufig als technische Lösungen für Ernährungsunsicherheit dargestellt werden, bergen sie umstrittene Implikationen für landwirtschaftliche Entwicklung, die Autonomie von bäuerliche Gemeinschaften sowie globale Machtverhältnisse. Auf Grundlage einer Kritischen Diskursanalyse und Frame Theorie analysiert die Masterarbeit, wie vier Organisationen (FAO, CGIAR, ETC Group, FIAN) Landwirtschaft 4.0 im Zusammenhang mit Ernährungssicherheit konzeptualisieren und rahmen. Besondere Aufmerksamkeit gilt den zugrunde liegenden Dichotomien und Paradigmen, die in diesen Frames zum Tragen kommen, sowie den Spannungen zwischen den vorherrschenden Diskursen der Ernährungssicherheit und gerechtigkeitsorientierten Alternativen. Durch die Untersuchung der Beziehungen zwischen unterschiedlichen Verständnissen von Landwirtschaft 4.0 identifiziert diese Masterarbeit umstrittene soziotechnische Imaginaries über die Zukunft von Technologie im Ernährungssystem und wessen Interessen diese Visionen bedienen könnten. Die Ergebnisse deuten darauf hin, dass utopische Imaginary von Landwirtschaft 4.0 eine zunehmende Beteiligung des Philanthropiekapitalismus an Agrar- und Ernährungssystemen unterstützen, während ihre dystopischen Gegenspieler breitere Gegensätze und Methoden des Widerstands im Agrar- und Ernährungsdiskurs widerspiegeln. Ebenso stellt das Aufkommen einer protopischen Imaginary einen möglichen Bruch mit tief verwurzelten Dichotomien dar. Diese Arbeit beleuchtet Streitpunkte in Agrar- und Ernährungsdialogen auf internationaler Ebene und leistet letztlich einen Beitrag zu den laufenden Debatten über die Transformation von Ernährungssystemen.

Stichworte: Ernährungssicherheit, Ernährungssouveränität, Landwirtschaft 4.0, Smart Farming, Ernährungssysteme, soziotechnisches Imaginary, Protopie, Utopie, Dystopie

List of Terms

Agri 4.0	Agriculture 4.0
AgriTech	Agricultural Technology
AI	Artificial Intelligence
Big Ag	Big Agriculture
Big Tech	Big Technology
BMGF	Bill and Melinda Gates Foundation
CDA	Critical Discourse Analysis
CFS	Committee on World Food Security
CGIAR	Consortium of International Agricultural Research Centers
CLOC	Coordinadora Latinoamericana de Organizaciones del Campo
CSA	Climate Smart Agriculture
CSIPM	The Civil Society and Indigenous Peoples' Mechanism
ETC Group	Action Group on Erosion, Technology and Concentration
FAO	Food Regime Theory
FIAN	Food First Information and Action Network
FRT	Food Regime Theory
GATT	General Agreement on Tariffs and Trade
HLPE	High Level Panel of Experts
HYV	High Yielding Varieties
IMF	International Monetary Fund
IoT	Internet of Things
ITO	International Trade Organization
MDG	Millenium Development Goal
NGO	Non-Governmental Organization
OECD	Organization for Economic Co-operation and Development
RtAF	The Right to Adequate Food
SDG	Sustainable Development Goal
UK	United Kingdom
UN	United Nations
UNCTAD	UN Trade and Development
UNFCCC	UN Framework Convention on Climate Change
US	United States of America
WFS	World Food Summit
WTO	World Trade Organization

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1. Introduction

To address world hunger, is a collective vision of the future necessary?

Despite decades of interventions, food security remains a major global issue (McCarthy et al., 2018, p. 12; Montenegro De Wit & Canfield, 2024, p. 384); the Food and Agricultural Organization (FAO) estimate that in 2023 over 700 people may have faced hunger and over 2 billion were food insecure (FAO, et al., 2024). With the emergence of Sustainable Development Goal (SDG) #2: Zero Hunger to the mainstream international stage, it has become clear that the world agrees that food security is a problem. Can the same be said, though, for how this problem is *understood*?

There is a history of contested understandings of food security, and food itself, in international arenas, in which each understanding is embedded in greater socioeconomic positions. A large body of literature addresses both different understandings of what an improved food system would look like (Anderson, 2024a; Gugganig et al., 2023; Juskaite & Haug, 2023) and the ways in which food systems issues are presented, particularly on international scales (Anderson & Rivera-Ferre, 2021; Bergier et al., 2024; Candel et al., 2014; Fairbairn, 2012; Glaros et al., 2023; Kelinsky-Jones et al., 2025; Lajoie-O'Malley et al., 2020; Maria et al., 2021; Montenegro de Wit & Canfield, 2024; Mooney & Hunt, 2009; Stephens & Hinton, 2025). What becomes salient is that there are differing motivations behind the presentation, or framing, of food security initiatives, and these presentations influence policy decisions. Innately, this inscribes and reinscribes power dynamics onto food security projects and into food systems. As global problems persist, so do initiatives like the SDGs which set agendas for the future.

The future is, therefore, an implicit topic in international policy arenas. This has become only more prominent with the development of Industry 4.0 technologies, whose impact and applications are still being hypothesized. For food systems, this has brought about Agriculture 4.0 (Agri 4.0), an umbrella of various “high tech” tools like artificial intelligence, block chains, and precise sensors which can provide new agricultural functions (Garg and Alam, 2023). However, this too naturally manifests contested understandings. It is here where this thesis takes focus; the ways in which new technologies in agriculture are presented illuminate the different understandings agriculture, food systems, and food security, and ultimately reflect differing food futures. Through a framing

analysis and deployment of Critical Discourse Analysis, different understandings of Agri 4.0 are uncovered, contextualized, and ultimately translated into different visions, or ‘sociotechnical imaginaries’ (Jasanoff & Kim, 2015) of food systems. I find that there exist primarily utopian and dystopian imaginaries around Agri 4.0, channeling the benefits and detriments that come with the inscriptions of power each understanding provides. Amid an array of oppositional frames, values, and visions, exists what I call a protopian imaginary, that perhaps provides an example of newness within the repetition of contested (albeit important) paradigms. Addressing food security requires a deeper level of engagement than has so far been seen, it requires addressing futures imagined, contested, and pursued.

1.1 Food Security, Technology, and Contested Futures

Food security has been on the Development¹ agenda since the post WWII era (McMichael, 2021), and interventions and initiatives from the international community have been widely influential, if not controversial. Paradigms that have been both supported and criticized by Development scholars and practitioners rear their head in the food security discourse: dependency theories, growth and degrowth concepts, and international aid, to name a few. Agri 4.0 provides a new facet to these complex institutions that influence food, and requires critical assessment. Smart Farming has the potential to reinscribe existing patterns of exploitation, or to utilize “radical arrangements” of digital tools to dismantle such patterns (Fraser, 2022, p. 206). What outcome eventually occurs depends greatly on the ideologies influencing policy making and system implementation.

The term ‘food security’ first entered the international policy arena in the 1970s in the wake of global grain shortages that skyrocketed food prices (Margulis, 2017, p. 29). Previously, international actors had discussed and executed interventions for food supplies, like the Marshall Plan in the wake of the Second World War. However, the emergence of ‘food security’ signaled international consensus on the responsibility all nations had in feeding the world, and the start of cooperations exercising this mindset (Shaw, 2007, p. 150). This archetype was greatly informed

¹ Scholars have made a distinction between ‘big D’ development and ‘little d’ development. ‘Big D’ refers to formal, planned interventions like projects and policies stemming from Western, post WWII modernization projects, while ‘little d’ describes broader processes of social, economic, and political change. The distinction highlights the difference between intentional and immanent development and remains a useful device (for more reading see: (Lewis, 2019).

by a Malthusian perspective, which argued that with the current rate of population growth, future generations will not be producing enough food to eat (Margulis, 2017, p. 28; Shaw, 2007, p. 115). Simply put, this asserts that food security is achieved through producing more food. This paradigm has been the main informant of food security discourses and policy to this day, although there have been significant developments. In the 1990's, following Amartya Sen's work on drivers of famine, the definition of food security was revised to include not just the availability of food, but its *accessibility* (Margulis, 2013, p. 54, 2017, p. 28; Sen, 1983; Shaw, 2007, p. 230). Yet, the status quo of both food security and agriculture still relies on increasing production.

In response to the neoliberal status quo, different food movements emerged to contest both its understanding of food security and agricultural production. Particularly, food sovereignty emerged as an ontological alternative to the neoliberal framework shaping international discourse and agricultural initiatives (Claeys et al., 2021, p. 238; Misra, 2018, p. 483; Mooney & Hunt, 2009, p. 478). It focuses on community rights on decisions about food production, challenging the authority of markets, corporations, and governments. It particularly advocates for production methods that align with natural ecosystems and draw on traditional and Indigenous farming practices (Carolan, 2018, p. 15; Misra, 2018, p. 483; Ume et al., 2025, p. 3). Although it stands in opposition to a neoliberal food security agenda, it is deemed by many to be the necessary means by which to achieve real food security (Mann, 2015, p. 458).

Agriculture 4.0, on the other hand, is also presented as a means to achieve food security. Indeed, its technologies could drastically change agriculture; precision farming has the potential to save water, eliminate fertilizers, and increase yield, while blockchain ledgers promise to keep the whole supply chain transparent (Choruma et al., 2024; Garg & Alam, 2023; Navarro et al., 2020). Development initiatives are targeting smart technologies and, increasingly, investments are being made in agriculture. However, few Agri 4.0 innovations have been implemented; they can be costly, hard to manage and drastically change how farmers function. (Carolan, 2024; DiNapoli, 2024). Numerous studies list the costs of these technologies and the new skills required to use them as barriers to their implementation on farms. Additionally, farmers express concern over these costs, and the way in which their farming practices will be reshaped (DiNapoli, 2024). Big data analytics, which promises to help with decision making on the farm, functions fundamentally differently than the perception skills of an experienced farmer (Barrett & Lansing, 2025). Data

rights, and the push for extracting agricultural data, is another concern of critics (Montenegro De Wit & Canfield, 2024, p. 410). In their² study, Montenegro de Wit and Canfield (2024) parse out the narratives used by global development actors to frame data. The ‘data productivist’ vision of the future, or sociotechnical imaginary, emerges from their results. Data productivism is the evolving story of this consensus, “the active building of institutions that take up and amplify these narratives, and the collective maintenance of global colonial hierarchies through modernity’s promises of technological change” (Montenegro de Wit and Canfield, 2024, p. 405). By using the concept of sociotechnical imaginaries, introduced by Jasanoff and Kim (2015), the authors can assess collective understandings and desires around data on the international stage.

Other scholars have also investigated the way international actors frame digital agriculture. Lajoie-O’Malley et al. (2020) analyze policy documents from the World Bank, FAO, and OECD between 2015 and 2018 to assess their view of future food systems. They found that the narratives employed “envision future food systems that prioritize maximizing food output through technology” (Lajoie-O’Malley et al., 2020, p. 1), with no present alternatives. They conclude that these perspectives advance a vision of technological solutions situated within industrial agriculture, even in the face of substantial criticism of this model. They urge the reader to “think critically about narratives of digital agriculture that favor maximizing food output alone through a technological fix within an industrial production model (Lajoie-O’Malley et al., 2020, p. 10).

In contemplation of this current agricultural model, and its effect on food security, Stephens & Hinton (2025) conduct a framing analysis of government responses to food crises. They find four prominent frames, two of which, in comparison to responses to the 2008 crisis, maintain the status quo while, the others represent new developments. The latter frames — “mobilizing private finance and leveraging data—are more nuanced in that they signal both historical continuity and shifting elements in the third food regime” (Stephens & Hinton, 2025, p. 82). Financialization and digitalization are changing shape and, consequentially, changing the shape of global food governance and security.

² This thesis uses gender-fair language to mark its place in academic discourse. In doing so, it attempts both an epistemological impact on non-sexist language norms as well as a contribution towards dismantling gender binaries. Gendered grammar forms like the pseudo-generic *he* and *man* are avoided, as will the substitution phrase *he* or *she*, or *his* or *hers*. In their stead phrases such as *one*, the neutral *they* or *theirs*, and plural forms are used. Titles, labels, and names are put in the neutral form unless done so to signify something specifically.

A framing analysis can be extremely useful when looking at new topics, especially when coupled with other, critical forms of analysis (Kanwal & García, 2019). A frame is selection of included, and conversely excluded, aspects of a topic, which change the way it is presented and perceived (Entman, 1993). Glaros et al. (2023) use Frame Theory to assess the perspectives of digital agriculture in online discourses. They establish that current frames center scaling-up production and profit, supply chain traceability, and technical sovereignty (p. 48), however “there is indeed a risk of overlooking farmer agency in discussion of digital agrifood system transformation” (Glaros et al., 2023, p. 53). Unlike studies that present frames as dichotomous, the breadth of Glaros et al. (2023) work allows them to suggest that actually “framings for agri-food system digitization are more complex and dynamic” (p. 53).

It is this complexity of framings that will constitute my research. Though previous research has been on dominant international policy actors, actors who are identified as “providing essential imaginative resources that influence food policy” (Lajoie-O’Malley et al., 2020, p. 3; Montenegro De Wit & Canfield, 2024), they do not consider non-dominant policy actors, nor a comparison of differently categorized actors. Though dominant actors, naturally, dominate influence on decision making, they are not the only influence. Some research has paired framing with discursive analyses, like Rychnovská (2014) study on the securitization of threat framing in the UN. This allows specific frames to be connected with larger Discourses and makes it possible to see what ideologies or hegemonic practices are inscribing and being reinscribed in these frames. Finally, there is little research on how these frames reflect imaginaries of not just the food system, but of food security. This thesis would build upon existing literature by synthesizing different approaches to fill in knowledge gaps.

Building on previous research of framings of Agriculture 4.0 (Lajoie-O’Malley et al., 2020; Montenegro de Wit & Canfield, 2024; Stephens & Hinton, 2025), this thesis expands the scope to include large non-governmental organizations (NGOs) and other influential but non-dominant actors. While existing research discusses common narratives about data, technology, agriculture, and food security, it often lacks critical analysis or comparison of how these discursive practices, and importantly their relation to each, other shape future visions of food systems. This gap is filled by examining four diverse organizations involved in global agricultural and food security efforts, with distinct institutional perspectives. These include the Consultative Group on International

Agricultural Research (CGIAR), the Food and Agriculture Organization (FAO), FIAN International, and the Action Group on Erosion, Technology and Concentration (ETC Group).

Critical Discourse Analysis (CDA) methods, following Fairclough (1995) are used to analyze texts and both find frames of Agriculture 4.0 as well as the understandings of food security that ground them. CDA works on three layers. Paired with CDA is Frame Theory, following Entman (1993), which enables an analysis of what assumptions underpin these frames, and how they relate to broader discourses and ideologies. The interdisciplinary paradigms of sociotechnical imaginaries and utopia studies are used to bridge this analysis into said discourses.

1.2 Theoretical Framework: Food Regimes

This thesis utilizes the theoretical framework of Food Regime Theory as established by Friedmann and McMichael. A ‘food regime’, as described by Friedmann and McMichael (1989), “links international relations of food production and consumption to forms of accumulation broadly distinguishing periods of capitalist transformation since 1870” (Friedmann & McMichael, 1989, p. 95). They originally distinguish two food regimes, the first around European colonial rule and the second rooted in the modern Nation State and US industrialized agriculture (Friedmann & McMichael, 1989). As a fundamentally comparative method of viewing food systems historically, it allows one to link diverse changes across time and space as interconnected parts of a larger historical process (Magnan, 2012, p. 374). This framework enables current Agri 4.0 frames to be connected to broader, historical sociopolitical discourses.

The first food regime reigned from the 1870s until 1914, was otherwise known as the British regime, and was characterized by Britain’s global dominance in trade, finance, and food provisioning, with wheat as the central commodity (Krausmann & Langthaler, 2019, p. 89). After the abolition of Corn Laws in 1846 repealed Britain’s protective tariffs, with the aim to reduce food costs (and labor costs), the growing of staple crops began to be outsourced to settler colonies. Tropical goods from colonies and staple crops like wheat and meat from settler states (like the US and Australia) could be cheaply imported to Europe, and a paradigm of ‘free trade imperialism’ formed (McMichael, 2021, p. 219). These staple crops, otherwise known as ‘wage foods’, were essential for feeding Europe’s growing working class cheaply and accelerating industrialization (Magnan, 2012). US grain production nearly tripled between 1859 and 1889, leading to a unified

global wheat price and a central role of settler states in farm industry economies. This settler-capitalist development model became idealized in the US and influenced mid-twentieth century international development thinking (McMichael, 2021, p. 218). This also gave rise to a global wheat market; Britain's use of sterling as an international currency facilitated a globally convergent wheat price (Krausmann & Langthaler, 2019, p. 89). As such, it was British hegemony that made this regime possible (McMichael, 2021), intrinsically linked to the rise of fossil fuels and industrialization (Krausmann & Langthaler, 2019, p. 93). It saw rise to a class of 'family farms', or commercial farming households, that were beholden to international markets (Magnan, 2012, p. 468).

The first food regime came into a period of prolonged *crisis* between 1925 and 1945, driven by a combination of political, economic, and ecological factors (Krausmann & Langthaler, 2019, p. 90; Magnan, 2012, p. 469). World War I exposed the vulnerability of European food systems dependent on overseas imports, leading to surging food prices and the abandonment of the free trade scheme that defined the regime as European countries implemented tariffs. The Great Depression further exacerbated this, causing a collapse of world grain prices in the mid-1920s, which led to severe hardship and dislocation for farming households and prompted a redirection of the state's role in capitalist countries (Krausmann & Langthaler, 2019, p. 93; Magnan, 2012, p. 469). So-called "soil mining" in settler colonies depleted plant nutrients, causing declining crop yields and eventually manifesting in the "Dust Bowl" years of the 1930s, when severe drought and wind erosion damaged prairies in North America (Krausmann & Langthaler, 2019, p. 93). These social and ecological crises propelled government intervention, notably with New Deal commodity programs that instituted price supports and encouraged production, thereby generating large agricultural surpluses (Magnan, 2012, p. 467; McMichael, 2009, p. 143). As the US arose as a global power and the center of the world economy in the wake of the two World Wars, with state supported agriculture and growing industry, so did a new food regime (Friedmann, 2016, p. 111; Krausmann & Langthaler, 2019, p. 91; McMichael, 2009, p. 143).

The second food regime, also known as the US food regime, from 1947 to 1973, was driven by the need to manage large agricultural surpluses generated by New Deal-instituted farming supports that encouraged production. Ideologically, this regime promoted a productivist vision of agriculture, emphasizing agro-technological progress to boost yields rather than expanding

agricultural land. This led to the fossil fuel-based industrialization of agriculture, with widespread adoption of chemical fertilizers, pesticides, new crop varieties, and mechanization like tractors. Furthermore, this led to a fundamental shift from land expansion to input intensification and yield improvement, marking a transition from extensive to intensive frontier expansion (Krausmann & Langthaler, 2019, p. 91; Magnan, 2012, pp. 469, 471). The US was able to export a large portion of surpluses through food aid in the European reconstruction efforts (a topic which will be elaborated in the following chapter), and later Public Law 480 (1954), or the Food for Peace program, which let non-communist affiliated countries purchase wheat in local currencies, portrayed also as a food aid program. This simultaneously cemented geopolitical ties and created dependency on cheap imports (Degerald, 2021, p. 248; Krausmann & Langthaler, 2019, p. 91; Magnan, 2012, p. 470). Changes in trade were politically manufactured and led to a rise of the agrifood sector; these changes mainly occurred through an *intensive meat complex* and a *durable food complex* (Friedmann & McMichael, 1989, p. 105). The former integrated specialized production of animal products and grains across a national frontier and the latter shifted food from perishables to mass produced, standardized, manufactured foods like packaged and frozen goods. The results were the establishments of supermarkets, meat and oil based Western diets, and the exportation of these norms to ‘developing countries’ (Friedmann & McMichael, 1989, p. 105; Magnan, 2012, p. 472). However, this intensive system incurred high ecological costs, becoming a significant contributor to global environmental change through reliance on finite resources, greenhouse gas emissions, and water consumption. The regime eventually entered a prolonged *crisis* in the early 1970s driven by the high cost of subsidizing overproduction, growing transnational corporate interests clashing with national protectionism, the end of the Bretton Woods monetary system, global food and oil price shocks, and increasing public concern over the environmental and health impacts of industrial agriculture (Krausmann & Langthaler, 2019, p. 92).

Two decades after the theory’s initial publication, McMichael (2009) presented a conceptual third food regime. The third food regime, spanning the late 1980s to present, has been called both the corporate food regime and the neoliberal food regime. Unlike previous regimes, which were geographically centered, the corporate food regime is characterized as decentralized but governed by the World Trade Organization’s (WTO) trade liberalization agenda, understood as the deregulation of agricultural markets (Krausmann & Langthaler, 2019, p. 91). As McMichael (2009) puts it, “in this era of financialization, agribusiness conglomeration accompanied the

universalization of export agriculture with an accelerated displacement of small-scale farming systems” (219). During the 1970s and 1980s, the US model of surplus exporting in the name of ‘feeding the world’, which (as we will be discussed in the following chapter) was a view informed by productivist motivations and Malthusian fears, intensified (McMichael, 2021, p. 219). The many trade negotiation rounds resulted in surplus management, which in turn led to the “dumping of surpluses in the world market” and, as the EU shifted from its Common Agricultural Policy (CAP) to US-style direct payments to agricultural producers, production costs were decoupled from prices, and so a single ‘world price’ was formed (McMichael, 2009, p. 153). Simultaneously, countries in the ‘Global South’ were pushed by the International Monetary Fund (IMF) structural adjustment programs to increase agro-exports to cover debts, and as cheap subsidized food was ‘dumped’ into the world market and exports increased, ‘Southern’ states moved further towards contract farming from large, ‘Northern’ agribusinesses (Clapp & Moseley, 2020, p. 1397; McMichael, 2009, p. 219). Essentially, in line with neoliberal trends of corporate concentration, agriculture saw a shift towards an extractive sector dominated by a few giant corporations and driven by technological advancements, weakened government regulation, and financial mechanisms (Clapp & Purugganan, 2020; McMichael, 2021). The neoliberal approach to agriculture restructured its systems and resulted in extreme concentration.

The extent of agricultural concentration is extremely evident. More than half the world’s calorie intake is from four staple crops (maize, wheat, rice, and soybeans), of which at least 72% of production has been, in the last decade, concentrated in five countries (China, The US, India, Brazil, and Argentina) (Margulis & Hopewell, K., & Qereshniku, E., 2022, p. 332). In addition, fertilizer production is also concentrated, with 70% being produced in six countries (Canada, China, India, Russia, Belarus, and the US) (Margulis & Hopewell, K., & Qereshniku, E., 2022, p. 334). This geographical concentration reflects the corporate consolidation that has taken place in the last fifty years. The number of mergers and acquisitions of agricultural companies has risen drastically, with the largest companies buying their smaller competitors and seed companies integrating with agrochemical companies (Clapp & Purugganan, 2020, p. 1266). What is now visible is the vertical integration and market concentration managed by a handful of companies. Out of the ten biggest pesticide companies in the 2010s, which made up 94% of global sales, six were the largest seed companies, namely Syngenta-ChemChina, Bayer-Monsanto, BASF,

Limagrain, Dow-DuPont, and KWS-AG (Béné, 2022, p. 4). In 2021, the four companies that controlled 70% of the pesticide market also made up more than half of the market share of the global seed market (Clapp et al., 2025, p. 3).

Despite its potency, the original theorization of Food Regime Theory has been criticized for its tendency to present an "overly determinist portrayal of capitalist accumulation" as the main driver of change, which ignores how capitalism is socially and institutionally regulated, distinctive national and regional contexts, as well as sites of political contestation" (Magnan, 2012, p. 373; Tilzey, 2019). Additionally, some scholars have argued that FRT has neglected issues of class, labor, and the agrarian proletariat altogether (Jakobsen, 2021; Tilzey, 2019). Furthermore, there remains an ongoing debate as to whether a distinct third food regime has fully materialized, or whether the present era represents merely a continuation of the *crisis* of the second food regime (Jakobsen, 2021; Magnan, 2012; McMichael, 2009). Tilzey (2019) argues that the conception of a corporate food regime itself has flaws; it ignores how other factions of capital, diverse business interests, actors, as well as the state, shape food systems (Tilzey, 2019, p. 234). Finally, Friedmann (2016) argues that the 'corporate food regime' implies a unified corporate agenda, and that as such it must be opposed to 'good' actors, positioning a rigid structure for the analysis of food systems (Friedmann, 2016).

Utilizing Food Regime Theory as a framework provides the possibility, as McMichael (2009) notes, "not simply to understand the dimensions of the food crisis, but also to situate the world food system and its crisis within a broader historical understanding of geo-political and ecological conditions" (McMichael, 2009, p. 139). This is what makes it valuable for work in this thesis; it allows us to situate a particular dimension of food, Agriculture 4.0, within broader discourses of food security and food systems, while also connecting these discourses to historical, geopolitical, and ecological conditions. Practically, this entails looking into historical foundations, not just current understandings, of the intersecting topics of food security, food system transformation, technology, and power. This framework enables an analysis of each topic that is interrelated and historically grounded; an analysis of food security considers not just figures on malnutrition and an account of intervention projects, but also the actors driving these projects, their motivations, and the different sociopolitical developments that have shaped them. The same goes for food movements, agricultural technology, and hunger interventions. By using Food Regime Theory to

situate Agri 4.0 in global historical conditions, we can subsequently illuminate how it relates to these conditions and better understand what its shaping influences are; we are able to piece together larger discourses around this topic. Ultimately, FRT provides the framework for a critical, historically situated, and interconnected analysis of food security and technology.

1.3 Structure of the Thesis

The following chapters build upon one another to develop a comprehensive analysis of Agriculture 4.0 as it is conceived of on the international stage, and its relationship to food security. Chapter 2 presents a brief overview of the history of food security focusing on its modern formation starting in the early twentieth century. This chapter provides context and insights on the debates within food security discourse and sets the stage for adding more complicated elements in the subsequent chapters. Chapter 3 broadens these debates by introducing food movements and so-called alternatives to food security, with a particular focus on food sovereignty and its impact. In Chapter 4 the concept of Agriculture 4.0 is laid out, as is its main components and examinations of its impact. Reflections on the role of data, business, and farmers in agriculture are undertaken, as well as its impact within the context of the corporate food regime. The methods and theories used for the empirical research are presented in Chapter 5, along with the organizations focused on. Chapter 6 recounts the results of the empirical analysis, establishing the seven major frames identified in the research and their characteristics. This section provides key examples and extrapolation of how they specifically relate to the larger debates previously discussed. Finally, Chapter 7 deploys the results and work of the other chapters, cumulating in a discussion on which collective understanding, or sociotechnical imaginaries, can be illuminated from this work and their significance. Aspects of utopian studies and other interconnected disciplines are utilized to bring varied sociotechnical imaginaries into relation with one another and the wider discourses on technology and agriculture that underpin this thesis.

2. Food Security

In order to understand current discourses around food security, systems, and technology, it is imperative to understand *what* is meant by “food security”. This section outlines the origins of food security starting with the seventeenth century until the present day, exploring the sociopolitical developments that underpin how the formations of famine and hunger turned into the concept of food insecurity. With this established, it will become possible to connect the frames of Agriculture 4.0 with these broader discourses around food security, ultimately contextualizing the visions of the future discussed later. This next section presents a brief history of food security.

The term ‘food security’ first entered the international policy arena in the 1970s in the wake of global grain shortages that skyrocketed food prices (Margulis, 2017, p. 29). However, as Salvatici (2015) argues, the realization of the modern idea of food security is situated within a longer chronology of ideas around development, agriculture, and globalization.

2.1 Food Security between 17th and mid-20th century: History of Hunger

Throughout history the world has had to cope with food crises, and with the problem of “availability, quality, and distribution of food” which, as Mukherjee (2019) states, is shaped by a cultural history of “economics and agricultural or technological development” as well as “a history of human responses, resilience, and representations in the long term” (Mukherjee, 2019, p. 3). As we will see, these factors are intrinsically intertwined and deeply command food systems. The long history of famines is exemplary; a combination of factors caused early modern famines which were extremely localized and context specific. Sociopolitical and technical changes, like improvements in production and distribution methods, as well as the broader development of capitalism in England in the seventeenth century, redesigned famines for people and policy makers. On the one hand, more production alleviated risks of famine, but the growth of families’ dependence on physical marketplaces for food increased risks as well. The traditional ‘political economy of dearth’, which had worked to provide food security regionally, was reshaped (Walter, 2019, p. 26). The combination of society, technology, and culture lead to a reshaping of food, hunger, and what we understand today as food security. One can even think of the most pivotal transition in human history, the Neolithic Revolution, on such terms. Ziska (2017) does by arguing that agriculture itself, the domestication of nature, spawned famine. The transition to stationary agriculture

settlements created risks, like malnutrition, labor-induced health problems, and even unequal societal norms, that were not present in hunter-gatherer, mobile societies (Ziska, 2017, p. 14).

Since their formation in societies, governments and monarchs have taken on practical and moral responsibility for feeding populations (Scott-Smith, 2020, p. 2; Walter, 2019, p. 21; Ziska, 2017, p. 17). This is what Rousseau described in the mid-eighteenth century as the ‘social contract’, where people submit to the rule of a sovereign under the condition that they will provide certain protections and ensure certain rights (Rousseau, 1762, p. 21). In the context of food security, this means that governing parties have a commitment to deter famines from their populations. However, some have argued that philanthropy undermines this agreement by creating sources of external dependence (Hickey, 2011, p. 16). Scott-Smith (2020) traces the ways in which the approach to this responsibility has changed, exploring the formation of humanitarianism and how food aid transitioned from being seen as a moral issue to one of rational methods for providing sustenance. This changed the approach of hunger interventions from one based on relationships, social environments and subjectivity, to one of measurements, nutrients, and rationales. This shift started with the scientific enlightenment of the 1800s and exploded after 1940 when “starvation began to be widely understood as a biochemical state: a physical problem rather than a moral one. Hunger, therefore, was recast as a biological rather than a social deficiency” (Scott-Smith, 2020, p. 11). As this approach to humanitarian food assistance started to crystalize at the turn of the century, the scale and devastation of the World Wars created a stage for international hunger interventions, effectively leaving behind local and social dynamics from the conversation on hunger.

The start of international assistance as we see it organized today, as well as the formalization of science-orientated food security, began with the era after the First World War. In the aftermath of the First World War, malnutrition and mortality raged and international aid programs, particularly food aid, proved vital to the stability of Europe (Salvatici, 2015, p. 349). The United States instituted post-war relief credits and subsequently 6.23 million tons of food shipped as food assistance during the reconstruction period in Europe (Shaw, 2007, p. 12). With the Great Depression in swing, the 1930s saw the emergence of an acknowledged nexus of agriculture, aid, and surpluses leading to a boom in research programs on nutritional science. The League of Nations started coordinated interventions, utilizing research, and enmeshing these domains

(Salvatici, 2015, p. 349). This laid the foundation for the precursor to modern ‘food security’, actions against hunger, malnutrition, and ‘feeding the world’. In the 1930s there was already a body of standardized international data on hunger provided by the League of Nations, which was used to justify and support feeding programs (Iversen et al., 2023, p. 1). This included the first standard of calories per day for adults (2,500 calories) and the recommendation that greater food production, as well as trade, could correct deficiencies in this standard where they existed (McDonald, 2017, p. 24).

The US issued various agricultural policies and subsidies under the New Deal programs since the 1930s, largely in response to Dust Bowls and agricultural declines of the Great Depression. This, coupled with newly evolving technology, led to major surpluses, particularly for grains (Margulis & Hopewell, K., & Qereshniku, E., 2022, pp. 338–339; Shaw, 2007, p. 13). During the period that followed the second world war, eradicating hunger became a key goal of the international system (Margulis, 2013, p. 55). Programs, most notably the Marshall Plan, were extremely influential in reshaping food supply and provided significant bilateral aid in food, seed and fertilizer, and a guaranteed export market (Shaw, 2007, pp. 13, 34). Wheat, being labelled by US President Truman as the most economical and nutritious crop, was positioned as the primary source of hunger relief. For the US, the utilization of a major national crop allowed the state to meet export needs, while supplying nutrients and gaining international influence in the face of the growing Soviet Union (McDonald, 2017, pp. 42–44). This reflected the broader use of food supply interventions during this time as international diplomacy and the common Malthusian perspective, which viewed the world’s rising population as the cause of inevitable, widespread food shortages. These topics drove the inclusion of food aid in international negotiations in the 1960s and the scaling up of bi- and multi-lateral assistance food aid *and* food production (Margulis, 2017, p. 28; McDonald, 2017, p. 44; Shaw, 2007, p. 11), and clearly aligned with US interests.

This schema was solidified through the creation of the Food and Agriculture Organization (FAO) in 1945, the first UN specialized agency tasked with improving global nutrition, food production, and distribution, and ensuring freedom from hunger (Margulis, 2013, p. 55). The FAO initially promoted international coordination of food production and trade, but major grain-exporting countries (such as the United States), pushed to expand agricultural trade rather than submit to global oversight, redirected the FAO’s efforts toward strengthening domestic food supply systems

in ‘developing countries’ (Margulis, 2013, p. 55). Within the decade, the FAO began coordinating the redistribution of surplus grain from Western countries to food-insecure populations in the ‘developing world’ (Margulis, 2017, p. 28).

Concurrent, and cognately, the General Agreement on Tariffs and Trade (GATT) was established. It effectively replaced the proposal of the Bretton Woods conference (1944) for three new “pillars” of a global economic system, one of which, the International Trade Organization (ITO), would work to stabilize primary commodity prices (Shaw, 2007, p. 30). After a first round of negotiations in the UN’s 1948 Havana Charter, the ITO was formed. Along with general economic cooperation, it sought to foster cooperation in agricultural trade, as agriculture was a key sector in both ‘developing’ and ‘developed’ economies. However, it was never ratified due to US political opposition, and so its role was replaced by GATT (Margulis, 2017, p. 30). The Havana Charter saw to eight rounds of trade negotiations until the last round resulted in the formation of the World Trade Organization (WTO) in the mid 1990s (Margulis, 2017, p. 31). These trade negotiations had major impact on the formation of the global economy, as well as shaped national and international food systems. Importantly, they also enshrined within international legal frameworks the necessity for international cooperation on food supply and food security (Margulis, 2017, p. 30).

The Malthusian take on food security that dominated at the time was reflected through trade negotiations. During the Havana Charter of 1948, export restrictions were permitted, though only as temporary measures (Margulis, 2017, p. 30). The resulting consensus showed that hunger was viewed primarily as a supply problem, which could be exacerbated by export bans and alleviated through surplus food flows (Margulis, 2017, p. 31). The combination of the US surplus, trade negotiations, and the need for aid that fostered this system of exporting surpluses, was especially focused on places with precarious economies. The issue of surpluses shaped many international negotiations on agriculture, often presented a divide in opinion between net-exporting and net importing countries (Margulis, 2017, p. 27).

In the following decades, various rounds of negotiations shaped international agricultural trade, and subsequently food systems. During the Dillon Round of 1960 -1962, the US was criticized by other wheat exporters for using non-commercially viable products for food aid, and concessionary sales on credit as food assistance (Margulis, 2017, p. 35). This coincided with major changes in the price of wheat on the global market. A few years later, during The Kennedy Round (1963-

1967) the angle of food exporters was to shape the management of grain supply so that countries like UK and France could not achieve self-sufficiency (Margulis, 2017, p. 35). During the Uruguay Round, which occurring parallel to the Washington consensus and just after the 1970s world food crisis, the US pushed the idea that agricultural trade liberalization, not food self-sufficiency, would be the most effective measure against food insecurity (Margulis, 2017, p. 43), resulting in the Marrakech Decision which established the WTO and provided guidelines to help net-importing countries address issue on food shortages (p. 49). These trade decisions were highly contested, especially by ‘developing countries’ who understood the trade dependencies they created and the (US) commercial interest driving them (p. 44). However, such trade reforms, which lead to more efficient markets, is still highly regarded by many international organizations and actors (Shaw, 2007, p. 363).

2.2 Food Security from 1970s to Present: ‘Modern’ Food Security

The term “Food Security” emerged in the 1970s in institutional development circles, as the global food crisis was occurring (Margulis, 2017, p. 29). The 1970s food crisis stemmed from severe supply shocks, including poor harvests in 1972 across major regions, a 450% oil price surge after the first oil shock, and a threefold rise in fertilizer costs, all amid low global food stocks and rising demand for animal feed. These factors drove food prices to record highs and caused widespread shortages, all at a time when food aid had hit a decline, consequently hitting ‘developing countries’ hardest (Custodis, 2012, pp. 302–303). Grain prices skyrocketed due to the shortage in production, and the consequence was a volatile food market and a stark rise in levels of hunger (Margulis, 2017, p. 29). Countries endorsed a resolution on an International Undertaking on World Food Security (IUWFS) at the FAO Council session in 1974, acknowledging that all nations had a responsibility in ensuring world food security (Shaw, 2007, p. 150).

The emergence of ‘food security’ signaled international consensus on the responsibility all nations had in feeding the world, and the start of cooperative efforts under this mindset (Shaw, 2007, p. 150). The market failures of the 1970s brought into perspective the effects of pricing on food security, something which previously had been unrecognized (Clapp et al., 2022, p. 2). However, it was the influence of Amartya Sen’s 1981 work on famines that really brought forward the idea that the major issues causing hunger were not a lack of food but rather lack of *access* to it (Clapp et al., 2022; Margulis, 2017, p. 29; Sen, 1983; Shaw, 2007, p. 230). As they state in their liminal

work, “starvation is the characteristic of some people not *having* enough food to eat. It is not the characteristic of there *being* not enough food to eat. While the latter can be a cause of the former, it is but one of many *possible* causes” (Sen, 1983, p. 1). They use the concept of entitlements to explain ownership, arguing it is legitimized through chain of connected claims of entitlements. The exchange of entitlements is important and depends on various factors; for example, if the price of food skyrockets while a worker’s wages remain the same, the worker’s ability to convert their wage into food (the exchange of entitlements) is altered, and their dependence on this exchange differs dramatically from that of a subsistence farmer (Sen, 1983, p. 5). Another important topic they bring to light is the *distribution* of food, posing critical questions on what determines it (Sen, 1983, p. 7).

As a consequence of Sen’s work, revisions to the definition of food security were made, and in the mid 1980s the World Bank published documents concluding that the world had ample food and import opportunities, and yet hunger was still persistent. This is understood through the distinction between transitory food insecurity (which happens after unexpected occurrences like bad harvests) and chronic, whose main driver is poverty (Shaw, 2007, p. 259). Ultimately, the 1990s brought forth the current definition of food security, as established at the 1996 World Food Summit:

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. (FAO, 2006, p. 1)

The influence of Sen’s work is evident in the emphasis on *access*, rather than merely the quantity of food. This definition that demands “access” can be interpreted in different ways. For the international institutions that facilitated the process of forging ‘food security,’ its interpretation is heavily influenced by the history of the last century; the transition towards thinking of hunger as a technical problem and the influences of large States’ trade motivations. As the definition of food security developed further in 2001 to include “social” in relation to access (although this is not always utilized), the earlier ideas of drivers and solutions to hunger were reflected, highlighting the growing influence of Sen’s work (Clapp et al., 2022, p. 3). This definition, still most predominant today, is understood as having four pillars which are stressed in a hierarchical order: availability, access, utilization, and stability (Clapp et al., 2022, p. 1).

Food security came to the forefront of public discussion again during the 2007–08 food crisis, after having slipped out of the limelight at the turn of the century. The crisis was marked by dramatic increases in global food prices; wheat prices more than doubled, rice prices tripled, and other staples like maize and soybeans rose steeply. This was caused by a constellation of factors. Government policies diverted crops like corn to biofuel production and reduced agricultural subsidies, causing supply shortages, while higher oil and metal prices raised input costs (like fertilizer), and financial speculation on rising food prices distorted the market. Export bans by major producers further tightened markets, and, like the previous crisis, ‘developing countries’ were hit the hardest (Custodis, 2012, p. 304). Reminiscent of the 1970s crisis, prices and the affordability of food directly affected levels of hunger.

Currently, agricultural and food aid still incur immense monetary and physical flows. Billions of USD are given as philanthropic donations and cross-boarder remittances for food security, foreign direct investment for food and agriculture, and loans (FAO, et al., 2024, p. 30). It is important to distinguish philanthropic donations from investments, as they reflect different approaches to food security. The first follows the traditions of post World War bilateral assistance, in which direct food or other supplies are given to those facing food insecurity. The second stems from the shift in development practices; in the wake of dependency theories, the concepts of ‘resilience’ and ‘self sufficiency’ and ‘self reliance’ within Development projects was installed (Kelinsky-Jones et al., 2025; Omata, 2023). Investments, in contrast to direct aid, are seen more as a tool to help communities establish stability and economic growth and continue their Development without assistance. It is important to note the difference in reported budgets for the respective branches: between 2017 and 2022, roughly 376 billion USD was given to food security in the form of consumable food, while roughly 29 billion USD for foreign direct investment and loans, a figure that is in decline. One must parse out the aid given for transitory food insecurity, but still the numbers are significant. Despite its positive short-term effects on nutrition and hunger, there is established evidence that direct food aid does not combat chronic food insecurity in the long run, but rather establishes new dependencies on aid agencies and donors (Altincekic & Bearce, 2014). Nonetheless, the financial flows remain immense. This is only amplified by the mainstreaming of food security initiatives.

2.3 Popular Paradigm: Mainstreaming through Sustainable Development Agenda

Food security has been widely mainstreamed, particularly through the 2000-2015 Millennium Development Goals (MDGs) and the 2015-2030 Sustainable Development Goals from (SDGs). Both agendas focused on food security, starting with MDG #1, which had the aim to “eradicate extreme poverty and hunger”, through to the current SDG #2, which aims for “zero Hunger” (United Nations, n.d.-a, n.d.-b). The mainstreaming of social issues through the MDGs has been noted to bring attention to neglected and underrepresented topics, giving them a sense of legitimacy on the international stage. However, as Fukuda-Parr & Orr (2014) argue, in the case of MDG #1, it did little to promote food security agendas. The hunger target grew out of a tension between two approaches; one inspired by international Development agendas set by the World Bank and OECD, which focused on agricultural productivity, and the other informed by the conclusions of the 1996 World Food Summit (WFS) (where the current food security definition was formed) and the 1992 International Conference on Nutrition (ICN), whose focus swayed towards nutrition and access (Fukuda-Parr & Orr, 2014, p. 150). The MGD’s effect on food security was considered minimal, the progress ‘off track’ for the first half of the time period (Fukuda-Parr & Orr, 2014, p. 151). Despite its acknowledgement in MDG #1, it wasn’t until the 2008 crisis that concrete food security frameworks were established, perhaps because of the competing approaches and the goals derived from combining hunger prevention with poverty eradication. Generally, the MDGs were criticized for fragmenting anti-poverty action and not addressing underlying causes of poverty, hunger, and inequality; Instead, they tended to fall in line with neoliberal policies that exacerbated these issues (Briant Carant, 2017; Fukuda-Parr & Orr, 2014).

The SDGs, though intended to improve weak points that hindered the MDGs, followed in the path of their predecessor through rearticulating neoliberal discourse of development (i.e. Development), with an added component of sustainability (Briant Carant, 2017, p. 28; Kumi et al., 2014). The issue of hunger has its own title in SDG #2, but with marginal differences from MDG #1; still focused on nutrition but now through a perspective of “people-, planet- and profit-based sustainability” (Briant Carant, 2017, p. 28). However, like its predecessor (and the issue of hunger in general), it is an interdisciplinary issue (Blesh et al., 2019, p. 2). The existing conversation around SDG 2 is grounded in a productionist perspective and has been criticized for overlooking

the root causes of food system crises, raising concerns about its suitability as a guiding framework for global and local action. However, while parts of the UN system have historically supported industrial agriculture, the UN also encompasses diverse initiatives, such as the UN Special Rapporteur on the Right to Food as well as the Committee on World Food Security (CFS), that mix civil society perspectives with private interests. Like the MDGs, the SDGs are likely to continue as a shaping force in international discourse and the priorities of governments, donors, and researchers (Blesh et al., 2019, p. 10).

Clearly, there are tensions within international discourse around food security. Diverging perspectives on the fundamentals of food production and the causes and solutions to food security are at fault. It is here that we can dive into these tensions and, more specifically, the critiques of mainstream food security agendas, as well as the concept itself.

2.4 Important Influences on Mainstream Food Security

Food security, in its present understanding, is grounded in the transitions of the mid-twentieth century. Namely, productivist motivations and rise of neoliberal economics and policy. This is the central point of concern for critics; the foundations of ‘food security’ are pieced together by a supreme faith in the market (Margulis & Hopewell, K., & Qereshniku, E., 2022, p. 336), a view that posits food as an interchangeable commodity (Noll & Murdock, 2020, p. 3), and the drive to transform agriculture into a profitable, ‘entrepreneurial endeavor’ (Byaruhanga & Isgren, 2023, p. 2). It is within this conceptual framework that MDG and SDG era food security projects were born, alongside a broader push by international actors for a ‘free-trade oriented food security paradigm’, otherwise understood as liberalization of food systems (Otero et al., 2013, p. 267). “Trade as Aid” and the move away from helping countries establish food self-sufficiency was motivated by neoliberal-supporting actors and the benefits that would incur from opening the agricultural markets (Kirwan & Maye, 2013, p. 98; Otero et al., 2013, p. 3). This free-trade-food-security model has in many ways exacerbated existing global inequalities and power dynamics. The exporting of surpluses (food export dumping, as it is sometimes referred to) can undermine smallholder farmers and existing local agriculture (Byaruhanga & Isgren, 2023, p. 8). Despite their massive contribution to worldwide food production, the cost of globalized farming has in many cases led to bankruptcies of rural farms, and the counterintuitive need for more food security

programming (Byaruhanga & Isgren, 2023; Noll & Murdock, 2020, p. 3). As Wittman (2023) puts it:

As part of the emergence of a globalized food system, many small-scale farmers and Indigenous communities across the globe found their traditional lands and livelihoods threatened, both by the influx of subsidized internationally traded commodities coming into local markets and the expansion of agribusiness into their traditional territories. (Wittman, 2023, p. 474)

The liberalizing of agriculture, fundamental to the neoliberalism and the twentieth century Development agenda had, to say the least, mixed effects on feeding the world (Baylis et al., 2019; Fan et al., 2024).

Another point of criticism, un-linkable from neoliberalism in its functions, are the Malthusian ideals that shaped the first formations of food security interventions. The Malthusian model essentially links population and living standards through two main ideas; higher incomes lead to faster population growth and larger populations, in turn, reduce living standards due to limits on fixed resources like land. This relationship had historically explained population and income patterns up until the Industrial Revolution. However, this model has proven itself outdated. Firstly, wealthier countries typically see falling, not rising, population growth. Secondly, although large population sizes do produce societal straining, there are often other instigators of societal issues that have nothing to do with limited resources (Weil & Wilde, 2010, pp. 1–2). The idea in line with this model, however, would posit that an increased production of food is needed to feed an increased population. This is another foundational block of mainstream food security, the necessity of increased agricultural production (Mooney & Hunt, 2009, p. 474). This ideal remains steadfast, although the WFS definition acknowledged other drivers of food insecurity besides availability, and many have explained that it is problem (Oteros-Rozas et al., 2019; Shepherd, 2012). A fear of a growing population acts as a strong justification for production and growth in agriculture which, unsurprisingly, falls well in line with neoliberal perspective on food security. Similar criticism has been given to the UN goals on ending hunger, which frame policy strategies as short term, measurable actions, displacing the long-term systemic problems driving hunger from the conversation (Fukuda-Parr & Orr, 2014, p. 154).

There are two important developments that further explain how neoliberalism shaped food security; the Green Revolution and financialization of agriculture. They also reveal some major faults in the fundamental thinking of food as a commodity, production as most important, the market as a leader, and, central to this thesis, (and which frames interventions as short-term and measurable) technology as a magic wand (Margulis & Hopewell, K., & Qereshniku, E., 2022). Neoliberalism shaped not only food security policies, but also fundamentally changed the formation of the food system. This can be understood through Food Regime Theory, which posits that, much like (and in line with) hegemonic trends, the constellation of and control over the production, distribution, and control of food follow patterns of organization that relate to geopolitical power structures

One of the major developments of the second half of the twentieth century, and towards the end of the second, or US food regime, was the ‘Green Revolution’. The Green Revolution, or the third agricultural revolution, refers to the technological developments in the 1970s of fertilizers and seeds that reshaped agriculture practices and industry. The Green Revolution was underpinned by the adoption of High Yielding Varieties (HYV) of crops, as well as ‘input packages’ that included other products like fertilizers (Dalrymple, 1974, p. 6). Previously, ‘crop improvement’ was only focused on non-food crops used as raw materials, like sugar, but as the production of wheat, rice, and maize had an uptake in the post WWII era, so did an interest in their breeding research (Gollin et al., 2021, p. 7). Simultaneously, internationally funded International Agricultural Research Centers (IARCs) were created and, in light of the geostrategic role of the production and exportation of these staple crops, as well as Western fears of communism and the growing popularity of agrarian reforms in South America, the US unsurprisingly supported this research (Gollin et al., 2021, p. 8). In 1948 Mexico the first HYV was released, a rust-disease resistant wheat, and a rapid adoption followed leading to these inputs covering 90% of the country’s land after just 12 years (Dalrymple, 1974, p. 7). Eventually, these initiatives spread, primarily through Latin America and South/East Asia. These changes in breeding increased yield, and classical development economists argue that without it, targeted countries would have been set back by decades in GDP growth and income per-capita, and would have seen major increases in population (Gollin et al., 2021, p. 34). Additionally, increased production created more employment and drove down food prices (Harwood, 2012, p. 118).

Green revolution technology provided a means of producing more agricultural outputs with the same inputs. However, it came with fundamental changes to farming. The HYV seeds were not stand-alone products, rather they required a full ‘input package’ of fertilizers, and improved management of water, weeding, seedbed preparation and pest control in order for the varieties to be effective (Dalrymple, 1974, p. 37). This was because HYVs were much more finicky and difficult to grow. These practices came with effects to the environment as well. Pesticides often seeped into water sources, crops required more intensive water usage, and the required inputs of fertilizers and pesticides changes the composition of the soil (John & Babu, 2021, pp. 2–3). Although these inputs increased nutrients needed to grow crops in the short term, they resulted in the degradation of organic soil matter (John & Babu, 2021, p. 3; Yanai et al., 2022). Additionally, these implemented monocultures (land used to grow just one crop) changed natural soil properties (John & Babu, 2021, p. 3) and, as HYV were designed to be monocultures, they did not perform well in traditional, mixed crop cultivation (Harwood, 2012, p. 122). In fact, many Indigenous crop varieties were lost or came to be endangered, pushed out by HYVs (John & Babu, 2021, p. 3). A few decades later, as the US and other countries rewrote patent laws and genetically modified organisms started being widely produced, seeds that were developed as food security measures, like “golden rice”, became intellectual property (in other words, were patented), overriding motivations for the public good (Barton & Berger, 2001). Therefore, a result of the Green Revolution was a new dependence of small farms in ‘Southern’ states on seeds and tools that must be purchased, and the degradation of natural agricultural systems.

The motivation for developing these technologies was exogenous to the context they were implemented in. As we have seen, trade aspirations and geopolitical fears underlaid much of the food security projects of the era, and though the humanitarian endeavors and Development goals of poverty alleviation and food security gave the Green Revolution justifications, critics still point out its political motivators (Harwood, 2012, p. 116). As Harwood (2012) argues, poverty alleviation was never really a goal of donor agencies:

Despite all of the rhetoric about alleviating hunger, the major aim of the programmes’ donors was instead to ‘modernize’ Third World economies. In the 1950s development economists – and many Third World governments – thought agriculture to be an unlikely engine of growth because ‘traditional’ farmers were believed to be unresponsive to

economic incentives. It would be better, it was thought, to concentrate upon promoting industrialization (Harwood, 2012, p. 119)

As it was, these packages were often taken up by large landowners or small but well-resourced farmers, leaving the landless poor and rural populations worse off. The introduction of Green Revolution technology ultimately served to deepen the divide between wealthy and poor rural populations (Harwood, 2012, p. 119). What can also be recognized is the benefit this phenomenon had to businesses producing ‘input packages’ products. Seed, fertilizer, pesticide (among other) businesses gained new markets and were backed by both research and humanitarian institutions. The newfound role of agribusinesses has only grown since.

As the second food regime fell into crisis and neoliberal policies and deregulation grew, so did the long-term consolidation of the agricultural industry. Additionally, deregulation also drastically changed the shape of agricultural markets and financial interactions. Rather than investment and financial return being based solely on the actual production of agricultural products, both started occurring due to financial activities. This is a process that has been called *financialization*. According to Epstein (2005), “financialization means the increasing role of financial motives, financial markets, financial actors and financial institutions in the operation of the domestic and international economies” (Epstein, 2005, p. 3). As they argue, the 1980s presented a major structural shift after which gains by financial corporations and from financial instruments (collected by a minority) jumped dramatically. In part, this can be attributed to the ways in which financial instruments distort, based on classical economics, the global trade market; speculation shifts exchange rates, thereby making it easier for countries to run trade deficits (or surpluses) and subsequently delegitimize the arguments of free trade and competitive advantage, which say that markets will inevitably balance themselves out (Epstein, 2005, p. 8).

As agricultural commodity markets were deregulated and new, complex financial instruments introduced, the agrifood sector transformed into a “new arena for profit accumulation” (Clapp & Isakson, 2021, p. 180). For this process, as Clapp and Isakson (2021) explain, “the cultural and physical qualities of food, agriculture and farmland must be transformed and recast into financial values that are of interest to investors, and the regulatory environment needs to be shaped in ways that enable those investments” (p. 160). Index funds and derivative investment tools have allowed

speculation to enter agricultural markets, sometimes influencing prices. For example, investments could be the speculations of rainfall sold as futures (often advertised as “insurance” for farmers) or of returns on purchased farmland (Bjørkhaug et al., 2018, p. 1; Clapp & Isakson, 2021, p. 180); the integration of financial markets and agriculture has been linked to food price volatility and noted as a risk to food security (Venegas et al., 2024). In fact, economists have attributed speculation as a driver of the food price shocks during the 2008 crisis (Bjørkhaug et al., 2018, p. 3). Financialization of agriculture fundamentally separates its financial activities from real-world activities, a form of “distancing” that makes it difficult to pinpoint responsibility for negative social and ecological consequences and complicates efforts to address them (Clapp, 2014; Clapp & Isakson, 2021, p. 800). This process prioritizes profit from financial instruments and shareholder value, subsequently encouraging further corporate consolidation, and ultimately exacerbating existing inequalities (Clapp & Isakson, 2021, p. 182).

Changes marked by neoliberalism and the corporate food regime extend to the ways in which food is understood, particularly in the ‘Global North’. Scholars, like McMichael and Campbell, have identified a central tension between two distinct yet coexisting food systems: “food from nowhere” and “food from somewhere” (Campbell, 2009, p. 311). ‘Food from nowhere’ refers to cheap, conventional, industrially produced food that is detached from its place of origin, reflecting the globalization and commodification of agriculture. In contrast, ‘food from somewhere’ represents place-based, often organic, higher priced food that emphasizes local identity and environmental sustainability (Krausmann & Langthaler, 2019, p. 92). As McMichael (2009) explains,

Just as the dynamics of the previous regimes centered on tensions between opposing geopolitical principles colonial/national relations in the first, national/transnational relations in the second, so the corporate food regime embodies a central contradiction between a ‘world agriculture’ (food from nowhere) and a place-based form of agro-ecology (food from somewhere). (McMichael, 2009, p. 147)

I would argue that this is another form of distancing; like financialization, complex intermediary spaces have been created, opportune for-profit accumulation, that obscure the connection between food production and distribution and the markets, money, and motives that are now their

intermediaries. Within this nowhere/somewhere tension lies the contradictory way food is understood and desired, and the responsibility for environmental and social degradation.

Food security within the corporate food regime has also shifted. Under this regime, food security has been inherently redefined as the *ability to buy food*, rather than a right to access to it (Krausmann & Langthaler, 2019, p. 92). This paradigm of global food security, based on increasing production, increasing purchasing power, and innovating technologies to do so, reinforces the corporate food regime (Claeys et al., 2021, p. 240).

2.5 Framing Food Security

How can one make sense of the tensions within the history of food security? By looking at which *frames* are deployed. As will be discussed in further detail in this thesis, a frame is characterized by the particular aspects of a topic included, and those conversely which are excluded, that affect the way the topic is presented to an audience (Entman, 1993, p. 52). This presentation subsequently assembles what the causes and solutions of a problem are. Food security appears at first glance a ‘consensus frame’ – a broadly accepted term with universal support and shared values (Gamson, 1995 in Mooney & Hunt, 2009, p. 470). However, as Mooney and Hunt (2009) argue, behind the apparent consensus lies different definitions and contested ownership of ‘food security’ (p. 470). They distinguish frames of food security as hunger, as community development, and as risk of industrial food system (Mooney & Hunt, 2009, p. 472), each presenting a different constellation of problems, causes, and solutions. Within these frames, there are differences as well. For food security as hunger, there exists both a ‘flat’ and ‘sharp’ key (as they call it); the former positions the problem as not enough food while the latter places access to food as the problem (Mooney & Hunt, 2009, p. 471). The cause of not enough food is too little production, meaning the solution is agricultural intensification. The cause of no access to food is unjust social systems and the solution is more democratic governing. As they state, “the mainstream flat key tends to be associated with high technology, globalizing, and individualizing tendencies; while the sharp key is more critical, oriented toward regional self-sufficiency, and committed to low-technology solutions” (Mooney & Hunt, 2009, p. 478).

This epistemic distinction has followed food security since the post-war era. Fukuda-Parr and Orr (2014) argue that MDG indicators worked to frame food security “as a commonsense issue of

supply and production, favoring quick and measurable gains in supply and production as the key solution, and marginalizing the complex socio-economic determinants and the human development and human rights priorities of distribution, discrimination, inequitable access, and lack of voice and autonomy” (p. 157). In this view, hunger and food insecurity are separated from systemic problems (Fukuda-Parr & Orr, 2014, p. 157). Shepherd (2012) argues that the current FAO definition of food security frames the issue without actors and as an economic problem; there are no specificities to who is responsible and who is at risk (p. 198). They argue that hunger is in fact a *security* issue, though it is not treated as such, rather,

The commandeering of food-security language helps explain the contradiction that, while it is ostensibly about hunger (achieving sufficient food for 'all people at all times'), food security has instead become a game for powerful actors competing for advantage (profit or scarce resources such as agricultural land) in an increasingly resource-constrained world (Shepherd, 2012, p. 198).

They propose instead to think of hunger from an emancipatory security perspective, and reframe it “in terms of securing vulnerable populations from the structural violence of hunger” (Shepherd, 2012, p. 198).

The point here is to show that through its long history and evolution, the problems characterizing food security, their causes, and their solutions have varied. The arguments constructed by different actors take on different angles to the topic; from each angle only certain things are illuminated, from each vantage point one can only see what is in view. Hence, food security, with its hodgepodge of definitions and motivations, is fickle. Discourse on food security, hunger, and feeding the world cannot be taken as a standard. In the following section, so-called alternative conceptions to food security will be discussed, illuminating further the competing visions of food systems.

3. Food Movements

In their formulation of a third, corporate food regime, McMichael (2009) highlights a central contradiction between ‘world agriculture’ and a localized, culturalized, agriculture, otherwise expressed as ‘food from nowhere’ and ‘food from somewhere’. Within this tension, *food sovereignty* is positioned as the resistive force to the dominating regime. Food sovereignty can be understood primarily as a political movement, and secondarily as an epistemic shift. In this chapter, I detail out the origins of food sovereignty, its goals and its crucial components, as well as other important movements around food system transformations. Then, I will engage with food sovereignty as an epistemic shift and the critical debates it instigates. Reflections on these ‘alternatives’ to the corporate food regime and status quo are needed to contextualize food security not only within historical developments, but larger discourses on food systems.

3.1 History of Food Sovereignty

Food sovereignty, at its core, is a vision of a food system without imposed motivations and exploitation, and with agency and equality. La Via Campesina, a transnational grassroots organizational network and long-term proponent, popularized the term *food sovereignty* at the 1996 World Food Summit and defined it as follows:

The right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. It puts the aspirations and needs of those who produce, distribute and consume food at the heart of food systems and policies rather than the demands of markets and corporations. (La Via Campesina, 2021)

In the face of the constraining definitions and interpretations of food security, food sovereignty arose as an ontological alternative to the neoliberal framework that has guided international dialogue and agricultural initiatives (Claeys et al., 2021, p. 238; Misra, 2018, p. 483; Mooney & Hunt, 2009, p. 478). Rather than focusing solely on access to (already produced and distributed) food, food sovereignty has a stake in *how* it is produced and asserts the rights of communities to make this decision, instead of leaving it to markets, corporations, or governmental institutions, with a particular emphasis on production means that work with natural ecosystems and traditional

and Indigenous farming techniques (Carolan, 2018, p. 15; Misra, 2018, p. 483; Ume et al., 2025, p. 3).

During the Nyéléni Forum on Food Sovereignty in 2007, around six hundred people came together to discuss and shape the concept of food sovereignty, representing “family farmers, Indigenous peoples, landless people, migrants, pastoralists, forest communities and artisanal fisherfolk, as well as civil society organisations, academics and researchers, rural workers, youth organisations, consumers, environmental and urban movements from more than 80 countries” (*Declaration of Nyéléni*, 2007; Pimbert, 2009, pp. 6–7). This resulted in an agreement that food sovereignty is grounded in six key pillars: prioritizing food for people, valuing food providers, localizing food systems, placing control in local hands, fostering knowledge and skills, and working in harmony with nature (Claeys et al., 2021, p. 238).

3.2 La Via Campesina and the Start of the Movement

La Via Campesina arose in Latin America as a successor to the many politically-affiliated peasant organizations during the import substitution era, which offered little in the interest of rural communities (Martínez-Torres & Rosset, 2010, p. 152). As neoliberal policies and trade arrangements reduced agricultural prices and put strain on ‘Southern’ producers, a new generation of organizations were born, who saw international actors as perpetrators. As Martínez-Torres & Rosset (2010) explain:

The organisations developed a political analysis that identified transnational corporations and international finance capital as driving forces behind the WTO, World Bank, International Monetary Fund (IMF), and free trade agreements, and it therefore became imperative to organise themselves at a supra- or transnational level. (Martínez-Torres and Rosset, 2010, p. 153)

In Latin America, the Coordinadora Latinoamericana de Organizaciones del Campo (CLOC) was founded in the early 1990s to coordinate struggles against the new neoliberal model, as it was there that income inequality and living standards were severely impacted by neoliberal policies. A campaign entitled the “500 Years of Indigenous, Afro-descendant, Peasant and Popular Resistance Continental Campaign” helped articulate the basis of a transnational peasant movement, drawing on the symbolism of Columbus's arrival in the Americas and James Scott’s concept of ‘moral

economy'. Scott (1976) argued that peasants had a 'right to subsistence', which could not be infringed upon by States or elites, and traditionally the relationship between these two groups ensured this right under moral obligations (James C. Scott, 1976, p. 33). Within the moral economy, "community economic relations are based on the logic of reciprocity and production for subsistence" (Martínez-Torres & Rosset, 2010, p. 154). The CLOC represented an expansion of these small Latin American movements, allowing them to gain political influence. Simultaneously, peasant and family farm organizations in India, Europe, and North America were recognizing the need for a transnational struggle to challenge neoliberalism (Martínez-Torres & Rosset, 2010, p. 156). La Via Campesina emerged as waves of peasant discontent and mobilization crested into the international arena, connecting into a transnational social movement in what scholars have called a 'globalization from below' (Martínez-Torres & Rosset, 2010, p. 156). The concept of 'globalization from below' sits in opposition to the corporate-led, elite, 'globalization from above' (Edelman, 2001, p. 304), bringing both agency and visibility to those actors who do the material labor that underpins a global (food) system.

After a meeting in Managua, Nicaragua, where peasant and farm leaders from Central America, the Caribbean, North America, and Europe agreed that an alternative to the neoliberal model with peasants at its core was desperately needed, La Via Campesina was formally established in 1993 (Martínez-Torres & Rosset, 2010, p. 157; Nicholson & Borras Jr., 2023, p. 1). The name "La Via Campesina" means "the peasant way", and honors the significant role of Latin American organizations, as well as the importance of peasants to the movement.

Using the term "peasant" has given it a new resonance in the modern lexicon, which groups diverse actors (like those at the Nyéléni Forum) into a collective movement and identity. This is done by emphasizing common concerns and deemphasizing points of divergence, in a way that focuses more on the oppositional 'them' rather than the parameters of the 'we' (Edelman, 2013, p. 10; von Redecker & Herzig, 2020, p. 661). As Martínez-Torres & Rosset (2010) put it, "the attempt to (re)create, maintain, and strengthen a peasant identity is a key cultural 'glue' that helps hold La Via Campesina together. There is a conscious sense of building a 'farmer pride'" (Martínez-Torres and Rosset, 2010, p. 166).

Activists use "peasant" and other terms interchangeable, depending on the context; "Campesino" and "farmer" are the most common, though particular distinctions exist, like between "family

farm” and “peasant” in Latin American context. Particularly, “La Via Campesina’s definition of ‘Peasants’ includes people who till the land to produce food, the fishers, the pastoralists, the farmworkers, the landless, the migrant workers, the Indigenous people, rural workers - of diverse identities, gender and age groups” (La Via Campesina, n.d.-a), while “family farmer” relates more to agricultural production as a means of reproduction, or in the form of a small business, as common in the ‘Global North’ (Martínez-Torres & Rosset, 2010, p. 150). As food sovereignty supporters challenge dominant development paradigms, like market liberalization and large transnational corporations, the peasantry defines itself as ‘distinctly different’ from these interlinked practices (Mann, 2015, p. 446).

The movement’s fluidity allows for context-specific practices based on local power dynamics and social structures, and is becoming increasingly more involved with Indigenous peasant movements (Motta, 2021, p. 607). Feminist principles and gender equity have been a theme since its founding and, as Calvário and Desmarais (2023) show, women have been central to the movement from its inception, advancing feminism through the creation of autonomous spaces, the implementation of parity politics, and the integration of a gender lens into its analyses and proposals. This has taken the form of a feminism from below—a praxis aimed at dismantling gendered power relations and addressing gendered divisions of labor (Calvário & Desmarais, 2023, pp. 647, 650).

As a political movement, food sovereignty implies the *rights* of individuals, communities, and nations to define their own markets, systems, cultures, and environments; control over agricultural, labor, fishing, food, land, and water policies; over food production, over domestic markets and aid inputs and imports, over natural resources (Mann, 2015, p. 449; Pimbert, 2009, p. 7). It strongly opposes surplus and aid dumping, distortion of agricultural prices, patents on seeds or living organisms, and the concentration of power by transnational corporations (Beuchelt & Virchow, 2012, p. 262). It aims to redistribute power and decision making over food systems to farmers and peasants. In their own words:

Food sovereignty promotes transparent trade that guarantees just incomes to all peoples as well as the rights of consumers to control their food and nutrition. It ensures that the rights to use and manage lands, territories, waters, seeds, livestock and biodiversity are in the hands of those of us who produce food. Food sovereignty implies new social relations free

of oppression and inequality between men and women, peoples, racial groups, social and economic classes and generations. (La Via Campesina, n.d.-b)

The social movement and its advocacy have translated into the adoption of the concept of food sovereignty into various laws, decrees, or frameworks governing agriculture and food security. Ecuador established it as a constitutional right in 2008, and it is a component of Brazil's 'Zero Hunger' policy and Indonesia's Food Law. Regional bodies have also integrated food sovereignty, like the 2002 European Parliament resolution, the 2005 ECOWAS Agricultural Policy, and the 2012 OAS Declaration of Cochabamba on Food Security with Sovereignty (Vergara-Romero et al., 2022, p. 1141; Wittman, 2023, p. 476). They have also been successful in implementing institutional reforms at the international level which, although uncertain if they will translate into concrete policy changes, are significant achievements with the potential to reshape the political landscape. The organization contributed to the 2009 reform of the Committee for Food Security (CFS) and the 2012 adoption of the Voluntary Guidelines on the Responsible Governance of Tenure (VGGT). It was also instrumental in securing the UN Declaration on the Rights of Peasants (UNDROP), a process that took seventeen years of advocacy with allies before its adoption by the UN General Assembly in 2018 (Nicholson & and Borras Jr., 2023, p. 2).

3.3 Agroecology

Though democratic processes and a restricting of power are central to food sovereignty's method of change, some agricultural practices have become commonly connected with the movement. One such practice is agroecology.

The underlying principle of agroecology is to "leverage biological processes"; often this is done through utilizing traditional or Indigenous practices within agriculture (Caquet et al., 2020, p. 9). Agroecology is a dynamic movement, practice, and discipline, ranging in its adoption and application. It applies ecological principles to agriculture and so seeks to establish agricultural practices within and through the relationships of living things and the environment.

As Wittman (2023) puts it:

As a *science*, agroecological research draws on insights from rural and environmental sociology, agronomy, gender studies, political science, ecology, and many other disciplines

to understand agriculture and food systems as integrated social and ecological processes. As a *movement* linked to food sovereignty, agroecological approaches to food production emphasize the importance of polycentric governance systems, with clear linkages between different scales of decision-making and different nodes of the food system. (Wittman, 2023, p. 477).

Additionally, as a *practice*, it redesigns farming and food systems around biological processes, diversity, and fairness through reducing reliance on external inputs, enhancing resilience, and integrating production with local economies (Caquet et al., 2020, p. 8). To guide the framing, defining, and implementation of agroecology, the High Level Panel of Experts (HLPE) on Food Security and Nutrition (advisors to the FAO's Committee on World Food Security) outlined 13 principles. They hinge upon three themes: improving resource efficiency, strengthening resilience, and securing social and equitable responsibility (Zaremba et al., 2021, p. 2). The HLPE principles show that agroecology is both about endeavors like reducing agrichemicals, in addition to self-determination and reclaiming food, land, and bodily autonomy from a profit-driven industrial agricultural system (Zaremba et al., 2021, p. 3).

Agroecology is often an integral component of the general food sovereignty platform. It works to redefine food systems to prioritize self-determination and autonomy for producers and consumers alike and center their relationship to land and nature and traditional knowledges. It subverts exploitative industrial agriculture and challenges corporate control by reducing dependence on external inputs and promoting local, diverse, and ecologically sustainable practices. Crucially, it centers social justice and equity, valuing local and Indigenous knowledge, fostering farmer-to-farmer exchanges, and ensuring participation and leadership from marginalized groups, including women, in shaping their food systems (Martínez-Torres & Rosset, 2010, p. 168; McKay et al., 2024; Zaremba et al., 2021).

For example, Khanal & Thapa (2023) describe how agroecological practices could advance food sovereignty and sustainability in Nepal, reversing the damage caused by past policies centered on external inputs and commercialization. The result of these past policies has been degraded resources, eroded Indigenous knowledge, and food import dependencies despite rich natural assets (Khanal & Thapa, 2023, p. 51). Agroecology is presented as a means to build resilient, self-reliant food systems through policy and planning that considers social needs as well as the natural

environment (Khanal & Thapa, 2023). Given Nepal's fragile mountainous region and severe rainfall, and the natural ecological diversity, it is prone to landslides, excessive runoff, and infrastructure damage (Khanal & Thapa, 2023, p. 52). Using frameworks like 'spatial bioengineering', agroecological approaches would promote the management of land by, for example, building structures like ponds or water collection systems to manage water resources, or terraces to prevent erosion (Khanal & Thapa, 2023, p. 58). Managing at the 'micro' level also allows for habitat mosaics to be created; this creates ecological niches featuring diverse crop types, which "enhances the landscape's carrying capacity, while also providing shelter for productive and supportive ecosystem services such as pollinators and natural enemies of pests, through the land-sharing approach" (Khanal & Thapa, 2023, p. 59). Overall, the agricultural landscape and social communities could be more resilient and self-sustaining.

More critical approaches to agroecology have arisen, taking on the task to approach farming practices from specific perspectives. One such is feminist agroecology, which approaches agriculture particularly from the perspective of women smallholder farmers. Feminist agroecology, as well as food sovereignty, are "critical frameworks for addressing systemic injustices in contemporary agrifood systems. Rooted in the principles of local control, environmental sustainability and social justice, these approaches challenge dominant paradigms that marginalise smallholder farmers and perpetuate gender inequalities" (Ume et al., 2025, p. 3). As such, many scholars, as well as members of La Via Campesina, call for feminist perspectives, agroecology, and food sovereignty to be well integrated for food systems transformations.

As agroecology approaches are bottom-up and small-scale centric, it is often assumed to have transformative power and include feminist approaches. However, as Zaremba et al. (2021) notes, the realization of the transformative potential of agroecology is not automatic and it is with necessity and intention that feminist agroecology must become explicit in agroecological paradigms (p. 4). They examine the 13 High Level Panel of Experts (HLPE) on Food Security and Nutrition principles from this perspective, highlighting where gender needs particular consideration. For example, differences in gender roles and norms, or disparity in decision making power, and access to resources must be illuminated and considered. Notably, Principle 5, Biodiversity, if ensured through feminist agroecology, would acknowledge the common exclusion

of women from decision-making on biodiversity issues and the evidence that greater equity results in better conservation outcomes (Zaremba et al., 2021, p. 7).

Perhaps the best way to illustrate this integration of feminist agroecology and food sovereignty as a critical framework is with an example of it in practice. In their research on a group of women farmers Southeastern Nigeria, Ume et al. (2025) show how such frameworks can be put into practice. Their study followed a group of women farmers, called the Agroecology Group, who created a parallel food system to the corporate one within the country. Their collaboration as a group pooled resources, shared land, and fostered organic farming practices, which allowed for diverse crops on their combined plots, more effective farming, and reduced costs and reliance on fertilizers (p. 8). They conceptualized finances in alternative ways; the members established a local market in which they created a barter food system for direct exchanges of crops between members, without the need for money, but with the opportunity to acquire more food sources (p. 8). They also had a system of monthly contributions, which provided an opportunity for members to acquire resources without relying on loans or aid (p. 9). The consequences of these practices were greater food security, independence, and sustainable systems. As the authors conclude:

They enacted the transition from individualistic, profit-maximising food systems to a collaborative system with practices including: resource pooling, tool sharing, and product bartering, all of which serve as evidence of the efficacy of non-monetary transactions within farming economies. (Ume et al., 2025, p. 14).

The emphasis on equity, autonomy, and leveraging both biological processes and *community* processes fostered an alternative, extremely localized system for the farmers involved. Ultimately, the use of feminist agroecology helped assert food sovereignty; fundamental systemic change grounded in justice, sustainability, and autonomy.

3.4 The Spectrum of Food Movements:

There exists a spectrum of trends, practices, and approaches towards food systems and hunger management. It is worthwhile to examine and compare some of these trends as they appear in practice and discourse, since they inform debates on food and highlight the different factors at play. How these movements manifest, which contexts they can be applied to, and their effects show us further the complexity of food systems transformations. In addition to food sovereignty and

food security, the human right to food, food justice, and food democracy emerge as variations on guiding paths for agriculture and food systems and will be briefly laid out in the following section.

The Right to Adequate food (RtAF) is an adjacent conceptualization of food security, initially conceived of in Article 25 of The Universal Declaration of Human Rights in 1948. Officially, it was first recognized in the 1966 International Covenant on Economic, Social and Cultural Rights (ICESCR), which came into force in 1976 with a detailed framework. Adopted by 160 countries, it established both international and national legal recognition to the right to adequate food and freedom from hunger, making core obligations of the Right to Food legally binding (Beuchelt & Virchow, 2012, p. 266; Milian Gómez, 2024, p. 589). According to the ICESCR declaration, the right to adequate food is not just about obtaining the minimal daily nutrition requirements, but “is realized only when each individual has physical and economic access to adequate food or to the means to procure such food” (Beuchelt & Virchow, 2012, p. 266). These means must be produced in sustainable and dignified ways, though what counts as such means, whether through self-production of food, income generation, or a combination, is left open to interpretation (Beuchelt & Virchow, 2012, p. 266; Milian Gómez, 2024, p. 590). Rooted in a state-centric approach, it emphasizes government accountability to respect, protect, and fulfil this right through laws, policies, and programs, addressing the structural barriers that prevent people from producing or affording adequate food (Claeys et al., 2021, p. 241).

In Nepal, the RtAF has been a constitutional right since 2015 and operationalized through the 2018 Right to Food and Food Sovereignty Act, and its subsequent 2024 Regulation (Koirala et al., 2024, p. 118). These legal frameworks outline provisions for identifying food-insecure households, providing targeted food distribution, protecting farmers, and establishing food planning and storage systems. However, significant challenges remain, including insufficient financial resources, shortages of technical manpower, issues with policy coherence across government tiers, and the influence of cultural and political factors that can hinder effective realization (Koirala et al., 2024, p. 124).

As Gomez (2024) argues, the RtAF’s dual components of adequate food and freedom from hunger provide it with a strict, limited framework to be used as a legal tool. They advocate for it to be thought of, rather, through a four-fold interpretation which aims to unify previously separate concepts and encompass not only the minimum essential food requirement and the right to

adequate food, but also integrate dimensions of food security (availability, physical/economic access, utilization, and stability) and the principles of food sovereignty (sustainability, locally controlled production, and traditional knowledge) (Milian Gómez, 2024).

In comparison to food sovereignty, the RtAF is much broader, encompassing the components of food sovereignty but not specifically demanding them. For example, the RtAF does not address the problems of a food system or its transformation, but if this system leads to poverty, hunger, and the marginalization of smallholder farms, then the RtAF calls for its reform (Beuchelt & Virchow, 2012, p. 268). Initially, agrarian movements were skeptical of the right to food due to its reliance on liberal state interventions (Claeys et al., 2021, p. 241). However, in spaces where food sovereignty is seen as too controversial, the RtAF is usually accepted. This leads to food sovereignty advocates' ability to engage within institutional processes, though they also risk co-optation and depoliticization of their efforts (Claeys et al., 2021, p. 241). Still, the Right to Adequate Food provides a legitimacy that is very useful. As a legal concept, it holds more weight than others, and it emphasizes accountability (Mann, 2015, pp. 457–458). As Beuchelt & Virchow (2012) argue, a benefit of the RtAF framework is its legal legitimacy:

Wherever the right to adequate food is embedded in national law, individuals as well as groups can bring their cases of neglect, discrimination, social, economic and ecological marginalization to court, and bring charges against the government. Although now powerless, marginalized people can be enabled to change the politics of a country through the legal enforcement of the human right to adequate food. (p. 271).

However, scholars often conceive of the right to food not as a separate movement or concept, but rather one that functions and exists in tandem to food sovereignty or food security (Beuchelt & Virchow, 2012; Byaruhanga & Isgren, 2023; Claeys et al., 2021; Clapp et al., 2022; Fairbairn, 2012; Koirala et al., 2024; Mann, 2015; Wittman, 2023).

Other influential movements include *food justice* and *food democracy*. Both are primarily geographically dependent, having gained prominence in particular places (Claeys et al., 2021, p. 239). Food Justice, for example, is heavily contextualized in the 'Global North', especially North America, and is ingrained in struggles against hierarchies of race, class, gender, and geography and how they shape access to and control over food systems. The concept originates in grassroots and community activism (in the United States) and often focuses on dismantling structural racism

and economic inequality in food systems (Claeys et al., 2021, p. 245; Gottlieb & Joshi, 2010). Food democracy refers to structuring the food system in ways that enable communities to actively engage in decision-making. Predominantly discussed in the United States and the United Kingdom, it encompasses initiatives such as farmers' markets, community-supported agriculture, food policy councils, and urban farming (Lang, 1999; Carlson & Chappell, 2015, as cited in Claeys et al., 2021, p. 245).

3.5 Food Sovereignty as an Epistemic Shift

In addition to its literal shaping of policy and political events, food sovereignty advocates for and represents an epistemic shift, an entirely new conception of food systems. A key functioning of this episteme is to act as a counter force to the hegemonic ideas. Unlike other movements and ideas around food systems, which act in reformist or progressive manners, food sovereignty is *radical*, in that it seeks to change not only the mechanisms of the food system, but the structural conditions within which they operate; it is anti-capitalist, anti-imperialist, anti-corporatist (Holt Giménez & Shattuck, 2011, p. 116). Thus, particularly in the context of Food Regimes Theory, it is a novel agricultural episteme. Some scholars articulate the current food regime through the tensions of Marx's *metabolic rift*, and food sovereignty as its reverse. The metabolic rift is the extreme departure of society from nature, of production from the earth, or as Foster (1999) puts it, "the material estrangement of human beings in capitalist society from the natural conditions of their existence" (Foster, 1999, p. 383). McMichael (2009) argues that this rift informs the epistemic foundations of how we understand agriculture today, as a commodity and value production (McMichael, 2009, p. 162). Food sovereignty is based upon an opposition to the neoliberal model of food systems and, more profoundly, to this irreparable rift (McMichael, 2009). As such, its ability to fundamentally change practices is presented as a counter-hegemonic force, aligning itself with emancipatory politics and post-growth agendas, which build and stabilize counterhegemonic currents (Raina & Kachroo, 2024, p. 907). For FRT framework and the corporate food regime, food sovereignty also represents the oppositional force, the 'food from somewhere', and the counterpart to a productivist world food system (McMichael, 2009, p. 147).

3.6 The Relationship between Food Sovereignty and Food Security

If food sovereignty is the oppositional force to the current food system and regime, is it a partner or opposer to food security? As food security has been a component of mainstream Development and used as a justification for national or corporate interests, the food security agenda is understood as upholding these pursuits. Consequently, food security and food sovereignty are often positioned in opposition. However, rather than being an alternative to food security, food sovereignty and other food movements are alternatives to current food systems, and the ideas about what causes and solves food insecurity. To better understand this nuance, an exploration of the relationship between food sovereignty and food security is needed.

A few key, theoretical differences exist, primarily contingent upon the political-economic background of food security. When food security and food sovereignty are put into relation, usually differences are highlighted based on critiques of the neoliberal foundation of food security, which has been detailed in the previous chapter. Food sovereignty emerged as a counter movement to the current regimes and as such it has inherently positioned itself in opposition to neoliberalism (Martínez-Torres & Rosset, 2010, p. 153). If food security is contingent upon the neoliberal model, food sovereignty must be in opposition to it. Many have noted this seemingly stark dichotomy between the project of food security and the project of food sovereignty, even noting that food sovereignty's rejection of agricultural production often works to delegitimize food security efforts (Jansen, 2015, p. 215). However, scholars also have noted that this dichotomy is understood as such primarily within the context of neoliberal Development and food systems. The conflict arises because of inherent different ideas in how food should be produced (Mann, 2015, p. 449). Nevertheless, some scholars have argued that it is not simply the modes that causes the conflict, or, like Noll and Murdock (2020) say, it is not just about "market-based mechanisms, but concern[s] competing conceptions of justice" (Noll & Murdock, 2020, p. 12). In that vein, the inherent difference is that food sovereignty places food injustices at the center of food systems (Fairbairn, 2012, p. 227). However, food security itself, as a conceptual tool, is not necessarily inherent to neoliberalism, unlike its character in practice. Some scholars and actors argue that true food security, based on its definition, is an aim only achievable *through* food sovereignty. Mann (2015) notes that "in emphasising the rights of producers, food sovereignty is a precondition to achieving the right to food and food security" (Mann, 2015, p. 458). In this sense, food security

has been *used* by the neoliberal (or corporate) models of agriculture rather being inherent to them. Humanitarian, progressive, or even radical ideas for food security and peace through food have been co-opted into agriculture and food for capitalist accumulation. It is here that critics, like Friedmann (2016), find fault with the constructing of the corporate food regime as a static, ultimate contradiction between ‘nowhere’ and ‘somewhere’, justice and injustice, since “it leads to the folly of assuming that capitalism cannot adapt again” (Friedmann, 2016, p. 675). Time and again radical, new, and oppositional movements have been co-opted by dominating forces, capitalism and hegemony, to dull their effect and extend dominating reigns of control.

Take agroecology; its real applications and interpretations have ranged widely and strayed from its core values. Caquet et al (2020) call this “weak” agroecology, in contrast to “strong” agroecology, where the former “maintains continuity with current systems, neither advocating for a qualitative leap in the efficiency of the use of inputs, nor explicitly calling to replace them with biological processes” (Caquet et al., 2020, p. 9). This is most often seen related to terms like ‘smart agriculture’ or ‘sustainable agriculture’. Indeed, scholars and activists engaged in food system transformation have expressed concerns that corporations and policymakers are co-opting concepts like agroecology by defining them in ways that preserve the status quo (Kelinsky-Jones et al., 2025, p. 18). Such a co-optation through mainstreaming is a frequent process done to movements which center around systemic change and empowerment, a phenomenon which Cornwall (2018) calls “empowerment lite” (p. 3). It is a version of the political paradigm of empowerment stripped of any confrontation, mimicking genuine strategies but embedded within the institutions it was created to subvert (Cornwall, 2018, p. 6). Empowerment lite, like weak agroecology, represents the adopting and subduing of transformative ideas into the neoliberal agenda.

There is range within what Holt Giménez & Shattuck (2011) call ‘global food movements’, the varied approaches and iterations of movements that seek to change the practices and systems of food production from the bottom up (p. 116); within the corporate food regime exists a diversity of trends as well (Holt Giménez & Shattuck, 2011, p. 115). From progressive and radical versions of the former, to the neoliberal and reformist approaches of the latter, food projects and motivations are wildly varied (Holt Giménez & Shattuck, 2011). It is this variation, this dynamism, that allows this thesis to flourish. International food system actors are shaping food policy, and subsequently

shaping other's approaches. As we will see in the following section, the emergence of new technologies and techno-fixing narratives only complicates these relationships further.

3.7 Critiques of Food Sovereignty

Food sovereignty is not without its critiques as well. Scholars have questioned its conceptual clarity, practical feasibility, and political positioning. Some argue it romanticizes and homogenizes 'peasants' while overlooking internal class differences, and others note contradictions in its stance toward the state, whereby it is both anti-establishment but also calls on the state to guarantee rights (Claeys et al., 2021, pp. 242–243).

For example, Agarwal (2014) argues that food sovereignty's aims face significant practical difficulties in their implementation, especially concerning the constraints faced by small farmers and the potential conflict with their individual democratic choices for how their farms operate, market oriented or not (p. 1249). They suggest, rather, that cooperative efforts among small farmers, particularly women, could offer a more effective path to increasing productivity and achieving food security than the emphasis on individual family farms, which might reinforce household dynamics of unpaid labor (Agarwal, 2014, p. 1265). Bernstein (2014) argues that this idealized, homogenous peasantry is positioned as capitalism's opposite, the 'other' to large scale farming, and in fact the 'peasant' does not exist in globalized capitalism, since all producers exist within, not outside of, agrarian capitalism (Bernstein, 2014, p. 1032; Claeys et al., 2021, p. 242). Conversely, McMichael tends to be positioned as opposing this view, insisting rather that the peasant experience is crucial in illuminating the agrarian crisis of the corporate food regime and providing insights into new ontological solutions (Claeys et al., 2021, p. 242; Jansen, 2015, p. 217). Jansen (2015) positions these two debates in relation to each other, but argues that although Bernstein's narrative of "differentiated agrarian classes that shape agrarian change" contrasts with McMichael's narrative of "a corporate agrarian capitalism in crisis and of smallholders who experience the pressure of dispossession" (Jansen, 2015, p. 227), together they form a clearer picture. The author states:

If the populist take on a homogeneous smallholder ('peasant') is redrawn and replaced by a recognition of the differentiated and often conflicting interests and political projects of

smallholders (and other actors), then it becomes possible to include and rethink ‘capitalism from below’ in the search for alternatives to the current food regime. (Jansen, 2015, p. 227)

A ‘capitalism from below’, differentiated from McMichael’s capitalism, would be one answer to the claims of food sovereignty’s unrealistic agenda. Rather than to dismantle the system of capitalism that underpins every industry, including agriculture and the many farmers dependent upon it, it would annex the system to a focal point of justice, smallholders, and producers.

These movements and debates, both political and academic, provide an alternative perspective to the food security paradigm. To understand the discourse around food security, it is necessary to engage with the different discourses that intersect with it. The so-called alternatives, often work with, modify, or oppose food security and the international food security agenda. With this contextualization, we (the participants of this thesis) will be able to place debates on Agriculture 4.0 within wider discourses.

4. Agriculture 4.0

Agriculture 4.0 has been positioned as a solution to problems of sustainability and food security, yet it remains a point of contention within the international discourse on food systems. It is not independent of the tensions between food regimes and food movements, and debates on how to end hunger. Therefore, it merits a comprehensive look into its different components, and the effects, problems, and reactions they instigate.

There are wide claims that Agri 4.0 has hugely beneficial potential to transform farming and transform the food system (Abbasi et al., 2022; Garg & Alam, 2023; Klerkx et al., 2019; Klerkx & Villalobos, 2024; Lajoie-O'Malley et al., 2020; Montenegro de Wit & Canfield, 2024; Navarro et al., 2020). It can provide quick, real-time decision making, preserve critical resources, produce more food, contribute to SDGs, and, in essence, 'solve' food insecurity. The market is expected to grow immensely and bring in revenue of billions of USD (Navarro et al., 2020, p. 3). However, the push for these technologies is often vehemently opposed by justice-based food movements (A Growing Culture, ETC Group, La Vía Campesina, & Alliance for Food Sovereignty in Africa, 2023, p. 4).

Agriculture 4.0 (Agri 4.0), which encapsulates many types of farming and farm adjacent technologies, as well as so many wider assumptions about food systems, is the crux of this thesis. It is the stage on which the discursive performances of international actors is portrayed, and the stage I look to to record these activities. This chapter will briefly detail out the technical aspects of the concept and subsequently engage with current debates.

4.1 What is 'Agriculture 4.0'?

Agriculture 4.0 is an umbrella term that refers to various technologies used in farming that come from the fourth industrial revolution, or Industry 4.0. This "4.0" - fourth wave - is characterized by the use of "disruptive" technologies and digitalization, such as the Internet of Thing (IOT), Artificial Intelligence (AI), big data analytics (BDA) Digital Twins (DT), Wireless sensor networks (WSN), and autonomous robotic systems (ARS), among others (Abbasi et al., 2022, p. 2; Garg & Alam, 2023, p. 1; Gordan et al., 2023, p. 2). Agriculture has typically evolved in parallel with industrial revolutions. Initial formations of agriculture, Agriculture 1.0, relied on manual labor and

simple tools, with generally low productivity. With the first industrial revolution, machinery like tractors and harvesters ushered in Agriculture 2.0, boosting yields and reducing manual work. The second industrial revolution brought oil, gas, and new transport systems, enabling global agrifood supply chains and the rise of intensive livestock farming. Later, the third industrial revolution introduced digital technologies and automation, leading to Agriculture 3.0. Overall, farming trends had shifted from labor-intensive practices to industrialized, technology-driven systems (Liu et al., 2021, p. 4322). As Industry 4.0 technology is being integrated into farming and food production, Agriculture 4.0, also referred to as ‘smart farming’, ‘digital agriculture’, and ‘digital farming’, has emerged as another revolution in agriculture. Within this revolution, ‘smart’ technologies are supposed to relieve farmers of hard labor and make growing food more efficient (Garg & Alam, 2023, p. 4; Klerkx et al., 2019, p. 2).

As Agriculture 4.0 is a very broad term, the technologies it encompasses are broad reaching as well, though they typically rely on the use of data and machine learning. They range from sensors that monitor crops and tell growers when to water, to milking robots, to vertical farming and blockchains that show under what conditions each crop was grown (Abbasi et al., 2022; Garg & Alam, 2023; Klerkx et al., 2019). This phenomenon has started in the ‘Global North’, but is quickly being adopted by other agricultural countries and their researchers; major adopters include the US, China, Germany, The Netherlands, India, and Finland (Navarro et al., 2020, p. 3).

Separate technologies of ‘smart farming’ function together as a package system. For example, precision farming depends on IoT, AI, and autonomous machines to carry out its monitoring and farming. This process, though, of integrating these packages into agriculture is *digitalization*. As digital tools become more common around the globe, it is necessary to distinguish between the adoption of digital technologies, and the transformation with digital technologies. With key words like ‘digital’ being used extensively, it is important to define the focus of this thesis.

4.1.1 Digitalization:

Most generally, digitalization refers to the transition of utilizing digital tools. However, in the last decade its definition has become watery. To this end, I distinguish between *digitization* and *digitalization*. *Digitization* refers mostly to the changing of analogue forms of information into digital ones, essentially creating digital artifacts, while *digitalization* refers to the transformation of social and economic environments through the utilization of digital tools (Gradillas & Thomas,

2025, p. 113). This still leaves room for a broad interpretation of digitalization applications in agriculture; it could mean simply uploading paper archives into computer drives, selling through online platforms, or the transformation of weeding procedures through drone and smart systems use. The OECD describes digitalization broadly as well:

Digitalisation refers to the adoption of information communication technologies, including the Internet, mobile technologies and devices, as well as data analytics, to improve the generation, collection, exchange, aggregation, combination, analysis, access, searchability and presentation of digital content, including for the development of services and applications. (McFadden et al., 2022, p. 5)

As these definitions are broad, *digital agriculture* refers to the application of digitalization in agriculture, and is interpreted differently by different actors. This is why the term *Agriculture 4.0* brings a necessary distinction, and connection to the types of technologies referred to in Industry 4.0. Some aspects of digitalization can refer to the building blocks of digitization. However, as this thesis focuses on Agriculture 4.0, it does not tend to refer to basic digital technologies. The following section will briefly lay out the main technologies involved in Agri 4.0, hopefully bringing clarity to the concept and its distinction.

4.1.2 The Internet of Things (IoT):

The internet of things refers to:

“the network of smart, interconnected devices and services that are capable of sensing or even listening to requests. IoT is an aggregation of endpoints that are uniquely identifiable and that communicate bidirectionally over a network using some form of automated connectivity. The IoT enables based on networked sensors to remotely connect, track and manage products, systems, and grids.” (Dayioğlu & Turker, 2021, p. 381)

In other words, sensors (things) are connected by communication networks (internet), which combined can collect, transmit, store, and later analyze information (Navarro et al., 2020, p. 1). Such technology is used in precision agriculture, weather tracking, and livestock monitoring among other things (Liu et al., 2021, p. 4326). Examples of this technology in practice in agriculture are sensors that measure the soil moisture of a given crop and the temperature outside, and transmit this information to a data management system (Navarro et al., 2020, p. 1). Typically,

this information will be used to make a conclusion about a crop, for example if it needs watering or fertilizer. This process, called precision agriculture, will be expanded upon later. The devices or “things” in IoT are often satellites, drones, agricultural sensors, and autonomous farm vehicles, each able to record information like geographical images, weather data, and soil data (Liu et al., 2021, p. 4326).

In theory, any device that is able to connect to a wireless network can be a “thing” in this internet of things (Navarro et al., 2020, p. 1). There are various constellations of IoT applications, differing in range, speed, energy consumption, among other factors. Some include widely available and applicable devices, which can connect to widely available and applicable operating systems (Navarro et al., 2020, p. 12). For example, some single board computers³, like Arduino, accept customizable programs. Programs, like Raspberry PI, can be compatible with many operating systems like Raspbian, Ubuntu Core, and Mozilla. Furthermore, some of these operating systems are even open source, which means that their source code can be customized as well (Navarro et al., 2020, p. 12). However, this is not the case for many computers and programs used for the IoT.

There are pros and cons as well to the types of networks used. For example, for Wi-Fi networks are very common, given that they are already popular for general use and easily accessible. However, they often incur high energy consumption or even high costs. Alternatively, Near Field Communication technologies, like Bluetooth, or programs that use remote servers to transmit to Bluetooth devices, can be implemented (Abbasi et al., 2022, p. 5; Navarro et al., 2020, p. 13).

Some of the issues in utilizing IoT technology are the lack of high-quality sensors, which ultimately impede the quality of work, its energy needs and finding energy sources, and the reliability of wireless signals (Liu et al., 2021, p. 4326).

4.1.3 Big Data:

Big Data is the term used to refer to the processing of large amounts of information into useful analytics. It requires specific techniques and methods often drawing upon newer informatics developments (Garg & Alam, 2023, p. 5). It is characterized by five dimensions (Volume, Velocity, Variety, Value, Veracity) and into three categories (descriptive, predictive, and prescriptive) (Garg

³ Single board computers are ones built upon a single circuit, without any types of extensions. This makes them usually portable, easier to customize and receptive to open source programming.

& Alam, 2023, p. 5). In the agricultural context, Big Data is a needed mechanism to enable things like precision agriculture. Rather than drawing upon the data from a single farm (a practice sometimes termed small data), Big Data combines information across farms for its analysis (Coble et al., 2018, p. 82). Practically, this looks like IoT sensors capturing information on weather patterns, soil moisture, humidity, and fertilizer topologies, sending them to their respective operating system, and using Big Data techniques to parse out applications for this data. Applications include precision farming tools like decision support systems and predictive analytics, which aim to optimize yields and manage risks (production, market, financial, etc.) (Liu et al., 2021, p. 4329).

There are some issues with Big Data. The huge volume and variety of agricultural data from IoT devices create difficulties in integrating and managing of diverse datasets. This leads to problems like fragmented data systems and potential errors in decision support services. Tracking plant growth and environmental interactions across space and time adds even more complexity to analytics, while issues of data quality, storage, security, and openness remain unresolved (Liu et al., 2021, p. 4330). Additionally, the reliance on big data risks excluding farmers who lack access, skills, or clear incentives to participate in data exchange. Power imbalances may emerge if data is controlled by a few actors, reducing farmer agency. Furthermore, the shortage of experts who combine agricultural knowledge with data science exacerbates inequality and could concentrate benefits among better-resourced institutions (Liu et al., 2021, p. 4330).

4.1.4 Robotics:

Machines that can do work without the need of a controller behind them are referred to as robots, autonomous machines, or autonomous systems. Applications include things like smart tractors, which can plan routes and sense obstacles; robotic weeders that use computer vision to target weeds without touching crops, harvesting robots for fruits and vegetables; drones that spray pesticides and fertilizers, and automatic animal husbandry systems for things like feeding, milking, and herding (Liu et al., 2021, p. 4328).

4.1.5 Artificial Intelligence (AI):

Artificial Intelligence is another key element in Agriculture 4.0. AI is the broad category of computing that emulates human thought and performs tasks (Columbia Engineering, n.d.). AI

programs apply different computing tools like rules-based systems, which rely on pre-programmed rules applying a fixed collection of if-then instructions to given situations, or machine learning, which recognizes patterns in large datasets to perform tasks without being directly programmed (Columbia Engineering, n.d.; Scharre et al., 2018, pp. 4–5). Smart systems depend on AI, as the literal instrument that enables big data analytics and trains autonomous systems. AI is what underpins decision support systems, like mobile phone apps and animal monitoring tools, which use the technology to provide advice to farmers and farm managers. For example, in apps where one can scan a photo of a diseased crop and get a diagnosis (Liu et al., 2021, p. 4329).

The way these programs come to conclusions, however, is not always transparent. The obscure decision making processes are referred to as ‘blackbox’ characteristics, and present a major issues for researchers to address (Islam et al., 2024). Essentially, users, and even programmers, cannot understand *how* a computing decision was made and based on what (Sparrow et al., 2021, p. 183). These ‘black boxes’, this opacity, as Burrell (2016) argues, can come in three forms:

(1) opacity as intentional corporate or institutional self-protection and concealment and, along with it, the possibility for knowing deception; (2) opacity stemming from the current state of affairs where writing (and reading) code is a specialist skill and; (3) an opacity that stems from the mismatch between mathematical optimization in high-dimensionality characteristic of machine learning and the demands of human-scale reasoning and styles of semantic interpretation. (Burrell, 2016, pp. 1–2).

Recent research has tried to tackle this issue, using the concept of Explainable Artificial Intelligence (XAI) which has been relatively successful when applied to some agricultural applications (Girmay & Möhrle, 2024; Islam et al., 2024; Wei et al., 2022). Nonetheless, it remains a major concern in the application of AI for important sectors like agriculture, finance and healthcare, and a topic for many justice-based food movements (Thomas, 2024).

4.1.6 Precision Agriculture:

Precision agriculture is the application of information in farm management that is tailored to specific areas. Although the concept and practice have been around since the 1990s, it takes on a new practice within (or as) smart farming (Dayioğlu & Turker, 2021, p. 378). In Agri 4.0 it combines IoT, autonomous systems, and data analytics to try and maximize efficiency of resources.

The core technologies of Precision Agriculture fall into four areas: guidance systems (automated steering and machinery control), information management (data collection via sensors, drones, and satellites), application technologies (variable-rate seeding, fertilization, irrigation, and crop protection), and data analysis tools (decision support systems and farm management platforms) (Dayioğlu & Turker, 2021, p. 380).

Generally, Precision Agriculture is said to be able to help make farming more sustainable (Shafi et al., 2019). However, as it relies on the other Agri 4.0 technologies, it holds the same shortcomings and challenges that each tool does as well. Furthermore, when considering the entire lifecycle of the machines (from production, to use, to end-of-life), using machines and technology for precision farming can have higher environmental impacts than without (Huck et al., 2024, p. 12).

4.1.7 Blockchains:

A blockchain, simply put, is an immutable digital ledger; each record recorded becomes a ‘block’, and is visible, traceable, and decentralized. As such, it is assumed to be a secure and transparent way to record information. Of course, it has its technical downsides and inefficiencies, particularly with the IoT. For example, it is not necessary to keep each data point (block) of the heating history of a room when using a smart system for heating (Ghiro et al., 2021). Yet the nature of a blockchain requires saving complete histories. Specifically in agriculture, it is usually praised for its potential as a transparent record of supply chains. In this way, for any product a consumer contemplates buying, they can see exactly which farm, which supplier, and which transport method it used to end up on the shelf; this mechanism can enable fair prices by transparently showing each step. It would be not only beneficial for conscious consumers, but also for food safety regulators who want to make sure protocol is followed (Garg & Alam, 2023, p. 5; Navarro et al., 2020, p. 19). This can manifest, for example, as a ‘smart contract’ (Liu et al., 2021, p. 4330). Finally, blockchains can be used for cybersecurity issues related other Agri 4.0 technology, as it is generally considered a very secure form of data storage. For example, if autonomous irrigation systems are hijacked, and incorrect information is inputted into its AI command systems, it would negatively affect crops (Liu et al., 2021, p. 4330). Alternatively, crop and yield information could be taken and disclosed to third parties, potentially effecting interactions with the farm and its business partners (Liu et al., 2021, p. 4330). Such issues would in theory be prevented by the

implementation of blockchains and provide benefit for farmers and consumers (Lakhan et al., 2025).

4.2 Critical Debates: Data Reflections, Autonomy, and the Technofix

Although it has immense potential for positive impacts, there are strong critiques to both Agriculture 4.0's technical aspects and its nontechnical impacts. This section deals with these impacts, as well as the problems and reactions they instigate.

Technical critiques often hinge upon its predictive nature at present, at what is its potential versus what is proven. There is little evidence that smart farming can be widely applicable and meet the high expectations it has incurred. Many technologies have low adoption rates (Garg & Alam, 2023, p. 32; Ingram et al., 2022, p. 3) or are proven to incur minimal, if any, legitimate utilization in fostering the change Agri 4.0 proponents advertised (Barrett & Lansing, 2025, p. 2; Garg & Alam, 2023, p. 32). Additionally, the entire life cycle of Agri 4.0 technologies can incur environmental detriments; for example, the production of electronics requires mining rare earth minerals, and the processing of data requires massive energy use (Huck et al., 2024, p. 12).

Furthermore, if they do change the way in which farming is practiced, thereby changing the culture and identities surrounding it, this could lead to farmers (especially small farmers) leaving the practice, and consequentially a farming future that has few farmers and bigger farms (Rose et al., 2021, p. 6). Decision makers seemingly are not considering such consequences, nor the potential power relations or inequalities it could exacerbate. Though the claimed improvements are increased sustainability and food security, they do little to change existing systems of food production that cause problems of environmental degradation and food insecurity, seemingly reproducing existing inequalities in a new form without addressing other potential system changes solutions (Klerkx & Villalobos, 2024, p. 7; Lajoie-O'Malley et al., 2020, p. 10). For example, although voices of Agri 4.0 claim it will empower women and reduce gender gaps, since inequality and even the gendered digital divide of access to technologies is culturally driven, scholars note that without addressing the structural causes of inequalities, Agri 4.0 risks exasperating them. This could mean the digital divide is worsened by more complex and expensive technologies (Abdulai, 2022, p. 1595; Choruma et al., 2024, p. 7; Ingram et al., 2022, p. 29; Wittman, 2023, p. 478)

Let us return to data, though not simply the Big Data methods of finding conclusions in information. There are two points to be considered here regarding data use and its specific role in the context of smart farming: data rights and the role of data in decision making.

One of the major foundations of Agriculture 4.0 is the collection of data. This data, as we have seen, is intended to act as a knowledge base and directory for smart farming systems. In 2013, media scholars coined the term ‘datafication,’; it refers to the process of converting social actions into quantifiable data, which can be used for monitoring and predictive analysis (Montenegro de Wit & Canfield, 2024, p. 386). Montenegro de Wit and Canfield (2024) propose that smart farming is a manifestation of datafication, where regular objects are ‘datafied’ and turned into tools for collection. They then suggest that the phenomenon of the drive to create data and the narrative that “data is intrinsically socially desirable, and that all parties benefit from increased output” should be described as ‘data productivism’ (Montenegro de Wit & Canfield, 2024, p. 387).

What is the driver behind data productivism? One is the financial benefits of data, where data becomes an economic resource, profitable through financialization or competitive advantage (Klimeczak & Fryczak, 2022). As such, scholars have noted that data is often extracted in a similar vein to other resources, often without consent of those who that data is based on and not for their gain either (Fairbairn et al., 2022; Montenegro de Wit & Canfield, 2024; Sadowski, 2019). As new digital terrains are created, the rules that govern ownership over them are unclear.

Do you have the right to your own data and its privacy, or do you have the right to access it? As Carolan (2018) points out, when you access an Apple product, you agree to limit your access to the information extracted from it (p. 2). They proceed to discuss the imaginaries of access that arise from different political understandings. John Deere, one of the largest agricultural machinery manufacturers, had been under fire for their political understanding of the role of farmers; they stated that farmers do not actually own their machinery once purchased, but rather only the right to operate the machine (Carolan, 2018, p. 5). These emerging issues show a continuation of patterns we have previously seen; they are reminiscent of the tensions of the Green Revolution and the implementation of HYVs and the entire input packages they required. The patenting of seeds changed the relationship between farmers and what they were farming and inscribed new power dynamics to input (seed) producers. Additionally, the ‘bundles’ provided by digital agriculture are reminiscent of the Green Revolution packages; these bundles go beyond the traditional packages

of seeds, fertilizers, pesticides, and resource management tools to include farming as well as financial and digital platform products (Brooks, 2021, p. 390). Dubbed the ‘long Green Revolution’ by some scholars, these initiatives, as Brooks (2021) puts it, sustain the patterns “superimposition of a narrow concept of agricultural technology has eroded the foundations of farming as an embodied and socially-embedded practice of continual experimentation and innovation” (Brooks, 2021, p. 390).

In contrast to these patterns of ownership, groups like Farm Hack and the Right to Repair movement work towards providing means and advocating for the legal right to repair, alter, and tinker with machinery and tools. This, as Carolan (2018) explains, shows a distinction between a collective mentality and an individualistic one; in the former, farmers would work together to collectively better agricultural methods, yields, and systems, while the latter is propagated by companies and farmers alike, where constricted access to needed markets and prices necessitate competition between farmers (Carolan, 2018, p. 755). The users of Farm Hack use the platform to share methods of using Agriculture 4.0 techniques and technologies without buying into the products, and power over ownership, of large businesses. Carolan argues this presents collectivist imaginaries around farming. Rather than seeing their neighboring farmers as competitors, they viewed each other as cooperatives and technology not as a competitive tool, but as a collaborative one (Carolan, 2018).

Farm hack is an example of open source, which, along with open data, has also been posited as a potential solution to concerns of data ownership and exploitation. However, open agrifood data projects can still reinforce neoliberal paradigms, or knowledge skewed toward the ‘Global North’ (Fairbairn & Kish, 2023, p. 1939). Furthermore, as data is increasingly becoming a desirable resource, open data can enable “data colonialism”, by which information is extracted and prioritized over farmers rights and ‘North’-‘South’ power dynamics are reproduced (Fairbairn & Kish, 2023, p. 1947). Additionally, open data attempts to universalize information, creating common terminologies and understanding of agricultural concepts which can both erase local differences and reinscribe the ontologies of these universalizes, typical ‘Northern’ intuitions (Fairbairn & Kish, 2023, p. 1950). Data colonialism represents a new form of extractivism and exploitation, a reproduction of neocolonial relationships, where data is the resource taken for accumulation.

Data's function as a resource, the benefits that can be reaped from accumulating it and who has access to it, highlight questions of inequality in power relations. Already 20 years ago this debate opened up, asking "does digitalization of agriculture transform supply chains or does it reinforce the position of dominant actors and industries?" (Klerkx et al., 2019, p. 6). This is a central question for Agriculture 4.0. Hackfort (2025) finds that there are three main features that inform the entanglements of the agrifood industry and digitalization. These are (1) data and digital tools as means for corporate control, (2) integration of financial interests and start-ups, and (3) legitimization of tools through sustainability arguments (Hackfort, 2025). As they write: "The intertwining of corporate concentration and financialization with new technological regimes and sustainability narratives in the food system has created a complex dynamic, potentially leading to further concentration of power and resources in the hands of a few dominant actors" (Hackfort, 2025, p. 9). These three themes are central to the debates on the effects, problems, and reactions to Agri 4.0, and will be addressed further in this section.

As we have seen, mergers and monopolies in the agriculture industry have been growing; the so-called Big Agriculture industry (Big Ag) has gained immense traction in the last few decades. Additionally, Big Tech has grown since the Silicon Valley boom of the 2000s. The growth of these industries and their combination only heighten corporate concentration.

Big Ag and Big Tech merge together in Agriculture 4.0. For example, John Deere has, since 2017, included sensors which capture data in their products, combine it with other sources of information like weather forecasts and historical data, and present it on online platforms for farmers to utilize and receive planting advice from (Carolan, 2017, p. 4). Another example includes Monsanto, who has been acquiring data analytics companies since 2012. These companies possess software platforms and tech start-ups that Monsanto can then integrate into their own products for purposes like precision agriculture (Carolan, 2017, p. 5). Both companies promote these endeavors as ways to boost yields and ultimately increase producer profits.

Monsanto and Bayer illustrate the extent of corporate concentration and control well; they are two of the biggest agricultural corporations ranking in 2017 among top seven seed and fertilizer producers (Dietz & Drechsel, 2021, p. 575) (with Bayer being engaged in other industries, like pharmaceuticals, as well). In the same year they entered into a merger, with Bayer acquiring Monsanto, signaling that Bayer has "even more control over which seed variety should be sprayed

with which pesticide in order to grow best” and monopolization is accelerating (Dietz & Drechsel, 2021, p. 575).

As the agricultural sector becomes more concentrated and the supply chains vertically integrated, data from farming endeavors presented by Agri 4.0 has potential to be the means to control. As Dietz and Drechsel (2021) say,

In line with the case of Bayer today, vertical integration and centralization will, under the conditions of digital agriculture, mean that the company producing agricultural machine X will decide which of its own seeds will be sown when, and which of its own fertilizers and pesticides will be used and at what time. The machine is simply incompatible with the products of other companies, securing the market position of the company that manufactured it. The farmers, then, are increasingly unable to make their own decisions, as they are forced to use the products from the same company as a complete package (Dietz & Drechsel, 2021, p. 565).

The growing corporate consolidation in agriculture, combined with decision making being transferred to Artificial Intelligence systems, increases the potential for exploitation. Bias on the information used to train AI systems is already a published concern, as this information primarily comes from the US, Europe and China (Sparrow et al., 2021, p. 182), but what about bias that occurs from the interests of those providing these systems? Research has found that input providers are increasingly linking their farming products to farm management services; Bayer’s data-driven recommendations encourage farmers to cultivate specific company-owned crops (Hackfort, 2025, p. 4). The combination of digitalization with corporate consolidation means increasing control over Big Data, and provides “agri-food and agritech companies the opportunity to use data to enhance their own products to bind farmers more closely to both these products and industrial food system pathways” (Hackfort, 2025, p. 4).

In addition to control over products used and decisions made, control over Big Data risks exploitation for financial speculation. Although Agri 4.0 includes features like blockchains providing security from the theft of farming information by third parties, it also provides mechanisms for farming information to be used by third parties, when the information is not owned by the farmer. Sparrow (2021) provides an illuminating postulation:

Some of these uses will inevitably be controversial. For instance, a company that leases out tractors that contain soil sensors might use the data gathered by those sensors to inform its speculations in the agricultural futures markets or sell it to other interested parties who might then use it to extract concessions from the farmers: if a company selling water has access to data about soil moisture content gathered by a farmer's tractors or drones, they may be able to raise prices in circumstances where the farmer might otherwise have been able to bluff about their willingness to walk away from a sale. (Sparrow et al., 2021, p. 181)

Indeed, as major concern over data ownership, distribution, and power dynamics exists (Klerkx et al., 2019, p. 7), these scenarios are not fantastical hypotheses. As the corporate food regime grows, so has financialization in agriculture. For example, BlackRock held significant agrifood shares in 2019, such as 7.2 percent of voting rights within Bayer-Monsanto (Prause et al., 2021, p. 647). The agrifood industry is becoming increasingly attractive to financial investments.

Financial investments in Agri 4.0 are transforming agriculture not only in terms of going beyond literal yields, but also in the relationships and roles of farmers and farming knowledge, and to the actors involved in agriculture. This is occurring, specifically, through AgriTech start-ups. Within the last 20 years agriculture was identified as an 'under invested' industry, piquing the interest of tech investors and cumulating in billions of dollars of start-up funding (Fairbairn et al., 2022, p. 653). In line with the 'disruptive' potential of Agri 4.0 technologies, agribusiness start-ups are also sometimes seen as potential catalysis for change, often with advertised goals of making impactful change (Klerkx & Villalobos, 2024, p. 2,5). However, scholars also note that due to their integration into financial systems and dependence on them, agrifood start-ups actively work with large, existing firms (Klerkx & Villalobos, 2024, p. 5). The biggest agrifood companies are progressively promising digital innovation, therefore fostering start-up incubators that mesh start-ups and research groups with investors (Hackfort, 2025, p. 5). In fact, these companies, utilizing financialized logics, are investing directly in AgriTech start-ups or buying them up, leading to gradual shifts in the start-ups to accommodate the interests of these established industries (Hackfort, 2025, p. 5).

What are the other implications of digitalization in farming, considering that platforms that collect data are providing guidance to farmers and producers? As farmers shift from making autonomous judgments to relying on these platforms for decisions - when to plant, harvest, water; which disease, pest, fertilizer - who bears responsibility for outcomes influenced in part by AI applications? Generally, there exists a ‘responsibility gap’ in these advanced computing systems, where there is no clear framework on where to assign blame for its negative outcomes; to the users, engineers, or machines themselves (Johnson, 2015; Sparrow et al., 2021, p. 183).

Moreover, these implications have opened up more ontological questions. What is the role of farmers, if not to decide on the outcomes of their own farms? What does it say about how farming is viewed if a machine should know better than the farmer, that this is progress? How do we contend with the fact that data is meant to replace farmers decision making ability, when it acquires all its knowledge on farming from generations of farming practices? The ways technologies influence how farming functions, like how decisions are made as well as how tasks are completed, reconfigure the farm and perhaps change what it means to be a farmer (Carolan, 2024, p. 1473).

In their study Barrett and Lansing (2025) explore the ‘je ne sais quoi’ of a longtime farmer practicing farmwork. In the case of technology sensing and predicting mastitis in dairy cows, there is a tension between data-based and experience-based decision making. Although data is usually presented as the filler for the deficiency in farmer knowledge, the authors found that often farmers were able to understand a cow was ill before digital monitors (Barrett & Lansing, 2025, p. 1). This understanding, this closeness with the animal called a ‘cow sense’, is not equal among all farmers but prevalent in those with lengthy experience (Barrett & Lansing, 2025, p. 4). This example shows how, despite the claims of data improving farm efficiency or providing accurate decisions, it is not always most effective. Sometimes farmer’s feeling of an off-ness of their animal and testing for disease immediately after proved more efficient than processing information of bacteria counts in milk. The authors state that,

Rather than being of lesser value than data-derived knowledge, farmers’ experiential knowledge is needed to perform the hidden labor that renders data useable and applicable to farm circumstances. In the case of mastitis management, data technologies do not always make decision making easier (Barrett & Lansing, 2025, p. 2)

The systems of values embedded in the current food system, the understandings of agriculture as technical and productionist, is easily transferred onto Agri 4.0. Although the tools themselves exist perhaps in a vacuum, any application of them do not. Specifically, they exist within the larger discourse on food systems, capitalism, and power.

Implementing smart technology in farming implies immense faith on current agricultural institutions. Moreover, some scholars argue it is the same, hegemonic values dressed in different clothes (Klerkx & Villalobos, 2024, p. 7). How can we best understand where Agriculture 4.0 falls within the discourse on food systems?

One way to explore this problem is through the concept of a *technofix*. In explaining what a ‘technofix’ is Dillet and Hatzisavvidou (2022) draw upon the brothers from Greek mythology, Epimetheus and Prometheus. The first brother, Epimetheus, represents afterthought, realizing mistakes after acting hastily, while the second brother, Prometheus, represents forethought, looking to the future for solutions. They argue that a type of ‘ambient Prometheanism’ (p. 352) has taken over political stages, with a tunnel vision for future solutions to address environmental problems (Dillet & Hatzisavvidou, 2022, p. 352). Without its ‘first brother’ (the afterthought) forethought overlooks lessons learned and present predicaments. Essentially, the authors describe a blinded look towards technological solutions, developed through capital-intensive projects, which leads to the economization and depoliticization of planetary environmental issues - in other words, a technofix (Dillet & Hatzisavvidou, 2022, p. 368). A technofix is ultimately something that is presented as a panacea to one or more problems, specifically used in the context of the climate crisis and other ecological issues. As Boehnert (2018) describes it: “Technological innovation is often presented as the solution to environmental problems. The technologies that assume this curative role are known as technofixes” (Boehnert, 2018, p. 161). As both authors argue, environmental crises are not just technical but social and political; the drivers of the climate crisis, the expansion of production and fossil fuels and the economic systems that enable and need them, if not addressed, will inhibit sustainable solutions (Boehnert, 2018; Dillet & Hatzisavvidou, 2022). As a future focused paradigm, technofixes do not typically engage with the history of the issues they cure. Montenegro de Wit & Canfield (2024) explain how this is the case for digitalization;

In the global debate over how to address these crises, digitalization is often posed as a solution free from the baggage and assumptions of past agricultural paradigms. However, critical agrarian scholars have pointed to several ways in which digital agricultural entrenches both productivist and neo-productivist principles. (Montenegro de Wit & Canfield, 2024, p. 384)

Digitalization in agriculture can be thought of as a technofix, and as such warrants critical inspection.

The hype of the technofix, like of data productivism, can steal limelight from established knowledge. The drive to create data, as Montenegro De Wit and Canfield (2024) argue, also acts as a distraction from building upon data that is already known, building upon reasons for systemic changes; “researchers have amassed copious data along the way: data demonstrating the centrality of structural changes including redistributive land reforms, territorially embedded markets, and parity pricing Data illustrating the effectiveness of farmer-to-farmer networks by which transformative knowledge spreads” (Montenegro de Wit & Canfield, 2024, p. 410). It is in this junction that the call of attention to neoliberalism rears its head again. As food security agendas have been criticized for being motivated by economic interests and the corporate food regime morphing food systems into businesses, so has Agriculture 4.0 been opposed, often presented as the antagonist in a food perspective dichotomy.

In the debate on the effects of Agri 4.0, comes also an epistemological question of what gets valued within the farm. As portrayed in the example above, the focus on data often obscures or even degrades the work done by other forms of knowledge. Technology in agriculture has generally received more funding, and therefore more mainstream legitimacy than practices of agroecology and Indigenous knowledge (Sullivan, 2023, p. 914). Broad sweeping implementation of Agri 4.0 technologies can risk excluding or overwrite traditional and Indigenous farming practices, as has historically been the case for epistemological traditions originating in the ‘Global North’ (Elliott & Sterner, 2025, p. 47; Yañez Serrano & Argüelles Ramos, 2025, p. 3).

4.3 Agri 4.0 and Addressing Food Security

Along with those who critique and critically analyze the technologies and proposals of Agri 4.0, there are actors who strongly oppose it, or at least act as an oppositional sounding board.

Proponents of food sovereignty, especially in contrast to their mainstream food security counterparts, are often doubtful of how beneficial smart farming technologies will really be in their effects on the food systems, citing instead the many instances that technological developments have hurt both farmers and consumers (A Growing Culture, ETC Group, La Vía Campesina, & the Alliance for Food Sovereignty in Africa, 2023; La Vía Campesina, n.d.). A main argument, from scholars, activists, and workers alike, is that the application of smart farming as it is now being advertised does not target drivers of food insecurity or hunger. Rather, it follows the legacy of the Green Revolution, promoting increased outputs for fewer inputs and “efforts to transform and modernize smallholders without due considerations to potential power and class restructuring” (Abdulai, 2022, p. 1600). Indeed, the most widespread criticisms is that the Agriculture 4.0 agenda is seemingly blind to inequality, farmer agency, and faults in the current economic systems.

Without attention to such details, the ‘great transformation’ of the food system, which there is overwhelming consensus for (though what exactly this entails is interpreted differently among those expressing consensus, and is the crux of this thesis), will not be possible; rather, what would result is an update on current, problematic and problem causing systems (Béné, 2022). With co-opting and ‘empowerment lite’ in mind, it is possible to understand the mechanisms of such a system as benefitting from or upholding smart farming.

The use of the word ‘smart’ as a prefix is significant. Although most literally it is meant to signal a type of technology (in align with industry 4.0), it is often used as a buzzword. Smith et al. (2023) explore how ‘smart economics’ in agriculture discourse, though promoted as empowering women, essentially touts neoliberal agenda. Such projects frame gender empowerment as economic productivity, where investing in women’s empowerment means integrating them into the market (Smith et al., 2023). Central to the ‘smart’ economics goal to integrate women farmers for increased agricultural productivity, is a view of women as “untapped adopters of the ‘smart’ agricultural technologies”, particularly within the agendas of the Bill and Melinda Gates foundations’ philanthropic endeavors (Smith et al., 2023, p. 584). Another ‘smart’-ified term, which has gained increasing traction, is ‘climate smart’ agriculture (CSM). CSM incorporates a range of practices aimed at mitigating the effects of climate change and building resilience in the agriculture industry which, in theory, address boosting sustainable production, assisting farmers in

adapting to climate change, and lowering greenhouse gas emissions (Chandra et al., 2018, p. 531). This has been connected to ‘sustainable intensification’, which critics have noted draws upon doomsday/Malthusian ideas on the urgency to increase production and maintain the climate (Chandra et al., 2018, p. 535). ‘Smart’, in this case, is unclear. Chandra (2018) reveals how CSA literature often refers to agroecological methods or conservation agriculture, while still utilizing a narrative of ‘sustainable intensification’. As they conclude,

In the absence of ‘smart’ characteristics and tools, CSA does not provide an alternative scientific agenda to sustainable intensification. Without such clarity, unsustainable models of agriculture may likely be reinforced, justified, and re-branded as CSA. (Chandra et al., 2018, p. 536)

As CSA is primarily in the forefront of research agendas of large Development organizations, what this use of ‘smart’ represents is the greenwashing of mainstream, neoliberal, approaches to agriculture and their attempts to mitigate criticism. For ‘sustainable intensification’, the insinuation that higher *efficiency* can lead to or be connected to sustainable practices, without changing the systemic drivers of environmental degradation, distracts from systemic changes and focuses on incremental technological advancements (Newell & Taylor, 2018, p. 15). The term is even often considered an oxymoron (Mahon et al., 2017). Additionally, these constellations of ‘sustainable’ and ‘smart’ act to increase the credibility of scientific and technical discourses, while sidelining social, economic, policy research (Chandra et al., 2018, p. 537).

Is there a space for synthesis? What has emerged is an opposition between Agriculture 4.0, and justice-based food systems like food sovereignty. This has been noted by scholars, and present in advocacy work (A Growing Culture, ETC Group, La Vía Campesina, & Alliance for Food Sovereignty in Africa, 2023; Bellon-Maurel et al., 2022; Ndabezihle, 2024). Is this binary, however, innate, or relevant because of the proxy conflicts of neoliberalism and collective justice? In other words, are the concepts of Agriculture 4.0 able to be pried away from the contexts they were formed in and used towards other ends? Initiatives like Farm Hack insinuate that this is possible, and scholars tend to engage with these possibilities as well (Fraser, 2020; Klerkx & Rose, 2020; Wittman et al., 2020). The debate around this opposition is central to the international discourses on Agriculture 4.0 and food security, and the deconstruction of this binary is perhaps most insightful in understanding how and from what basis food futures are constructed.

5. Methods

Using Critical Discourse Analysis (CDA), this thesis investigates how Agriculture 4.0 is framed and the underlying assumptions about food security that these framings reveal. CDA is combined with Frame Theory to not only identify dominant frames, but also to unpack the ideologies that underpin them and the specific understandings of food security they promote. The goal is to shed light on the imaginaries held by international actors, the values they assign to technological developments, and the potential influence these framings have on policy and practice.

This thesis builds on previous research examining the framings of Agriculture 4.0 (Tomlinson, 2013; Lajoie-O'Malley et al., 2020; Montenegro de Wit & Canfield, 2024; Stephens & Hinton, 2025). While these studies offer valuable insights, they primarily focus on major international institutions as dominant international policy actors, overlooking the roles of large non-governmental organizations (NGOs) and other influential but non-dominant actors. Moreover, while these works describe prevailing narratives around data, technology, agriculture, and food security, they often do not critically analyze nor compare how such discourses are formed and inform sociotechnical imaginaries of the future of food. This thesis addresses that gap by including four diverse organizations, each engaged in global dialogues and programs on agriculture and food security, yet with differing institutional backgrounds. These are the Consortium of International Agricultural Research Centers (CGIAR), a large international public-private research consortium; the Food and Agriculture Organization (FAO), a specialized UN agency; Food First Information and Action Network (FIAN) International, an NGO advocating for the human right to food and food sovereignty; and the Action Group on Erosion, Technology and Concentration (ETC group), an NGO focusing on human rights, technology and sustainability.

Critical Discourse Analysis (CDA) techniques, following Fairclough (1995), are used to analyze texts and both find frames of Agriculture 4.0, and the understandings of food security that ground them. According to Fairclough, CDA works on three layers; the text itself, the interpretation of the text (discursive practices) and the social context it sits in (Fairclough, 1995). Therefore, my analysis of each document will look at the actual writing, the context of the writing, and its relationship to wider sociopolitical landscapes. I will pair CDA with Frame Theory to enable not just an identification of frames, but also an analysis of what assumptions underpin these frames,

and how they relate to broader discourses and ideologies. Frame Theory, following Entman (1993) looks at what is and isn't included about a topic and consequently how and what is presented as the problem, cause, morals, and solution (Entman, 1993). Further elaboration on discourse and frames is given in the Theoretical Tools section.

This thesis investigates conceptions of the future of agrifood through the question: *how do the FAO, FIAN, ETC Group, and CGIAR frame Agriculture 4.0 and what does this reveal about their underlying understanding of food security?* Following this exploration, the following sub-questions emerge: What assumptions are embedded in these framings? What kinds of power are ascribed to different understanding of food security and to whom? Which agricultural futures do these frames illuminate, and by contrast, obscure?

5.1 Research Design and Process

The four organizations selected aim to broaden the representation of frames and allow for an enriched comparative as well as critical analysis. The FAO and CGIAR (in its new restructuring as One CGIAR) have been under investigation in numerous studies on food security and framing. Within this literature they have been identified as *international influential policy actors* (Tomlinson, 2013; Lajoie-O'Malley et al., 2020; Montenegro de Wit & Canfield, 2024; Stephens & Hinton, 2025). Such actors are identified as providing “essential imaginative resources” for policy and decision making (Lajoie-O'Malley et al., 2020, p. 2), in what Tomlinson (2013) has called the ‘international policy arena of food security’. Understanding how these actors imagine the future of food and food security is important since, as Lajoie-O'Malley et al. (2020) explain, one can think of “the future as an ongoing project that is still taking shape under the influence of human thoughts and actions taken in the present” (Lajoie-O'Malley et al., 2020, p. 3). Although the FAO and CGIAR are certainly dominant actors, it would be totalizing to pay attention only to those historically influential actors if one is to understand just how the futures of food systems are taking shape. For this reason, I chose to widen the sample of organizations to include a range of perspectives on food and food security and provide ‘imaginative resources’ that potentially interact, contradict, or support each other. If the human actions are actively shaping the future, then their interactions must be as well.

Additionally, the choice of organizations was influenced by practical factors, such as amount of and access to relevant documents. Although La Via Campesina is an influential organization in the food systems stage, the search method employed did not provide enough relevant documents to utilize them for the analysis in this thesis. The organizations chosen were both relevant and provided accessible material. In the following paragraphs a brief background of the organizations chosen will be provided, as well as the search process.

The FAO (Food and Agricultural Organization) was chosen to represent the governmental/international community, as a historical voice for food security on the international stage. Established in 1945 after the second world war, it is a specialized UN agency meant to lead international efforts to combat hunger. As has been laid out in previous chapters, it was formed at a time when hunger rates were high, multilateral aid was developing, and nutrition science emerging. It is primarily funded by voluntary contributions by members and ‘resource partners’ as well as assessed (compulsory) contributions from members. Top funders include governments like the US and European Union, other international organizations like the World bank, and funds like the Green Climate Fund (GCF)⁴ (FAO, n.d.). It is governed by a biannual conference of member states, although it has become decentralized in its daily functioning (Mingst, 2025).

CGIAR (Consortium of International Agricultural Research Centers) represents a private-public perspective. Originally founded by the Rockefeller Center and influenced by the FAO and USDA, it is a network of international agricultural research centers, some of which existed prior to its founding in 1971 (Byerlee & Lynam, 2020, p. 2). Its original aim was to improve agricultural research and foster better crops. It was involved in creating new varieties of crops like wheat and rice, and there is evidence that this has had a major impact on crop improvement, and research and development programs (Byerlee & Lynam, 2020, p. 15). In the early 2000s it underwent significant changes; the organization shifted towards MDG initiatives and increasingly acquired funding through donors, leading to a restructuring of priorities and more influence by donors over research programs (Lynam et al., 2024, p. 8). The Bill and Melinda Gates foundation has been a major funder since early 2000s, and of the top two funders since at least 2018 (CGAIR, n.d.). As BMGF has been under scrutiny for its involvement in agricultural programs and particularly its

⁴ The GCF is funded by pledged donations from States as well as private sector investments.

involvement with CGIAR (M. Canfield, 2023), it represents potentially private-sector skewed, science driven perspectives.

FIAN International (Food First Information and Action Network) is a human rights NGO advocating for the right to food and nutrition. Founded in 1986 by a network of Amnesty International branches it existed initially in Germany but spread in the following two decades to the other continents, where there are now various branches. It is funded by member fees, donations, and grants (Klum, 2016). It attempts to bridge the gap between academics and activists, contributing to the debate on the right to food and engaging with other international NGOs (Claeys, 2015, p. 68).

ETC Group (Action Group on Erosion, Technology and Concentration) is a research and advocacy organization on human rights and food sovereignty. Its goal is to monitor new technologies and strategies within agrifood systems and publish and advocate based on principles of justice and food sovereignty. Originally, it was known as the 1970s Rural Advancement Foundation International (RAFI), which researched and lobbied for farmers rights and seed monopoly laws. Their early work was centered around seeds and biopiracy. The group changed their name in 2000 to ETC Group, reflecting the shift in focus from agricultural issues on food security and biodiversity, to converging technologies and their impact on agricultural communities. Additionally, the name change served to allow the group to be registered as an NGO in the US. ETC group was pioneered by Pat Mooney, Hope Shand, and Cary Fowler, US and Canadian scholars and authors. They work with various international organizations as advisories and participants (FAO, CGIAR, UNFCCC, UNTACD) and are funded through donations and grants (ETC Group, n.d., 2000; Mehta, 2010)

Documents for the study were searched for on the “Publications” page of each organization’s website, found through keyword search (“digital,” “technology,” “tech” “smart,” “precision,” “agriculture 4.0”). For the ETC group, which did not have a search function on the publications page, the lists of articles were scrolled through in order to find relevant publications. The time frame was constricted from 2020-2025, to ensure a range of material that is current and a wide enough scope to find a suitable number of sources. It was attempted to find an even and well distributed sample of documents. Country specific profiles were excluded, because their narrow focus has the potential to distort the analysis by referring to very specific situations. Instead,

publications meant to inform on the topic most generally, like policy briefs or position papers, were considered ideal. This is because they are geared towards wider audiences (in consideration of Fairclough’s second layer, the interpretation of the text) and I regard them as a good basis for a framing analysis. Each document focuses on the topic of Agriculture 4.0 primarily, with different specifications. For example, even though many documents centered around ‘digitalization’, only two of such were chosen. This is also because each text was assessed on its relevance, and even though some contained the relevant keywords they were not necessarily focused on Agriculture 4.0. ‘Digitalization’, though a component of Agri 4.0, also encompasses any use of digital technology, like social media or SMS. In the case of FIAN, only two publications fit the criteria. Additionally, for the FAO, only three publications were selected. The selection was informed by the length and detail of each document, given that the FAO publications were significantly longer than the others. Overall, a balanced sample was pursued and thirteen documents chosen, which are shown in Table 1.

Table 1 *Documents Analyzed*

FIAN	1	The Big Tech Takeover of Food Systems in Latin America: Elements for a Human Rights-based Alternative	2023
	2	Remote Control and Peasant Intelligence: On Automating Decisions, Suppressing Knowledges and Transforming Ways of Knowing	2023
ETC Group	3	A Future of Farms without Farmers? Deployment of Agricultural Digitalization in Indonesia, Malaysia and the Philippines	2022
	4	Ditching Techno-Patriarchy and the “Permacrisis”: What’s Missing on Digitalisation in the CSW67 Zero Draft	2023
	5	Challenging the digitalization of the agrifood chain: Trojan Horses on the Farm	2024
	6	A Long Food Movement: Transforming Food Systems by 2045	2021
CGIAR	7	Policy Brief: Critiques of Digital Tools in Agriculture: Challenges & opportunities for Using Digital Tools to Scale Agroecology by Smallholders	2022
	8	Digital Transformation for More Nutritious Food System	2021
	9	Food Systems Summit Brief: Food System Innovations and Digital Technologies to Foster Productivity Growth and Rural Transformation	2021
	10	ASTGS Flagship 8: Strengthening Research and Innovation Symposium Report	2023
FAO	11	Digital Agriculture in Action: Artificial Intelligence for Agriculture	2021
	12	Agricultural Robotics and Automated Equipment for Sustainable Crop Production	2020
	13	Shaping Sustainable Agrifood Futures: Pre-emerging and Emerging Technologies and Innovations for Impact	2024

Given the vastness, breadth and diversity of documents, the initial coding identified themes and documents were initially assessed through a first cycle eclectic coding method (Saldaña, 2021) to gain an overview for the contents of the text, and pick out relevant sections. MAXQDA was used as a tool to code these sections and highlight different themes. Figure 1 shows the initial coding process.

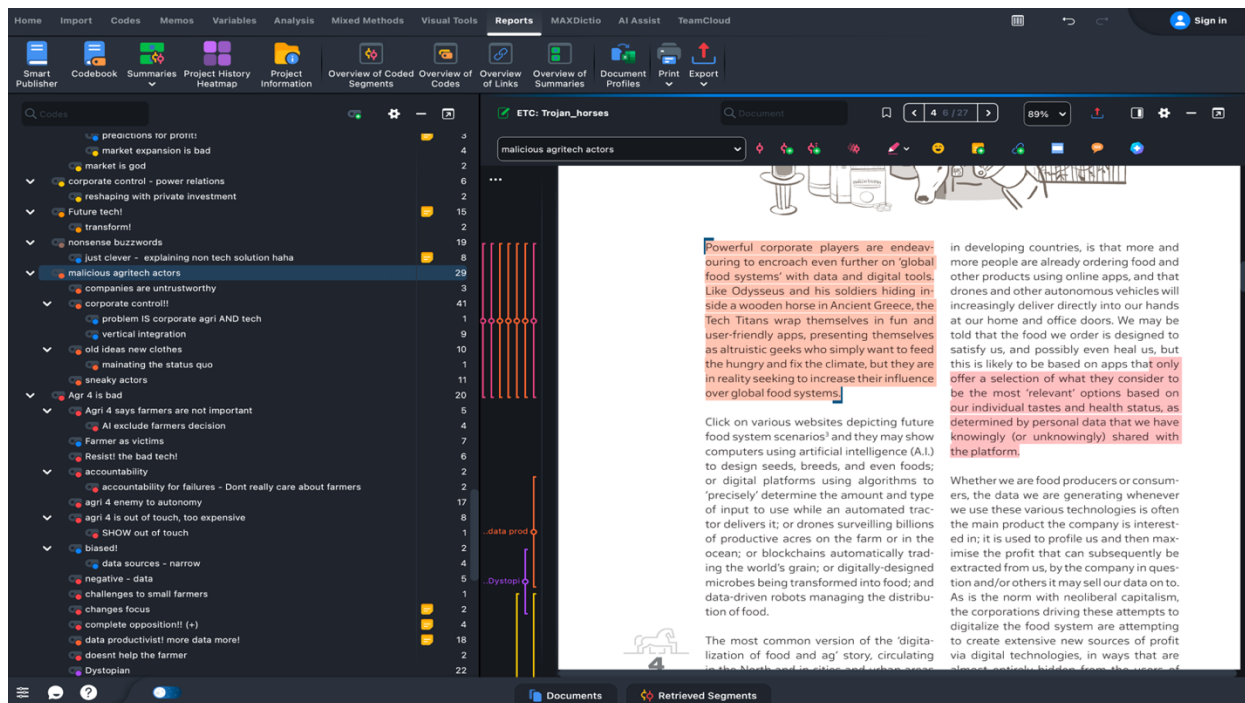


Figure 1. The MAXQDA desktop, which shows the list of eclectic codes created (right) and the document analyzed (left)

Then, CDA was applied to analyze highlighted aspects and organize them further through inductive coding. The software MAXQDA provides a streamlined means of accessing coded segments, and so highlighted aspects could be reassessed easily, shown in Figure 2. This second assessment was done by examining how and what information was presented and made salient (more noticeable), through symbols, repetitions, or contrasts (Entman, 1993, p. 53). CDA informed the lens through which this salience was assessed, connecting symbols with wider cultural discourses and language with their discursive functions. This process entailed close reading of passages, grouping and connecting, and thematizing the text.

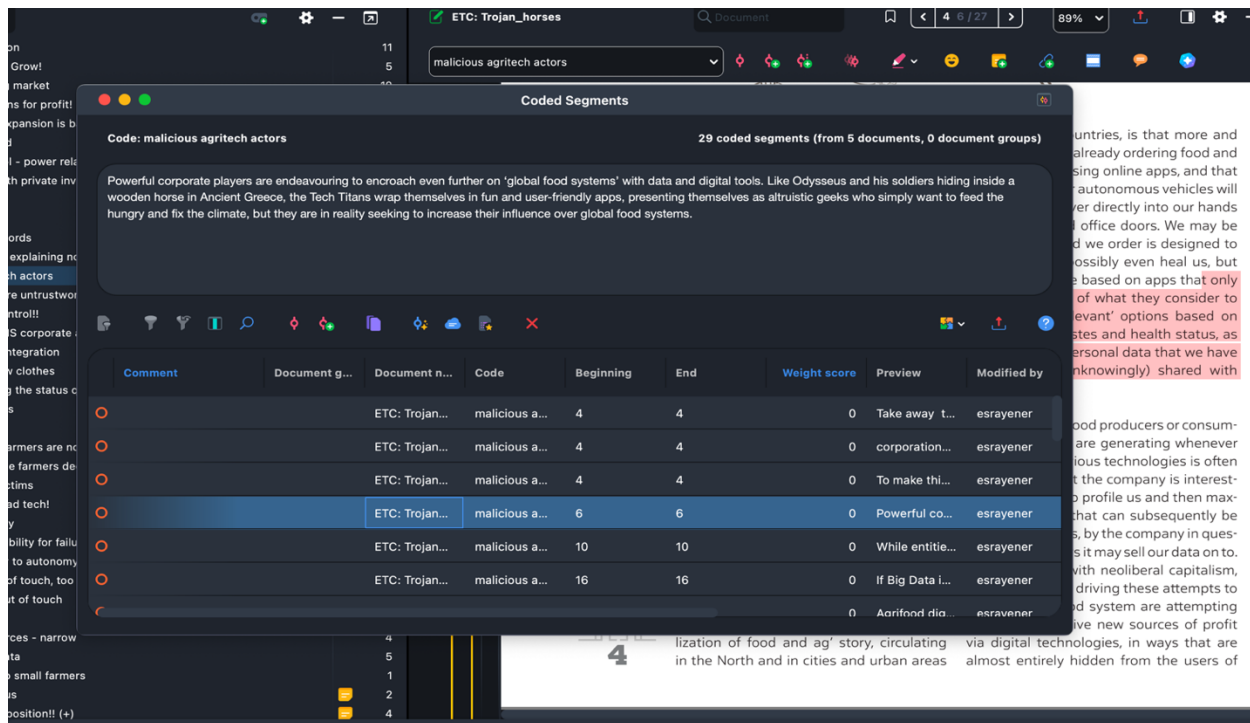


Figure 2. Accessing coded segments for second coding process by using the 'coded segments' window.

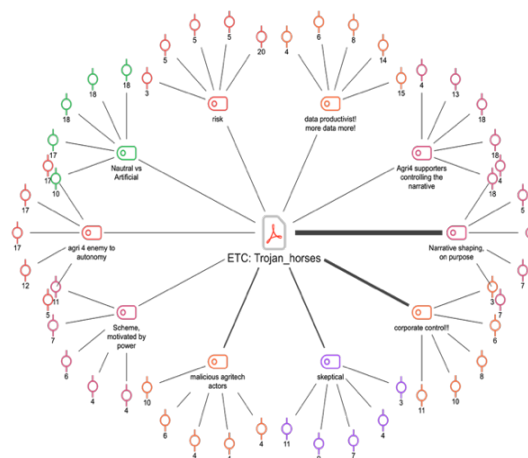


Figure 3. Visual of the ten most frequent codes for one text (aka single-case model) with line thickness based on frequency.

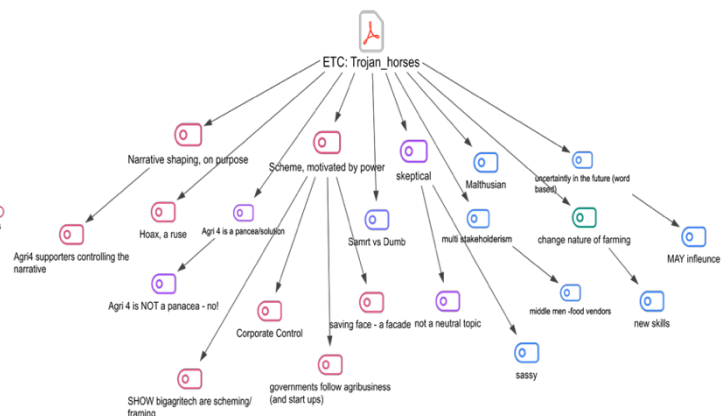


Figure 4. Visual of the ten most frequent codes for one text (aka single-case model) with two levels of sub-codes (aka code hierarchy).

The frequency of codes present in each document informed the organization of codes into frames, considering in the empirical work that frames rely upon general presentation of information, not simply specific examples. This was assessed through various visual tools in MAXQDA (Figure 3 and 4), which illustrated the prevalence of frames within each document. Taken together, the insights from CDA that informed codes and themes, and the prevalence of these codes and themes, were evaluated and different frames of Agriculture 4.0 crafted. These frames illuminate the understandings of Argi 4.0's place within food security, and the underlying discourses that inform them. These results will be detailed in the following sections.

5.2 Theoretical Tools: Critical Discourse Analysis and Frame Theory

In order to execute the document analysis, CDA and framing theories were utilized. Both stem from rich theoretical foundations, which are necessary in understanding their functions and applications.

By “discourse” there are generally two concepts meant. The first is conversations and writings, the use of language, on any topic, as defined by the literal meaning of the word. The second, born in scholarship and through the writings of Foucault, is the idea of *discourse*, a historically contingent social system that produces knowledge and meaning; essentially the molding of reality through language and thought (Olssen, 2014, p. 29). In this sense, discourses are made up of statements, ‘things said’, which are produced by systems of power, and produce ‘truth’ about subjects that reinforce these systems of power. They are positioned as ‘a priori’, or an inherent norm (Olssen, 2014, p. 28). In the mid-twentieth century there came a theoretical shift which questioned thinking of representations (i.e. words) as a direct reflection of reality. It instead moved to see them as a form of *signification* of reality (Locke, 2004, p. 11); through this shift, meaning and power is thought of as socially constructed. In this tradition, discourse analyzes the ‘things said’ to understand how they shape knowledge and power.

Critical Discourse Analysis, according to Fairclough, is then the study of the ways in which different texts or acts of speech are both formed by and form discourse. This perspective also understands the prevailing social order as historically situated, socially constructed, and subject to change, shaped less by individual will than by dominant discourses that define reality. It views human subjectivity as partially constituted through these discourses, which are enacted in how

people present themselves and perform their social identities (Locke, 2004, p. 1). CDA tries to work with both the macro and micro levels of this social construction, creating an analytic framework that ties the text and discursive practices to the discourse and social context. As Fairclough (1995) explains, “CDA looks to establish connections between properties of texts, features of discourse practice (text production, consumption and distribution), and wider sociocultural practice” (Fairclough, 1995, p. 87). Furthermore, the goal of CDA is to use this analysis, the clarified of the underworking of the text, practice, and context, to deconstruct the formations of sociocultural practices and ultimately deconstruct the foundations of ideologies. As Fairclough argues, “language is a material form of ideology, and language is invested by ideology” (Fairclough, 1995, p. 73), and “discoursal practices are ideologically invested in so far as they contribute to sustaining or undermining power relations” (Fairclough, 1995, p. 82). Locke (2004) defines ideology as “an elaborate story told about the ideal conduct of some aspect of human affairs” (p. 33). They further describe the power (what they call truth) of ideology:

In short, the truth of an ideology is determined by the number subscribing to it. The related term, 'hegemony', can consequently be defined as the state of affairs which exists when the subscription base of an ideology is broad in terms of numbers and reinforced 'vertically' by the social status of its subscribers. (Locke, 2004, p. 33)

Furthermore, they argue that “some discourses are more powerful than others” and those who subscribe to less powerful discourses are marginalized compared to their counterparts (p. 37).

Though it can be an influential tool for supporting those who “suffer from linguistic-discursive forms of domination and exploitation” by raising “critical awareness of language as a factor in domination” (Fairclough, 1995, p. 186), it is not without its shortcomings. CDA assumes homogeneity and passivity in its reader, not analyzing “how a text can be read in many ways, or under what social circumstances it is produced and consumed” (Blommaert & Bulcaen, 2000, p. 455). However, it remains an unparalleled approach to assessing and linking the macro-domains of governments and policy with micro-domains of discursive practices (Fairclough, 1995, p. 87).

How is one to make sense of the many components and layers involved in CDA? For the context of this thesis, which seeks to parse out the different ways food futures are perceived and conveyed, one can couple CDA with the concept of frames. Frame Theory stretches across the disciplines of psychology, sociology, and communication studies, with variations in its formation. Entman

(1993) laid out a set of fundamentals, based on framing as a research paradigm (p. 56) and the components of selection and salience. As he writes:

To frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described. (Entman, 1993, p. 52)

To put it plainly, what is included in a text about a topic (and conversely what is *excluded*) changes the way in which it is presented to an audience. As a research paradigm, framing is useful; it identifies the dominant messages in communications, those most likely to be interpreted by the audience, rather than focusing on uncommon themes and weighing them equally (Entman, 1993, p. 57). As noted, there are four components to the work of a frame according to Entman (1993); *the problem* and the forces creating it, or *the causes*; *the moral evaluation*; and the treatment, or rather, *solution*. Other traditions identify three aspects of a frame (diagnostic, prognostic, and motivational) (Benford & Snow, 2000), but this thesis benefits from specifically identifying the four components following Entman's tradition.

Benford and Snow (2000), in their assessment of framing in social movements, note that “social movement scholars conceptualize this signifying work or meaning construction by employing the verb ‘framing’” (Benford & Snow, 2000, p. 614). It is an active, dynamic process of reality construction, denoted by the work of social movements and activist who generate frames differing from dominant ones, referred to as “collective action frames” (Benford & Snow, 2000, p. 614). This type of meaning construction is not bound to social movements however, as Rychnovská (2014) shows in their analysis on securitization and frames, particularly in a debate-oriented setting like the UN Security Council. They argue that reconceptualizing securitization through a process of ‘threat framing’ “allows for highlighting more specific discursive ‘struggles’ over [its] interpretation” and “the analyst can look at the different discursive contexts in which the framing processes are embedded and trace how the underlying power relations play out in the process of negotiating the meanings of frames” (Dagmar Rychnovská, 2014, p. 16). In other words, the meanings of threats are formed by their particular frames, which are ‘negotiated’ through discursive practices and informed by power relations. The process of presenting a topic is also a process of constructing meaning.

As Bolman (2022) says, the ‘frame’ is “a mental structure of beliefs, perceptions, and valuations social actors use to interpret their worlds” (Bollman, 2022, p. 2). Based on these diversified mental structures, various frames emerge and “the notion of a problem or solution, can be understood in different ways, according to different frames, highlighting specific aspects and leaving out others.” (Van Hulst et al., 2025, p. 79). In this way, the same topic, like food security or smart farming, can be framed in very different ways, attributing to it very different problems, causes, solutions, and blames. Combining frames with CDA allows for not only an assessment of the attributes of a topic, but also the foundations of its construction; the power relations it is embedded in, the ideologies it builds, and the specifics of how it negotiates meaning. Through this analytical combination, it is possible to understand how these frames illuminate or obscure visions of the future, or sociotechnical imaginaries, which will be discussed in the final section. The application of these tools onto the documents will be presented in the following section, providing an overview of the frames identified and insights into how the three layers of CDA informed these formations.

6. Results: Frames of Agriculture 4.0

Informed by the Critical Discourse Analysis, seven prominent frames were identified. The frames identified are not exclusive, nor exhaustive, of the ways in which Agriculture 4.0 is presented in international texts or the publications of these organizations. Rather, based on the sample, they encompass the most prominent frames used by the diverse organizations in order to better understand the conceptualizations of Agri 4.0 and their relationships to each other. Texts can use multiple frames, often which work to reinforce each other's positions. As such, some frames overlap on aspects of their problem, solution, cause, and moral judgement. However, some frames contradict each other and stand in opposition. In general, the frames all deal with similar problems of hunger, food security, environmental degradation, and livelihoods, though with different focuses and different causes, solutions, and morals evaluations.

6.1 The Panacea Frame

In this frame, Agriculture 4.0 and its encompassed technologies and plans are presented as the solution to a vast array of problems facing the agricultural world and the world in general. The word 'panacea' come from Greek and Latin roots for medicinal sources, and means a cure-all or remedy for all problems; typically, it is used in the negation of its definition, describing that something is *not* a cure-all. This use has also been peppered throughout literature on Agri 4.0 and within the utilized documents. The problems presented in this frame, like hunger and malnutrition, are presented as very technical problems, caused in essence by a lack of tools or adoption of tools. Although there is usually acknowledgement of the need to implement tools in local contexts and support farmers, the emphasis is still on the necessity of the tools. Other agricultural issues (which can affect food security) like poor yields, environmental degradation, or even unjust agricultural production can, under this frame, be resolved with the right technical utilities. In this frame, the cause of, for example, dwindling water resources, is the inefficacy of watering systems. Therefore, the solution would be a way to, while upkeeping current agricultural production, use water more efficiently. Agri 4.0 is then an obvious *means* for this solution, as it includes practices like precision agriculture. The examples below showcase these aspects of this frame.

Rapid evolution of artificial intelligence (AI) technology offers a new tool for making agricultural practices more efficient, equitable and less damaging to the environment at a

time when progress is critical to achieve the targets set by the global community. (Elbehri & Chestnov, 2021, p. 11) [Document 11, FAO]

The threefold outcome of efficient, equal, and environmentally friendly agriculture shows how the ‘new tool’ is or will be able to fix a wide array of issues present in agriculture. ‘Critical’ progress is clearly referring to artificial intelligence, positioning it as both necessary and desired by the global community. Finally, as ‘global community’ targets are prioritized, this shows a top-down approach to the agricultural practices referred to; the threefold improvements will (and should) in this frame occur based on the global communities’ judgments.

The following example shows how Agri 4.0 can solve challenges facing smallholder farms.

Increased crop production and diversification of the types of crops grown due to the optimization of the cropping system can contribute to reducing the dependence on food items from distant production areas. Furthermore, diversifying food consumption can enhance the dietary intake and overall nutrition of the farmers. (Valle & Kienzle, 2020, p. 17) [Document 12, FAO]

Here, more production, facilitated by smart farming, is asserted to be able to help solve import dependencies. The idea that ‘optimizing’ farming can allow for crop diversification shows Agri 4.0 is presented as having the ability to do so (despite it being scientifically debatable). The authors then connect this Agri 4.0 outcome with the improvement of farmers’ diets, ignoring the question of whether farmers consume their own crops, especially if they are in import-dependent- risk contexts.

In the Panacea frame, problems of ethical production are solved by blockchain supply chains, pests are “solved” using digital identifiers and even the weather can be managed and conquered by the right technology. In this frame, large scale agricultural production can be sustainable, increased, and help feed the world. *Innovation* has the means to solve the problems facing the world and therefore all energies and resources should be put towards fostering innovation. It is assumed that the organization of food and economic systems are fine, should remain as they are, but need better tools. In this frame, technology and Agri 4.0 are not only uncritically accepted, but also expected. As it is positioned as the solution, it is unquestionable that it is needed and should be adopted; Agriculture 4.0 is *inevitable*. As such, it exclusively given a positive connotation;

Data-driven agriculture, with the help of robotic solutions incorporating artificial intelligence (AI) techniques, is the basis of sustainable agriculture in the future. (Valle & Kienzle, 2020, p. 13) [Document 12, FAO]

The idea of data-driven agriculture implies an agriculture that is driven by things other than data or evidence. This is the beginning of a dichotomy between smart farming and its implicit opposite, ‘dumb farming’ (Klerkx et al., 2019, p. 9). The text makes again clear that Agri 4.0 is inevitable, is the practice of the future. Additionally, the claim that these practices are the ‘basis’ of sustainable agriculture in the future, imply not only inevitability but also that practices without the use of such technology would *not* contribute to sustainable agriculture.

The Panacea frame assumes the position that current production of food is both needed and will even need to increase. Its focus on innovation and technology effectively leaves out other factors that affect the issues of food security, sustainability, and farming. Although the texts involved in these frames acknowledge the need for good governance and inequalities based on gender, location, or income, it is usually through a lens of how they will affect the adoption of innovations;

In addition, agriculture has an indirect impact on global health (food quality being one of the disease risk factors), gender equality (through its potential to increase access to resources and employment for women and children); and infrastructure (acting as a driver of local infrastructural development) ...

In this context, innovation in agriculture emerges as a crucial priority and an essential component of post-COVID-19 recovery. (Elbehri & Chestnov, 2021, p. 2) [Document 11, FAO]

The intersectional nature of agriculture was not lost in this text, but the sociopolitical aspects of this nature were. Rather, the technical aspects (employment, resources, food quality, construction) were acknowledged and presented as the critical factors for health, gender equality, and infrastructure. This is the context (literally presented) in which Agri 4.0 is the panacea; even when applied indirectly, it can solve all problems. Hence, the priority is innovation, which is ‘crucial’, rather than reform or redistribution. As this text is from 2020, Covid recovery was still a major theme – another challenge, according to this frame, solvable by Agri 4.0. The text also portrays

innovation as a technical feat that requires smart technologies, rather than just new ideas and methods.

Although the idea of adapting technologies to local contexts is usually promoted in texts, in one text the necessity of technology was so starkly ingrained that the opposite was presented,

The reality is quite the opposite, and in order to achieve the best results, the farm system must adapt to the robot. Farmers needs to adapt, in terms of both timing and mentality. (Valle & Kienzle, 2020, p. 12) [Document 12, FAO]

The ‘best results’ referred to, the groundbreaking potential benefits of Agri 4.0, are only possible through utilizing technology and prioritizing it. There is a steadfast assumption that this predetermined path will happen and should happen. Farmers are presented as passive participants, without the potential insight to decide upon the path forward. Instead, they must ‘adapt to the robot’, even in mentality. What exactly this means is unclear, but it represents the overarching assumption that farming *will change*, and farmers should change with it. What we can also point out from this example is the top-down nature of Agri 4.0 in this frame.

As Agri 4.0 is framed as positive and inevitable, any alternative ideas for food systems can easily be immediately dismissed. Food security is conceived as a technical issue, needing a technical solution, which is presented as Agriculture 4.0. In classical Malthusian and neoliberal tradition, more food production, now amended to be more *efficient* food production, is the solution to in food security.

This frame closely aligns with the idea of a technofix (hence the labelling it the “panacea” frame). As previously discussed, a technofix often overshadows sociopolitical drivers of problems, specifically climate problems. In the Panacea frame, smart farming acts as a technofix, enabling tunnel vision on technical causes and solutions to large, complex problems. It is reminiscent of the Green Revolution, with its top-down, technofix approach and introduction of innovations like High Yielding Varieties or robotics with the aim to drastically improve global issues of hunger and health. In such a frame, value is ascribed to scientific innovation and those who create and enable it.

6.1 The Development Frame

Although this frame shares similarities with the Panacea Frame, there are some significant differences. Like in the former frame, the problems of hunger, food insecurity, as well as environmental concerns are centered, but poverty is also centered. It is labelled as the Development frame because it aligns well with the canon of classical Development, as will be elaborated below. The causes of these issues are not simply lack of inventions and tools but also hinge heavily upon the *adoption* of tools. Hence, antiquated methods of agricultural production, unmodern institutions, weak economies and general ‘underdevelopment’ are positioned as the drivers. This frame, therefore, also sees Agriculture 4.0 as a solution (at least partly) to current issues as it adheres to (neo)modernization of farming, increasing agricultural production and subsequently enlarging agricultural sectors and economic growth;

Unfortunately, hand tools and animal power are still in common use in developing countries, hampering agricultural productivity and negatively affecting the livelihoods of small-scale farmers. Mechanization developments are therefore driven by the desire to reduce drudgery and eliminate hard work during labour peaks (land preparation, weeding, harvesting, transport etc.). (Valle & Kienzle, 2020, p. 1) [Document 12, FAO]

The use of ‘unfortunately’ to describe the state of traditional agricultural practices is significant, in that it signifies such practices as negative, bad, and even something to be pitied. This is amplified by the statement that, essentially, the loss of potential negatively impacts small scale farmers. This places farmers, agricultural production, and technology within the Development discourse, where ‘productivity’ leads to Development, which leads to better livelihoods. The negative connotation of ‘hand and animal power’ tools creates an opposite to the positively connotated mechanized agriculture. The statement that mechanization is driven by a desire to ‘reduce drudgery’ and ‘hard work’ not only ignores the previously mentioned productivity potential (and motivation), but also positions the transition of digitalization as one that is generally helpful. An overarching theme that can be seen from this passage is a sort of savior sentiment, in which machines and those who provide them can better the economic standing and daily experiences of farmers.

This frame also positions Agri 4.0 as inevitable, not necessarily because of faith in innovation and technology, but because those things are drivers of progress and development. Agri 4.0 symbolizes progress, and progress is both desirable and inevitable;

Traditional agricultural mechanization, characterized by the use of tractors and engine power, will be matched and even surpassed by automated equipment and robotics and the precision they can provide in farm operations. (Valle & Kienzle, 2020, p. 5) [Document 12, FAO]

In this passage, the idea of a succession of progress, each outdoing or ‘surpassing’ each other, within agricultural production is shown. This aligns with classical theories of Development, that suggest societies follow a series of changes, in a particular order, starting from primitive to modern. This succession starts with economic growth and ultimately leads to equality and improved livelihoods (Litonjua, 2012, p. 28). The implications of this frame are that old fashioned methods are both inefficient and (negatively) primitive. This frame, although generally applied, is especially potent when applied to agricultural contexts of the ‘Global South’, where a majority of farmers work on small farms and depend on them for income subsistence (Lowder et al., 2021). Agriculture 4.0 is a tool to implement Development initiatives and help farmers ‘catch up’; they can improve their own lives by increasing farming ‘precision’, yields, and income, and by increasing yields they can contribute to food security. The moral judgement of this frame is that smart farming is good because it *helps people*. This excerpt serves as a potent example:

She went from a farmer not recognizing diseases in her field to one who could easily spot them on her farm and on other farms, applying the knowledge she acquired from the PlantVillage app. (Elbehri & Chestnov, 2021, p. 35) [Document 11, FAO]

The farmer referred to is presented as being clueless of the diseases on her own crops, until she was given the tool to change that and ultimately better her practice. What makes this specific to the Development frame, rather than the Panacea frame, is the focus on the improvement to the individual, rather than the fixing of the problem as a whole.

Food security in this frame is seen both as a technical problem as well as one that is dependent on social factors like income. Both the increased production of food and the improvement of rural livelihoods are deemed necessary. What is also insinuated is that this cannot happen without the

intervention technology and Agri 4.0. As a result, a savior sentiment is formed; these technologies, and the people and institutions behind them, have a duty to *help* the farmers of the world, the food systems, and the environment. This is in fact the sentiment of the largest international organizations and many countries alike and has been since the food security agendas of the 1970s, and even since World War era interventions. It follows the sentiments of what was the social contract, now morphed into the Development project. As the US and newly formed international organizations (League of Nations, UN, World Bank) exported food and funded Green Revolution research in the name of *helping*, so too are Agri 4.0 endeavors positioned from a moral high ground. As we have seen with those past endeavors, the effects were multifold, but the interventions were exogenous to their context, often motivated by interveners' own interests and created hierarchies that followed suit. Yet, the idea of 'empowering' farmers, communities, or businesspeople is highly present in this frame;

Experiences in Kenya show that farmers who use the AI platform Ida can increase milk production and significantly improve basic knowledge on insemination time and heat detection. This empowers dairy farmers in rural areas to lift communities as a whole, to invest more in their farm and grow their business. (Elbehri & Chestnov, 2021, p. 47)
[Document 11, FAO]

This example clearly shows how empowerment has been integrated into the Development discourse (akin to 'empowerment lite', mentioned in previous chapters) so that it is enabled by increases in production. The empowerment mentioned is essentially economic growth for the farmer, which is insinuated to have a trickle-down effect into a wider community. In this way, this frame presents increasing production as a means of helping, and technology and its administrators as the saviors who facilitate this help, or Development.

It is important to note here that potential inequalities, specifically on data rights, are almost always mentioned. However, potential longstanding systemic structures less so. To understand fully the motivations behind interventions and Agri 4.0 endeavors, would be a different research project⁵. This thesis aims to point out similarities, and relationships to wider, established discourses.

⁵ See Klerkx et al., (2019) for a thorough list of potential research endeavors.

6.3 The Corporate Frame

The Corporate Frame is not far removed from the previous two frames, but has particular divergences that make its distinction necessary. In this frame, the problems of hunger and environmental crises are also viewed as technical problems, if not also related to Developmental issues, as their causes are lack of technology and underdevelopment. The solution, however, is very clearly rooted in economic growth. As it embodies a business-driven standpoint, it is designated as the Corporate frame. *How* to innovate and modernize? Through investments. *How* to improve livelihoods? Through new industries and more production. *How* to solve food insecurity? Through growing agricultural markets;

The availability of adequate and efficient equipment and its timely use are key factors in the transformation from subsistence-based to market-oriented agriculture. (Valle & Kienzle, 2020, p. 1) [Document 12, FAO]

This example shows how the Corporate frame positions agriculture as a business endeavor; the goal presented is to shift away from farming for food and towards ‘market-oriented’ farming, farming for profit. Although this sentiment overlaps with the Development frame, market-supremacy is a key distinction of this frame, where the farming industry is the focus (rather than the farmer) and the solution is market integration.

This frame conceives innovation and Development as business endeavors, or at least in need of private industry support. Here, market integration is the goal, and integration into the market is what can act as the savior or solution. This frame essentially puts everything up to the value of efficiency, specifically market efficiency. If farmers can be more profitable, they can produce more food or sell food at a lower cost, gaining advantages for them and all actors in the value chain. Agri 4.0 is a tool that can help do this.

This shift towards data-driven decision-making and collaborative partnerships is a promising step in revitalizing the agricultural sector, bridging the gap between researchers, extension services, and farmers at the grassroots level. By leveraging data and fostering synergies between various stakeholders, the agricultural sector can undergo a transformative change and regain its position as a key driver of economic growth and food security in Kenya. (Ndegwa & Maina, 2023, p. 30) [Document 10, CGIAR]

In this excerpt, ‘data driven decision making’ (the use of Agri 4.0 tools) and the inclusion of various stakeholders from throughout the value chain are what can achieve a goal, which is presented as revitalizing the industry. The idea of connecting different actors together enables both those working on and working outside the farm as relevant for the functioning of the industry (this is akin to multistakeholderism, which will be presented in the following frame). Here, it is through both data and the inclusions of actors outside the farm that the agricultural industry can again become profitable, and inevitably contribute to food security. In the Corporate frame, these solutions are explicitly presented as ‘grassroots’ or bottom up. However, whether they present a bottom-up approach, or are reminiscent of ‘empowerment lite’ attempts, is questionable. As discussed, ‘data-driven’ farming and decision making implies inadequacy in non-data decision making, i.e. farmer decision making. As is present in the Panacea, Development, and Corporate frames, the collaboration of technology and policy makers with farmers is a *desire*, though not something that is frequently happening.

The drive of business in this frame is made clear by other examples of multistakeholderism;

Farmers can access high-frequency, high-resolution data to make customized decisions. Traders can predict food supply and demand dynamically and connect producers and markets at the right time with the right volume. Policymakers can make informed decisions related to investments, smart subsidies, and risk management. (Benfica et al., 2021, p. 7)
[Document 9, CGIAR]

Each benefit provided by Agri 4.0 relates in some way to finance. To begin with, the idea that data is used for ‘customized decisions’ ignores the fact that a human-made decision is, indeed, already customized. Data collection, as has been mentioned in previous chapters, is often connected to the economic benefits it brings data collectors. The other benefits that traders and policy makers acquire are also based on the agricultural industry and financial functions. Finally, including *traders* as relevant actors in the agrifood system positions financialized practices as normal and established parts of agricultural sector.

In this frame, not only is capitalism extremely positive, but its success is the solution. Hence, actors that can bring about economic growth are valuable, such as start-ups, large agribusinesses, and financial institutions. Conversely, as enhancers of finance are valued, actors or sentiments that do not provide increased economic worth are not valued as much. Take the passage below as example;

Many commercial farmers struggle to find sufficient manpower to cover labour needs during the harvest season, especially in fruit and vegetable plantations. Agricultural robots can eliminate this gap and reduce the cost of specialized manpower. (Valle & Kienzle, 2020, p. 11) [Document 12, FAO]

The profits and accessibility to labor of farmers, particularly commercial farmers, is centered here. High value is placed on the robots, which can (deterministically said) assist such profits. What is left out is the importance of farmwork for seasonal laborers. In the context of wages for manual farmwork and also *who* these workers are (for example, in the US seasonal workers are often migrants with specific visas (DiNapoli, 2024)) or *who* they are elsewhere, this frame represents valuing profitability for commercial farms over disenfranchisement of seasonal workers.

Additionally, this frame, having centered businesses and growth, puts topics of autonomy, power, and longevity outside of the frame. If Agri 4.0 tools are not accessible or affordable to small scale farmers, the Corporate frame, given its solution is market-orientation (through Agri 4.0), uses financial mechanisms to ensure the adoption of Agri 4.0 tools for increased profits;

Small robots at an affordable price for purchase or hire represent a potential alternative in areas where manpower is scarce and conventional machinery is not available or is too costly for smallholders. Although farmers traditionally own most farm equipment, in the case of robotics, leasing or a service provision model may have advantages for both farmers and equipment providers. (Valle & Kienzle, 2020, p. 28) [Document 12, FAO]

The multistakeholder approach attempts a win-win for both farmers and equipment sellers. Leasing an agricultural robot is presented as a fix to limited farming resources, offering greater accessibility than either manpower or machinery. The question of how a robot could be more affordable to buy than a conventional machine is not presented in this frame, but the leasing scheme is. Renting can often impart a higher price than the cost of payment for a purchase over time, and usually has immediate economic gains for the owner or renter. The implications of changing the traditional ownership methods of farming equipment, to a leasing model also reflects wider trends in capitalists societies; as subscription-based services dominate, subscribers are beholden to the whims of the service providers.

On a macro level, it reinscribes an ideology of food as commodity regulated by markets, and capitalist relationships where workers are valued solely on their ability to create surplus. This ascribes power to the commercial farm and accepts the corporate model of food production. Issues of ownership, corporate consolidation, and exploitation are left out of this frame, as the focus is steadfast on constellations of collaboration for economic growth. This frame is also reminiscent of ‘sustainable intensification’ and ‘climate-smart’ agriculture, in that they all tend to reinscribe capitalist ideal onto agricultural practices, though frame such ideals as the solutions to global problems.

6.4 The Pragmatic Frame

This Pragmatic frame was utilized by most organizations to some extent, but particularly by two documents from the FAO and CGIAR. It presents the problems of food security, environmental issues, and inequalities from a much more intersectional standpoint. It questions the status quo but is not revolutionary, hence its name represents a middle ground intent on improvements, or pragmatism. In this frame, problems are caused by multiple factors; rising populations and environmental degradation are leading to poor and not enough agricultural productivity, old methods of production are unsustainable, and undemocratic processes are swaying food systems and bolstering injustices.

The solution is, in essence, reform. Agriculture 4.0, being potentially disruptive tool, *can* be the solution. However, it is not necessarily the fix and is acknowledged to have risks. What makes this frame stand out is its critique of both Agri 4.0 and aspects of current food systems, something which the previous frames acknowledge in passing if at all. The pragmatic frame keeps steadfast a belief in innovation but not necessarily in the ways it is cultivated. The example below illustrates this.

In an age of polycrisis, where challenges are interconnected and often escalate, simply minimizing inputs and optimizing outputs is not enough. Beyond their traditional roles in food production and processing, technologies and innovations must catalyze systemic change, with ethical and sustainable use at the forefront. (Alexandrova-Stefanova et al., 2024, p. 26) [Document 13, FAO]

This example shows how the frame views the problems of food security, environmental degradation, and livelihoods as interconnected, as ‘polycrisis’. Rather than a technical outlook on these issues, it views them through a more multifaceted lens. Addressing uses for technologies ‘beyond’ agricultural production does not refute such uses, but also does not present them as all-encompassing nor as a solution. Instead, using tools for ‘systemic change’ would both keep the set paths of innovation, but alleviate the problems they cause. The disconnect, or misuse of tools and systems is the issue, and reform is the solution. A second example clarifies this further;

Many tools don’t include progressive agriculture content or practices and lack robust scientific evidence behind recommendations. A greater effort to include diverse and progressive practices for climate change adaptation and mitigation as well as agroecology is needed to strengthen the resilience of smallholders. (Shelton et al., 2022, p. 2) [Document 7, CGIAR]

Here, Agri 4.0 is criticized for its hypothetical nature and the tendency to sideline non-technical methods of improving agriculture. What is telling is the use of ‘progressive’ agriculture, which based on context, implies traditional and collective methods of farming as well as agroecology. The term ‘progressive’ is highly charged (especially in the current political climate) and is almost inescapable from its political connotations. ‘Progressive’ implies left leaning, in some cases liberal perspectives, usually pertaining to social justice and social systems⁶. To call these collective practices (components of food sovereignty approaches) by the name ‘progressive’ both refuses to acknowledge movements that outwardly oppose agribusinesses and presents the practices as having political alignments (as they often do). However, the text still calls for their inclusion, deems it necessary, showing both that it adheres to general systemic structures but opposes their current constellations. In other words, reformist.

A key component of the solution in this frame is multistakeholderism; it is the act of different actors engaging in governance over public issues (Raymond & DeNardis, 2015, p. 574). Like the Corporate frame, all actors in the value chain are promoted to cooperate and are said to hold equality on the same platform. Unlike the Corporate frame, where actors without profitability are

⁶ Although ‘progressive agriculture’ can literally hold different meanings, in the context of the text it signifies an agricultural approach with a set of values. The following article gives a contextual example see: (Goldstein, 2023)

inherently less valued, the Pragmatic frame positions all stakeholders on a level plane. It asserts that all parties must be listened to

This frame places Agriculture 4.0 as a tool, but one that must be *used responsibly*. It does not leave out how market failures and monopolies inhibit food security, but does not advocate for a new system. In this sense it is reformist, not radical. Those involved in the system have a duty to uphold it *the way it should be*. The system is not inherently faulty, but rather there are faults in the system that need to be fixed. This frame places responsibility on the policy makers, implementors, corporate actors and farmers to use Agri 4.0 well, and ensure it helps, not exacerbates, problems.

Digital and social justice movements and the agroecology community must work together to lobby for the needed legislation and regulation to create an inclusive digital ecosystem that preserves local and indigenous understanding and promotes co-creation of knowledge and practices with marginalized populations. (Shelton et al., 2022, p. 5) [Document 7, CGIAR]

In this example, the task of food movements is to create equitable ‘digital ecosystems’ within the current agrifood structure. The importance of movements is included, as well as local and Indigenous knowledges, but systemic injustices are left out.

Food security is understood similarly to the Development frame, where production and poverty alleviation must be tackled in a democratic and reflective way. All actors involved have a duty to uphold food systems, and as such all actors are valued and should be active participants in shaping agriculture. Large commercial agriculture is a part of the solution as well, since food production is still seen in a Malthusian way, but not at the expense of other stakeholders.

The Pragmatic frame sees agriculture as complex matter, one built upon relationships between the environment, people, and industries. In this frame, agroecological approaches to farming are given significant space, with or without the inclusion of smart farming, and concerns for the future of food systems are broad reaching. In this frame, Agriculture 4.0 is not seen as inevitable, but a change in food systems is. Much like how Holt Giménez & Shattuck (2011) describe the ‘reformist’ food movement of the mainstream, the Pragmatic frame seeks to improve upon existing structures, though exactly how this can be done presents a point of departure. However, cooperation between food systems actors is needed. As mentioned, this presents a multistakholderism, in which all

actors, or rather stakeholders (so those not directly involved in agriculture but involved indirectly), should cooperate to ensure the greatest utility for everyone.

The concept of multistakeholderism, particularly in food systems, has been criticized as a means of giving corporate actors more influence within food systems. Canfield et al. (2021) describes how the inclusion of powerful organizations in the UN Food Systems Summit presented a conflict of interest and an attempt at capturing narratives on food system transformation. Through legitimizing all interests in agriculture onto an equal stage, multistakeholderism does little to prioritize providing platforms for those stakeholders who have fewer opportunities to do so, or fewer resources (M. Canfield et al., 2021). In this way, with its quasi-equality, not-equity approach, it upholds power imbalances already in place, and even creates new ones where new, already powerful, actors are brought into decision making.

6.5 The Environmental Frame

In the Environmental frame, the primary problem is ecological degradation, hence its emphasis in the name. This is also connected to agricultural supplies and food security, but the main problem presented in the documents on Agri 4.0 focused on the environment. Unlike previous frames that also included ecological crises as a problem, this frame presents the cause as current ways of life; extreme production, resource extraction, energy consumption, disruption of ecosystems, emissions and so on. Broadly, capitalism and industrialization are the causes. Furthermore, current governance that has failed to institute environmental protections are also at fault. While in the Panacea frame the solution was innovation and Agriculture 4.0, in the Environmental frame innovation is in part the problem. New technologies and machines require materials and power sources, requirements which ultimately propel industrial-capitalist endeavors further;

Pandemics, climate change and the destruction of our planetary home have all been propelled forward by runaway technological fixes – always in pursuit of short-term corporate and capital gains, and seemingly without thought or care for long-term impacts and collateral damage, including in terms of massive disruption to lives, livelihoods and our environment. (ETC Group, 2023, pp. 2–3) [Document 4, ETC Group]

Indeed, digitalisation is responsible for environmental pollution and degradation across the world. (Schimpf et al., 2023, p. 10) [Document 2, FIAN]

As the two examples make clear, technology is the *problem*. Additionally, innovations are presented as technofixes, with neither good intentions nor positive outcomes. There is also a collective ‘us’ created, seen in ‘our planetary home’ which consequentially creates the opposing ‘them’, the perpetrators of the technofixes. Additionally, by claiming the environment, and as a ‘home’, rather than presenting it as an unpossessed object, the importance of the environment’s wellbeing is starkly centered. Here, capital gains are cast in an extremely negative light, and the pursuit of these gains is presented a cause of damaging livelihoods and the environment.

The solution in this frame, then, is methods of agricultural production and resource security that are connected to natural systems and are as unintrusive as possible. In other words, agroecology and other ecology-based approaches. Unlike the Panacea, Development, and Corporate frames which include ‘sustainability’ and ‘sustainable intensification’, this frame presents the solution as distinct from current processes. Capitalist endeavors, or large-scale farming, *is* the issue, therefore the procedure should be changed. In this frame, Agri 4.0 is often called out directly;

None of these so-called digital solutions will address the root causes of climate change;
(Chowdhry et al., 2022, p. 26) [Document 3, ETC Group]

Here, there is a rejection of Agri 4.0 as a solution, along with a skepticism on its title as such, through the use of ‘so-called’. This works to cast doubt upon the whole paradigm and delegitimize its claims.

In this frame, the moral judgment is that innovation, profits, and economic development have been prioritized over environmental concerns. Decision makers have let this happen and are continuing that praxis in the face of Agriculture 4.0. New technologies are exacerbating ecological crises and, unless greatly altered, will continue to do so. However, what this frame leaves out are the effects of technologies that do not incur environmental degradation. Food security in this frame is not seen as a question of food production alone, although environmental decline would possibly inhibit food supplies. This frame generally considers agriculture from a traditional standpoint, with a focus on land and nature as mode of farming. It broadly leaves food production done outside a farm, like in vertical farming or hydroponics, out of the frame.

6.6 The Iconoclastic Sovereignty Frame

In this frame food insecurity and environmental degradation are the main problems, as well as poverty, inequality, and power relations. The cause of these issues are very clearly corporate actors and the institutions that uphold them, whether that be financial institutions or supporting international ones. The title is combination of two words that describe the essence of the frame, which will be clarified subsequently. The cause, unlike the previous frames which focused on abstractions and systems, is very specific to the *actors*, or institutions as actors, that are to blame. Take this example on how pointedly the cause is framed;

Powerful corporate players are endeavouring to encroach even further on ‘global food systems’ with data and digital tools. Like Odysseus and his soldiers hiding inside a wooden horse in Ancient Greece, the Tech Titans wrap themselves in fun and user-friendly apps, presenting themselves as altruistic geeks who simply want to feed the hungry and fix the climate, but they are in reality seeking to increase their influence over global food systems. (Thomas & ETC Group, 2024, p. 6) [Document 5, ETC Group]

Here, corporate actors are positioned as antagonists. Not just corporate actors, but ‘powerful’ ones, who are attempting to ‘encroach’ upon food systems; this immediately posits corporate actions as negative. The reference to Greek mythology acts both as an analogy and to dramatize the statement and to increase its urgency. The analogy, which positions corporate actors as soldiers hiding in the wooden Trojan horse and the horse as the applications and software they have made, strongly asserts that the goal of these actors is control. It also asserts that any uses for the common good, or altruistic uses, are simply a ruse. Additionally, calling the façade corporate actors wear as ‘altruistic geeks’ does heavy work to discredit these actors and not only portray them deceivers but also strip them and their work of all legitimacy. What this example shows is one way in which this frame molds corporate actors (as well as others) into antagonists, plainly fraudulent and malicious, and therefore the *cause* of problems.

The solution, ergo, is the disempowering of the actors and institutions that have caused these crises in the first place. In their stead, new and more just institutions should be implemented; food sovereignty, sustainable or circular economics, agroecology practices. In parallel, the *empowering* of farmers (and peasants) is also part of the solution;

The vision of farming without farmers as artificial intelligence and digitalisation powered by algorithm created by those who benefit from these technologies take over agriculture and food systems need to be exposed, resisted and challenged (Chowdhry et al., 2022, p. 26) [Document 3, ETC Group]

This example shows a major component of Iconoclastic Sovereignty Frame, which is the disenfranchisement of farmers and peasants by corporate and powerful actors. The ‘vision’ referred to is a future plan for agriculture made by agribusinesses and tech actors (the established cause of problems) and it entails an AI and digital ‘take over’ of agriculture. Take over implies an unwanted and coercive shift, which starkly contrasts the language of the previous frames where this shift was inevitable, progressive and desired. Again Agri 4.0 is presented as means to a ‘benefit’ for these powerful corporate actors. Additionally, this example includes the phrase “farming without farmers” as the Agri 4.0 plan for agriculture; this phrase actively positions farmers as the center of the frame, of agriculture, rather than production or progress. It acts as another delegitimizing method, given that that a farmer’s activity is farming, and without the person it seems ridiculous that their activity can be executed.

Finally, this example also includes a call to action to ‘expose’, ‘resist’, and ‘challenge’ the mentioned take over, showing how this frame presents the solution as subverting power structures and actors in power. This is why the frame is called Iconoclastic Sovereignty; the word ‘iconoclastic’ embodies the tendencies to push against establishment, to subvert and take a radical position, while ‘sovereignty’ embodies independence and autonomy, and the central point of bottom-up authority. Hence, together they form an idea of autonomy through deconstruction of present institutions. As this frame is not just about resistance or sovereignty, the title should embody both.

Under this frame, big businesses are understood as an antagonist. Whether it be Big Ag, Big Tech, or newly formed AgriTech companies, seen as the cause of framed problems, they *should not* be a part of food systems, or at least decision making. Their involvement is presented as a coercive seizure of power. Investments in agriculture are displayed as nothing but another means to the same end – profit. Agriculture 4.0 is simply another mask for these corporate actors to wear while plundering the resources of the earth and societies. All statements of the benefits of smart farming and the promise of progress are interpreted with skepticism and cast aside as narratives, detached

from the reality of the subjects they speak on. There is clearly a good and bad side presented in this frame. Take another example of these distinctions;

Big Tech’s “solutions” narrative could be encapsulated in three words: “Don’t look down!” They want to keep us focused on the technofix tale of digital technologies being in “the cloud”, with an implication that those technologies are light and ethereal, and can contribute to achieving a clean, green future. What they don’t want is for us to look down and see that they are quite literally digging the ground, our territories and resources, from under our feet. (ETC Group, 2023, p. 6) [Document 4, ETC Group]

Here, Agri 4.0 technologies are again presented as a guise, rather than useful tools, and definitely not as real solutions. As the ‘tale’ referred to here that Big Tech is telling is for a ‘clean, green future’, this frame clearly presents that narrative (or even that framing) as false and deceitful. The connection of ‘cloud’ to light and ethereal, and its subsequent negation, show how the ‘tale’ of Agri 4.0 as helpful and (importantly) harmless, is inverted in this frame. Instead, powerful corporate or Big Tech actors use ‘tales’ to divert attention away from their malevolent activities. This text also presents an explicit ‘us’ and ‘them’ through referring to what ‘they’ do and do not want, and the digging (or extracting) around ‘our’ feet. In this way the ‘us’ advocates for justice, farmers, or other similar actors, and are protagonists diametrically opposed to the ‘them’. Furthermore, this example shows the portrayal in the Iconoclastic Sovereignty frame of resources and land as belonging to this narrative ‘us’. As a moral judgement, this assertion of belonging gives legitimacy to the ‘us’ actors, and authority over the management of resources and land. Conversely, it delegitimizes that of the ‘them’ (corporate, powerful, large AgriTech actors) and their authority and involvement within the management of these resources. Ultimately, it positions Agriculture 4.0 (as is currently stands) as a stunt for antagonists to steal power and resources.

What emerges is *distrust* in these actors, and subsequently the mainstream systems of international organization and governance. Hence, as the name of the frame attempts to suggest, a radical departure from these systems should occur, one that fosters autonomy for those currently disenfranchised by antagonistic corporate actors. More generally, this frame signifies dissent towards neoliberalism, and potentially capitalism itself.

This connects to wider ontological and political discourses, critiquing neoliberalism, food systems, and food security projects. In this frame, food security (not food security agendas) is conceived as

possible only through food sovereignty, only through radical subversion that reconstructs food systems entirely. It assumes that capitalism and market mechanisms cannot and will not provide what is needed for food security, because it suggests that it is not a technical issue, but rather one primarily caused by systemic injustice and greed. As ‘Iconoclastic Sovereignty’, it de-inscribes power from large organizations, companies, financial institutions and States, and instead places power relations as bottom up, as done by food sovereignty.

However, by antagonizing corporate actors, this frame also tends to present the protagonists, the reinscribed power holders, as victims of neoliberal greed;

Together, these potential negative outcomes suggest that the current corporate-driven push for digital technologies in rural areas in general, and AgriTech in particular, will result in an exploitative inclusion of small-scale food producers and rural people into markets. (Suárez & Seufert, 2023, p. 1) [Document 1, FIAN]

In this excerpt, AgriTech is predicted to have negative outcomes for small scale farmers (a stark contrast to the predictions of the positive impacts seen in other frames). Specifically, inclusion into markets is predicted to be exploitative, not beneficial, to rural people and producers. Although this expresses historic trends of market expansion into rural areas and specifically the Global South, it is also a totalizing prediction. In some instances, traditional economic growth and market inclusion can be beneficial to small scale farmers (Ma et al., 2024), just as traditional Development has had its advantages. This is not to say that the tendency towards exploitation is overstated (it is not), but rather that it is totalizing.

Although the solution is autonomy, decision making, and empowerment for these groups of people, the victimization assumes *one perspective*. What is left out are the legitimate experiences of people, especially those who have benefitted from economic growth or are interested in Agri 4.0 tools. As we have seen in previous chapters, the food security projects of the last century have produced mixed results, but have inherently changed the ways in which it was thought of. Economic growth has contributed to poverty alleviation, MDGs and SDGs have publicized socioeconomic issues, and Sen’s food security is, I would argue, the closest return to the Social Contract since its initial departure.

However, this frame does not dismiss technology all outright, but rather dismisses *Agriculture 4.0* as a paradigm.

Finally, we can see a clear tendency among bottom-up initiatives to use digital tools to advance broader aims of social and environmental justice, instead of focusing solely on maximizing economic benefits, increasing production, creating new marketing opportunities... (Suárez & Seufert, 2023, p. 2) [Document 1, FIAN]

This example shows that the Iconoclastic Sovereignty Frame does not take issue with technology itself, but rather those it deems as the puppet masters behind it. Here, the *use* of technology determines if it contributes to the problem (the goals of the antagonist actors, in this case ‘maximizing economic benefits’) or the solution (the endeavors of iconoclastic sovereignty, in this case ‘social and environmental justice’). By asserting that bottom-up initiatives use Agri 4.0 technologies for positive outcomes, they assert the positive and negative connotations of the two groups; powerful AgriTech actors and farmers, antagonists and protagonists, ‘them’ and ‘us’.

6.7 The Traditional Frame

The Traditional Frame is very similar to the Iconoclastic Sovereignty Frame but, like with all of those identified, has important distinctions. It also identifies food security, environmental crises, inequality as problems, but additionally stresses the erasure of traditional and Indigenous knowledge. Given its focus on traditional practices, it is dubbed as the Traditional frame. Though this is touched upon in the Iconoclastic and even Environmental frame, it is not in focus in them. The causes are, then, both corporate actors and institutions, and Development and industrialization more generally. As agriculture increasingly transforms into a profitable business and interested actors get involved, so fades the time weathered traditions of farming. In this way, Agriculture 4.0 is an extension of the cause; it is a direct replacement for both the people and practices that have historically made-up agriculture;

In agriculture, digitalization turns farming into a set of machine driven interactions between peasant farmers and their land, without any thought to the importance of a peasant’s relationship with the more than human worlds. This risks losing integral peasant knowledge, practices and innovations. (Schimpf et al., 2023, p. 10) [Document 2, FIAN]

In this example, the text portrays the transformation of digitalization not as one of progress and improvement, but as one of disenfranchisement of peasants and ‘traditional’ ways of life. Agri 4.0 is therefore, presented as ‘machine driven’, void of humans (like ‘farming without farmers’) and, additionally, ignorant. The digitalization transition is posited as not giving ‘any thought’ to the significance of relationships between humans and non-humans, indicating that it is ignorant, or perhaps just careless, of that fact. As Agri 4.0 is a cause of losing this knowledge and practices, the solution lies within these themselves. Additionally, the use of *peasant innovation* removes the term from deeply assumed position within new or digital technology and into its literal definition as new ideas or practices.

The solution in this frame is therefore a return to practices that functioned *before* and without industrial technology. If farming did not instigate ecological crises pre-industrial agriculture, then it won’t again. If food was independent of global inflation rates before colonial export systems, and was priced based on local arrangements, then it can be again.

This frame makes similar conclusions to the Environmental and Iconoclastic Sovereignty frames, which antagonize corporate actors and point out failures of governing and scientific systems, but it also establishes an anti-data position. While the Iconoclastic Sovereignty Frame is generally anti-establishment, the Traditional is anti-data, or partially anti-technology in that they risk overwriting tradition;

The undervaluing of indigenous and local knowledge systems and their monetization when reduced into data that feed digital systems need to be resisted and the rights and control of farmers and communities over data on them and their farms must be defended. (Chowdhry et al., 2022, p. 24) [Document 3, ETC Group]

Here a key point of the frame is portrayed, that the process of data collection of agricultural knowledge and transforming it into monetary value, undervalues this knowledge. Fighting against this trend is needed, as it is asserted that this ‘undervaluing’ of peasant knowledge must be ‘resisted’. Additionally, Agri 4.0 is presented as a threat, as this text declares farmers and communities should be ‘defended’. Finally, the text interestingly presents digital systems in parallel to food systems, where resources (be they food or data) are extracted from the farm and used to ‘feed’ the system.

The Traditional frame maintains that traditional knowledge and practices are valuable and *necessary*, despite their dismissal within Agri 4.0;

Despite this, corporations are very interested in this knowledge. For example, knowledge about the characteristics of plants and breeds selected by peasants and Indigenous Peoples have been pirated for scientific research and industry. (Schimpf et al., 2023, p. 13)
[Document 2, FIAN]

Actors within the science industry have ‘pirated’ information used by Indigenous Peoples for years. The use of ‘pirated’ here positions those actors as unethical or malicious, indicating not only that this knowledge is the basis for scientific research but also that it does not get due credit. Like in the previous two frames, corporations are presented as antagonists, though here their wrongdoings consist of *epistemological violence* against knowledge and practices; they cast them aside and simultaneously seek to profit from them.

This frame has semblances of similar sentiments concerning going back to the *Zeitgeist* of simplistic times, in this case referring to cultural revivalism, especially of Indigenous cultures. However, it generally omits the challenges of pre-industrial farming and rural life, and by antagonizing the scientific community, also overlooks its positive contributions. By centering traditional and Indigenous practices, it places greater value on them than other frames but does so at the risk of dismissing certain positive outcomes of technological innovations.

Food security, subsequently, is also understood as a systemic problem, created in part by the innovations and barriers of the industrial and neoliberal era. Again, food sovereignty is a way towards solution. Although it is not uncritically examined, and not always touted as being the only method of farming needed to increase food security, local food systems are central to the frame. Historically (something this frame draws upon), exogenous intervention to agricultural practice has altered those rural contexts and often resulted in loss. Specifically, this frame is related to the Green Revolution, when traditional seed varieties were discarded, or permanently lost, in the wake of HYVs and monocultures;

Discounting and marginalising diverse knowledge systems evolved by farmers and indigenous communities over centuries would not only make cultures and practices that enabled resilience and adaptation to ecological, environmental and social shocks disappear

but would wipe out local and indigenous varieties of crops and species of animals that provide food security for the population. (Chowdhry et al., 2022, p. 23) [Document 3, ETC Group]

Here, the text articulates that knowledge systems by farmers and Indigenous communities enable ‘resilience’ and have the capability of dealing with the problems of environmental and social shocks. Additionally, as it states that Indigenous varieties of crops and animal species provide food security, it insinuates that their replacements (i.e. monocultures) would not do so. Hence, these practices are presented as the solution in this frame, and Agri 4.0 as a risk to them. This example also mentions ‘cultures’ in addition to practices, which both illuminates the more-than-technical aspects of agriculture and agricultural communities as well as the perspectives of agriculture as a more-than-technical practice, rather a relational one as its seen as in agroecology. Agroecology is presented in this frame as well in line with traditional practices, and therefore part of the solution.

The Traditional frame deals with epistemological discourses on Development, colonialism, and agriculture. Power is reinscribed to Indigenous and small farming communities, their knowledge and traditions centered and presented as superior, or more knowing, than high-tech knowledge, which emerges as their counterpart.

Each document presented more than one frame, given that frames are relational and texts lend themselves to multiple interpretations. Some reinforce each other and work well within a single document. Some documents, namely those of the ECT Group and FIAN, seemed to ‘call out’ types of existing frames, using this as a basis for their own framing. Some frames are more heavily embodied by some documents than others, but it is especially clear that the Panacea, Development, and Corporate frames are embodied by the FAO and CGIAR documents, while the Environmental, Iconoclastic Sovereignty, and Traditional are embodied by FIAN and ETC Group documents. The Pragmatic frame is mostly embodied by two documents from the FAO and CGIAR.

As apparent, some of these frames directly clash with one another. This, I would argue, results in the apparent dichotomies of Agri 4.0 and Food Sovereignty (among similar dichotomies). To this end, I distinguish several binary distinctions that inform this opposition. The most prominent perhaps, is a “smart /dumb” binary. Touched upon by other scholarship (Klerkx et al., 2019, p. 9), this binary shows that by conveying as certain things as ‘smart’ (economics, farming, climate

actions), inherently, what does not fall under this label must be conceived of as ‘dumb’. Similar binaries (using language from the texts) are modern/primitive and innovation/regression.

Table 2 *Frames*

	<i>Problem</i>	<i>Cause</i>	<i>Moral</i>	<i>Solution</i>
Panacea	Hunger, Food Insecurity, Climate	Outdated tools, External factors	Innovation is inevitable, Agri 4.0 is inevitable	Innovation, New tools, Technology
Development	Hunger, Food Insecurity, Poverty, Sustainability	Underdevelopment, Lagging behind, External factors	Savior sentiment, Progress is inevitable, Agri 4.0 is progress	Catching-up, Leapfrogging, Technology adoption, Interventions
Corporate	Hunger, Food Insecurity, Poverty	Lack of investments, Slow economic Growth, External factors	Market supremacy, Economic growth priorities, Agriculture as business	Market integration, Industry growth, New markets, Technology
Pragmatic	Hunger, Food Insecurity, Poverty, Climate, Inequality	Underdevelopment, Monopolies, Undemocratic governance	Technology is neutral, Agri 4.0 needs critical assessment	System reform, Responsible technology use, Multistakeholderism
Environmental	Climate, Food Insecurity, Poverty	Industrialization and Development, Profit seeking	Anti-Industrial, Anti-Institution	Systemic change, Agroecology
Iconoclastic Sovereignty	Food Insecurity, Inequality, Poverty, Autonomy	Companies, Financialization, Powerful institutions, Profit seeking	Malicious AgriTech actors, Agri 4.0 as trick, oppositional	Dismantle power structures, Food Sovereignty,
Traditional	Food Insecurity, Inequality, Poverty, Climate	Financialization, Powerful institutions, Companies, Industrialization and Development, Epistemic changes	Traditional and Indigenous knowledge value, Agri 4.0 ignorant, Epistemic violence	Return to tradition, Systemic Change, Food Sovereignty

What approaches are valued and why? As we see, the Panacea frame draws upon classical Development discourses, originating in colonialism, that value epistemic traditions of the enlightenment in Europe. Meanwhile, the Traditional frame values Indigenous, pre-colonial epistemologies. They represent two divergent ways of interacting with the natural world; a rational and a relational way. How does one make sense of these frames, and the oppositions and relationships they present? As Agriculture 4.0 is an emerging paradigm, much of its discourse is

focused on the future; as such, the frames identified present both an understanding of food security and a frame for its future. Agri 4.0 frames provide insight to wider conceptions, values, desires, and plans. They inform, therefore, broader imaginaries on the future of food, the relationships between technology, humans, and nature, and positions within this future. The following section will deal with the discussion of how these frames translate into visions of food futures, and the implications they hold for power structures within food systems.

7. Discussion

The differing frames presented by international organizations illuminate contested understandings of food security, and how these understanding fit into broader discourses. In turn, these frames, with their choices of salience, inform not just how Agriculture 4.0 is understood at present, but the imagined futures it exists in. To foster discussion on (contested, related, and supported) visions of the future of food with Agri 4.0, the employment of imaginaries, specifically, sociotechnical imaginaries, is beneficial.

7.1 Contested Futures: Sociotechnical Imaginaries of Agriculture 4.0

The Imaginary is a term used to describe a set of values, visions, and desires on real or perceived aspects of life within collective society. It is considered a loosely defined term closely tied to (post)structuralist ideas of signification and sight that, as mentioned, shifted studies in the social sciences. It has varied traditions, and slight distinctions from other forms of meta interpretation, like a master narrative, in that it is changeable, changing, and nonrigid, and operates outside of binaries (Jasanoff, 2015, p. 29). In their anthology, Jasanoff & Kim (2015) form a conceptual tool to understand the ways in which collective perspectives of the future are formed. Sociotechnical imaginaries, as they are called, are defined as “collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology” (Jasanoff, 2015, p. 4). As the authors claim, little research has been done to understand why differences occur in the moral establishment and utilization of technologies by different groups, or even the interplay between technology and society in general. For, indeed, it is “users, from commuters to racers, who ultimately gave cars their utility, appeal, and meaning” (Jasanoff, 2015, p. 2); technology and the social are intrinsically shaping and shaped by one another, an aspect which the authors call “co-dependence” (Jasanoff & Kim, 2015). Sociotechnical imaginaries fill in this analytical gap by providing a theoretical framework to understand the complexity of these relationships.

The sociotechnical imaginary is a way to assess visions of the future and is particularly valuable when worked into a comparison as, like imaginaries in general, it allows for different visions to coexists. As Jasanoff writes: “Then, too, by allowing for competition among different visions of

futures, the framework of sociotechnical imaginaries restores some of the indeterminacy of history and avoids the determinism built into grand narratives of scientific progress” (Jasanoff, 2015, p. 23). The future is not deterministic, nor is the course of technology, but rather deeply dependent upon the will of people and societies. It was not inevitable that cars overtook US transport, but an interplay of desires, fears, perceptions and performances that ultimately shaped their path.

Jasanoff makes a distinction between sociotechnical imaginaries and other social theories, positioning *master narratives* as too immovable and *discourses* as too focused on language; plans as formal designs for the future rather than “shared cultural property”, and policies as indications of action rather than rationale (Jasanoff, 2015, p. 20). Furthermore, they attempt to lay out some best methods in order to understand sociotechnical imaginaries, which are, generally, “methods of interpretive research and analysis that probe the nature of structure-agency relationships through inquiries into meaning making” (Jasanoff, 2015, p. 24). They emphasize the usefulness of comparison, which can help “identify the content and contours of sociotechnical imaginaries” while avoiding taking epistemic and ethical assumptions as universal rather than situated (Jasanoff, 2015, p. 24). Although there are many “fertile grounds” on which to realize such an analysis, “policy discourses and processes of issue framing and agenda setting offer one commonly recognized starting point” (Jasanoff, 2015, p. 25). It is with this in mind that this thesis attempts to situate its empirical work within the schematic of sociotechnical imaginaries.

Although imaginaries are positioned by Jasanoff & Kim (2015) as distinguished from discourse, this does not mean they are mutually exclusive. As discourse is pivotal in shaping ideology, power relations, and influence on our understandings of the world, they unequivocally influence the imaginary. This thesis uses Critical Discourse Analysis as the analytical paint and framing as the brush, to ultimately canvass the varying sociotechnical imaginaries on the future of food as presented by prominent international organizations. The varied array of actors chosen can provide a stage for comparison, allowing us to understand the varying frames and, consequentially, better understand sociotechnical imaginaries and the way they “coexist within a society in tension or in a productive dialectical relationship” (Jasanoff, 2015, p. 4). Essentially, I argue that utilizing these different analytical tools is useful in understanding and deconstructing meaning construction, power relations, and their positionality. Visions of the future are contextually situated in and

informed and influenced by hierarchies and ideologies, which are visible through the frames chosen to present a topic, and discursively produced through communication and performance.

As such, the results of this empirical work, the frames identified, can now contribute to understanding competing visions for the future of agriculture and, as Jasanoff (2015) said, avoid the determinism of scientific progress. The frames show us distinctions between the ways these different organizations view Agriculture 4.0 and food security, and the framework of sociotechnical imaginaries allow us to make sense of them in larger contexts and in relation to each other. What is clear from the results of this analysis is that different frames interact with each other; some validate and strengthen one another, some stand in contradiction or opposition. Ultimately, technology and food security are presented under a range of different interpretations, resulting in varied judgements of their relationships in and to the future.

Some of these visions of the future are diametrically opposed to one another. While Agriculture 4.0 is the solution in the Panacea frame, it is a cause in Environmental frame. In fact, Panacea, Development, and Corporate frames stand strongly in opposition to Environmental, Iconoclastic Sovereignty, and Traditional. This means that between the FAO and CGIAR (who embody the former three) and ETC Group and FIAN (the latter three), there exists contradictory understandings on food security, sustainability, and Agriculture 4.0. Through conceptualizing these differences within sociotechnical imaginaries, we can analyze their relationships and the dynamics within the international food policy arena.

A striking result is the emergence of Agri 4.0 bringing about food futures that are either utopian or dystopian. Utopias, and consequently dystopias, are most present in literary studies, where stories embody extreme visions of the future. A utopia paints a perfect world or society, while a dystopia is the opposite, a worst-case horror. Both are prominently connected with ideas of the future and conceptualizing the unknown effects of today's actions on future societies, very often being embodied in science fiction (Gallardo & Russell, 2014). Some scholars have argued that development as a discipline itself can be conceived as a utopia because, as Daniel and Neubert (2024) claim, it includes aspirations of the future that are unrealizable; it is unable to contend with “contradictory promises” of eradicating poverty and improving living standards with sustainability (Daniel & Neubert, 2024, p. 192). As the Panacea, Development, and Corporate frames see Agri 4.0 as a solution to global problems of food security and climate (especially the Panacea frame,

given its name also indicates utopian ideals), I would argue they represent a *utopian imaginary* of the future of food systems involving Agriculture 4.0. On the other hand, the Environmental, Iconoclastic Sovereignty, and Traditional frames position the growing influence of Agri 4.0 as a threat, a risk, and a problem to people and the planet and so would represent a *dystopian imaginary*. To be clear, there is a existing body of research on ‘food utopias’ specifically.

Typically, ‘food utopias’ are diverse philosophies of hope about food, which also represent a shift away from a confined, dominant narrative of production (Stock et al., 2015a, p. 4). However, as Horton (2024) points out in their paper on utopian narratives in the 2021 Australian Food Systems Summit, although originally food utopias were meant to represent hopeful, justice-based visions of the future, their article “has illustrated that not all food utopias are necessarily aligned with principles of care, justice, and sustainability. Rather, they may reflect entirely different ideas, and emerge according to complex power dynamics” (Horton, 2024, pp. 7–8). Therefore, what a ‘food utopia’ would entail in the dystopian sociotechnical imaginary of Agri 4.0 has core differences to a ‘food utopia’ in the utopian sociotechnical imaginary of Agri 4.0.

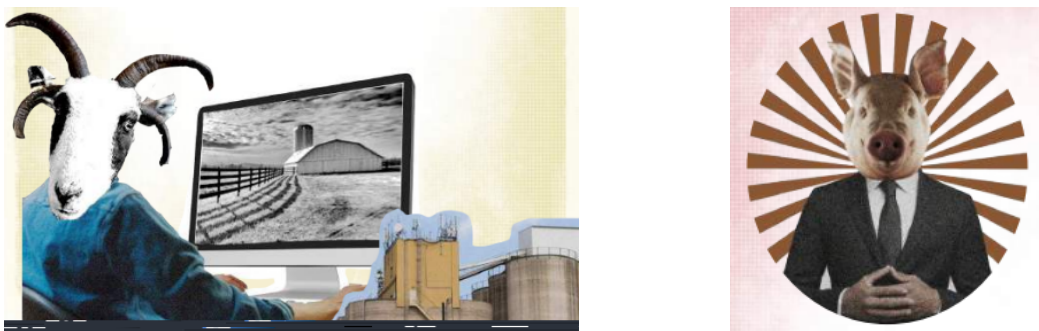


Figure 5. Dystopian-style illustrations. Image by K. Romero & M. R. Blasco, In Remote control and peasant intelligence (Schimpf, M., Seufert, P., & Van Dyck, B., 2023, p. 38, p. 26) Copyright 2023 by K. Romero & M. R. Blasco

Although this study did not undertake a visual analysis, it would be remiss to ignore some of the compelling imagery presented in the documents. With particular regard to the formation of dystopian and utopian notions, the images both reflect these ideas and (most probably) contribute to them. To illustrate this point, a few potent examples are included. These images all portray themes of Agri 4.0, but the undertones, and hence meanings are widely different. Some are jarring and would certainly stir up strong reactions in a viewer, as demonstrated in Figure 5. Although a comprehensive analysis of these images is not provided here (but would be an interesting

endeavor), these visuals reinforce the conclusions of this thesis regarding dystopias and utopias sociotechnical imaginaries, and their stark distinctions. Even the cover pages show a striking contrast, presenting a bright harmony of technology and farming (Figure 6), contrasted with a frightening, dismal aesthetic (Figure 7).



Figure 6. Utopian-style cover art. Image by Freepik in *Shaping sustainable agrifood futures* (Alexandrova-Stefanova, N., et al., 2024) Copyright 2024 by Freepik.



Figure 7. Dystopian-style cover art. Image by G. Laidlaw in *Challenging the digitalization of the agrifood chain* (Thomas, J. & ETC Group, 2024). Copyright 2024 by G. Laidlaw.

Differences in the understanding of food itself, to draw from Borghini et al. (2020), emerge from these distinctions. The authors conceptualize that the polarization in food discourse is underpinned by different ontological understandings; on the one hand, technological fixes to human diets “convey the idea that each food can be food for everyone since a universal technology can feed humanity despite social differences” and see food as something controllable and artificial, while “anthropological fixes, instead, assume that a universal moral change can save humanity from food crises” and see food as something autonomous and natural (Borghini et al., 2020, p. 121). This falls in line with notion of development as utopian and the visible rift between academic and civil society advocates for alternatives and the science, politics, and industry proponents of dominant economic Development models. In it,

one side promotes technology-based growth within the framework of a globalised capitalist economy with a greater or lesser degree of welfare-state cushioning. The other side criticises this belief in growth and technology and sets the goal of ecological and social

sustainability, a fair distribution of goods based on self-reliance and local self-governance. (Daniel & Neubert, 2024, p. 191).

Distinctly, this techno/anthro-fix divide is exemplified again, and is evidently a consistent theme in global governance and development discourses.

As we have seen, Agriculture 4.0 is often regarded as a technofix, and the utopian imaginary generally understands it as a catch-all as well, following a longer history of technological interventions into global farming starting with nutrition sciences in the post-war era. As such, “imagining the future of food, the advocates of the technological fix tend to think about food in the nutritional dimension only. They focus on yields, production per acre, minimal caloric requirement, framing the problem of feeding the world in terms of input and output” while, “conversely, anthropological fixes by and large privilege the cultural dimension of food” (Borghini et al., 2020, p. 126). This rift has been present time and again in food security discourses, starting with the post-enlightenment shift that viewed hunger as a biochemical, rather than social deficiency (Scott-Smith, 2020, p. 11), through to the promotion of ‘sustainable intensification’ for feeding the world. One could argue that the sociotechnical imaginary of food security in the international community has been dominated by a glorification of technology and rationality, which is present today. The existence of the dystopian Agri 4.0 imaginary denotes that, in the least, there are multiple collective desires, or that this utopian imaginary is not representative of the *people’s* collective desire. The Agri 4.0 dystopian imaginary presents, perhaps, the disillusionment of people and the perception that technology and governance is no longer following the social contract, as with the developments of neoliberalism, and does not serve the majority anymore (Misaki et al., 2008; Rousseau, 1762). However, to understand how representative these imaginaries of international actors are of civil society, other studies should be undertaken.

Despite the need for empirical evidence on the sociotechnical imaginaries of Agri 4.0 in food and food security from civil societies, based on current research an educated guess would be that this version of a ‘food utopia’ - productivist, profitable, and technological - is not representative of most people or institutions within civil societies⁷. This can be seen through the motivations and formations of power within the food system and policy arena, which privilege particular values

⁷ Many publications deal with the traditional idea of ‘food utopias’, centered around local contexts, civil societies, or strong visions of justice. Further reading see: (Stock et al., 2015b).

and closed groups. The concentration of power in the agrifood system is well documented, as we can recall from our framework of food regimes theory and the current constellation of the corporate food regime. With particular regard to the international food policy arena and influential actors, the emerging paradigm of *Philanthrocapitalism* is prevalent, and helps contextualize the frames identified in this research and the subsequent imaginaries.

Philanthrocapitalism is the new formation of combining philanthropic endeavors with capitalist ventures, sometimes referred to as ‘venture philanthropy’; actors providing capital for philanthropy are increasingly gaining influence in the processes and products of these endeavors (Edwards, 2011, p. 389). Hence, wealthy individuals are gaining more power within these systems and, as decision making is skewed to the origins of donations, are facing less accountability. More than that, as Edwards (2011) points out, the products of philanthropy are being geared towards private interests, since “after all, if the actions of the philanthrocapitalists were as successful as is often claimed in reducing poverty and inequality, and improving health and education, few would oppose them on accountability grounds alone” (Edwards, 2011, p. 389). According to Thompson (2018) there are three components to the ideology of philanthrocapitalist rule; firstly, that “financial wealth equals expertise” (p. 53), secondly, “the explicit confusion of the billionaire’s private interests with collective interests or even the collective good” (p. 54), and thirdly, the drive to “promote and enshrine expertise over democracy” (p. 55). Through these components, wealthy individuals are able to exert power over charity and Development projects to promote whichever ends they see fit.

This has been prominent for many years within agricultural projects, since organizations from wealthy donors like Rockefeller and Ford promoted crop research for the Green Revolution (Brooks, 2013, p. 3; Smith et al., 2023, p. 577). The ‘new’ formation of philanthrocapitalists in agriculture has been dominated by work of the Bill and Melinda Gates Foundation (BMGF). The Gates foundation has been investing in agricultural projects and research since the 2000’s, and in 2006, formed the Alliance for a Green Revolution in Africa (AGRA) focused on this work (Brooks, 2013, p. 3; Schurman, 2018, p. 180). In the following years, the Gates foundation became more involved, particularly with CGIAR, helping to reorganize seed bank systems between 2008-2010 (Thompson, 2018, p. 59). As mentioned in Chapter 5, the BMGF is of the top two largest donors to CGIAR. Their involvement with the organization is unequivocal, and there is a growing body

of research showing how this involvement, in line with philanthrocapitalism, is fostering influence over the decisions of the organization. For example, in the early 2000's the Gates Foundation funded the Drought Tolerant Maize for Africa (DTMA) Program coordinated by CGIAR. Unlike previous projects that attempted to include a focus on a 'smallholder paradigm' (which was highly evaluated), these projects focused on the impacts of climate change, and specifically on battling drought, ignoring other challenges faced by small farmers (Brooks, 2013, p. 7). Importantly, these projects prioritized the production of hybrid solution packages which included both new seed variants *and* fertilizers; these packages were available for purchase from agro-companies acting as extensions of the program (Brooks, 2013, p. 7). This project differed from its predecessors in its priorities and solutions, centering much more of a business mindset. Another example includes the BMGF influence on International Crops Research Institute for Semi-Arid Tropics (ICRISAT), which is used to provide smallholder farmers with new seed strains which they themselves could grow to a limited extent and sell to local seed providers. However, after the Gates Foundation became involved, the seeds bred by their scientists for this type of outgrowing "went to the highest bidder, changing 'benefit sharing' to a simplistic cash transaction at volatile prices. Smallholder farmers now must outbid larger commercial growers if they want to continue their successful local entrepreneurial business of seed multiplication" (Thompson, 2018, p. 59).

This is unsurprising, given the priorities and culture of the BMGF and its parent Microsoft. Schurman (2018) describes how this culture seeps into the philanthropic efforts, of the Gates Foundation, specifically its Agricultural Development program. They find that this influence was present in a number of ways, like how the program hired staff with strong analytical skills, and by "charging them with solving the perceived problems of African agriculture, the Agricultural Development program became populated by individuals who applied their business thinking and analytical skills to 'fixing' rural Africa and rural Africans" (Schurman, 2018, p. 181). Additionally, the involvement of Bill Gates himself led to a culture of "managing up", which focused on the desires of partners and managers rather than the farmers they were programming for (Schurman, 2018, p. 183). The results are extremely top-down, Seattle-situated approaches manifesting in BMGF fund-recipient projects (Schurman, 2018, p. 186), which ultimately re-transcribes neoliberal ideals onto the projects.

This reinscribing was also analyzed by Smith et al. (2023) in their assessment of the influence of BMGF on women's empowerment programs in agriculture. As previously mentioned, they found a construction of women's empowerment as defined by integration into agricultural markets. For this study, they utilized a 'power in institutions matrix' presented by Kashwan et al. (2019) to understand *how* the Gates Foundation exerted this influence. Two approaches to power most relevant, namely "agenda power", which works to illuminate how "certain discourses and approaches are promoted that can be seen to benefit and align to the BMGF's neoliberal ideology" and "discursive/ideational power", which shows how discourses "reinforce historical mainstream neoliberal approaches to development within which the status quo – and the BMGF's position as a key development actor within this – is both beneficial and fixed, marginalising alternative perspectives in the process" (Kashwan et al., 2019; Smith et al., 2023, p. 580). For this thesis, using Critical Discourse Analysis to inform its analysis on the documents chosen, power is an integral component in understanding how 'things said', or frames, form ideologies, and influence and are influenced by food systems. We can connect this empirical analysis to 'agenda power' and 'discursive/ideational power' within agriculture and Development.

Employing Panacea, Development, and Corporate frames and informing a utopian sociotechnical imaginary work in ways to benefit philanthrocapitalists. As we have seen, it is the leveraging of donations that give influence to particular individuals or groups, and integrate their ideologies into the workings of international agricultural organizations like CGIAR. This can be understood as agenda power; positioning Agriculture 4.0 as a solution benefits actors looking to simultaneously 'solve' global issues like hunger while upkeeping productivist, neoliberal ideology. If those who mold international agendas benefit from an uptake in the production of autonomous pickers, data processing or sensors, by means of literal profit from the production of these things or from ideological reinforcement of private public partnerships, this reflects the influence of said actors' power within these agenda setting arenas. Subsequently, if within an envisioned utopia the status quo is fixed and desired, and fundamentally informed by frames, agendas, and projects which are controlled (or at the very least influenced) by actors who stand to benefit from the status quo, said actors are clearly portraying ideational power. Hence, the discursive practices of the CGAIR documents analyzed in this thesis reflect ways in which the organization exercises power in the

international policy arena of food systems and security. Particularly, how they reinforce neoliberal values which advance philanthrocapitalist interests.

Something similar, though from different roots, is reflected in the FAO. Historically, despite its fundamental aims, the FAO has fared being bulldozed by the motivations of other influential actors, like the WTO and United States on export restriction post WWII. There have been numerous moments which weakened the organization's commitment to food as a human right. Jarosz (2009) argues that the FAO has faced a steady erosion of influence since the food crisis of the 1970s, due to tensions within the organization about how to approach food security (Jarosz, 2009, p. 38). Additionally, non-UN actors have worked in contrast to the FAO and undermined it, for example when the World Bank declared food security through the ability to *purchase* food in 1989, and the US ambassador to the FAO in 2020 rebuked the organization for its support of agroecology and its deviation from traditional Green Revolution agendas (M. Canfield et al., 2021, pp. 4–5). Most recently, the UN Food Systems Summit of 2021 was organized and run outside of normal UN guidelines, facing criticism and usurping the role of the FAO as the facilitator of food security governance (Anderson, 2024b; M. Canfield et al., 2021; M. C. Canfield et al., 2021; Selimian et al., 2022). The summit, under the umbrella of multistakeholderism, included large corporations like Nestle and Unilever, and omitted the Civil Society and Indigenous Peoples' Mechanism (CSIPM), an integral part of the United Nations Committee on World Food Security (CFS), from its relationships in the conference and with other bodies (Anderson, 2024b, p. 197). The CSIPM makes demands to better balance representation and address corporate influence in food systems, which were not met and ultimately the summit organizers did not work with the group (Anderson, 2024b, p. 198).

Like with CGIAR, the majority of FAO documents analyzed in this thesis preproduce the utopian imaginary of Agriculture 4.0. I would argue that adjacent to the power dynamics illustrated by the CGIAR documents, the discursive practices in the FAO documents reflect the growing influence of philanthrocapitalists and corporate actors within food governance and UN, public sector agendas. The pervasiveness of the utopian imaginary, in the context of the FAO's framework being eroded, reflects the emerging "corporate capture", of food systems and international policy arenas (Ackermann Aredes, 2023; Chandrasekaran et al., 2021). Most recently, the combination of corporate capture and Big Tech is presenting itself into inter-governmental relations, as the Trump

administration is withdrawing federal investigations on large tech companies, and facilitating the ‘Tech Prosperity Deal’ with the UK government to expedite the expansion of these companies (Claypool, 2025; David-Barrett, 2025; Orru & Hart, 2025).

As ideational power works to marginalize alternative perspectives, it is important to include those perspectives wherever possible. That is why this thesis, in its discussion on international food policy arenas, has included both actors from the mainstream as well as those who still sit relatively outside the establishment but are nonetheless prominent. Within the documents from FIAN and ETC Group, the Environmental, Iconoclastic Sovereignty, and Traditional frames were identified, standing almost wholly in opposition to the three previously highlighted, and yielding a dystopian sociotechnical imaginary around Agriculture 4.0 for food security. This, too, reflects dynamics of power; within the power in institutions matrix by Kashwan et al. (2019). It can be considered as the concept of ‘power to’, which is the act of co-opting or resisting discursive power (Kashwan et al., 2019, p. 137; Smith et al., 2023, p. 580). Other scholars have classified this as *resistance*. Lilja and Vinthagen (2014) lay out types of resistance to different Foucauldian powers and, specifically for disciplinary power, Foucault presents the idea of a ‘reversed discourse’. This occurs when subjugated groups utilize the language of oppressors into counter narratives that challenge the dominant discourses (Foucault in Lilja & Vinthagen, 2014, p. 115). Butler describes this as resistance through rearticulation of dominant discourses, which as a reverse discourse, is parasitic to the dominant discourses, manifesting as resistance through the effects of the innate properties of power (Butler in Lilja & Vinthagen, 2014, p. 115). In other words, it is in power’s nature to exercise itself through language which allows for a counter-pressure to be exercised in the same vein. I would argue that the dystopian sociotechnical imaginary presented in the documents by FIAN and ETC Group reflect this type of counter-pressure, or resistance. The same components exist between the frames, where similar problems of food security and climate (among varied others) must be addressed, and Agriculture 4.0, while still an integral component, shifts from solution to cause, effectively molding an opposite perspective, effectively shaping a dystopia from what was utopia.

Both FIAN and ETC Group are Non-profit organizations focused on not just food security but also justice in the food system, and have explicitly called out corporate interests in food systems. Within the sphere of international policy and organizations on food, contradictory imaginaries on the

future of food with Agriculture 4.0 solidify that there is not one, inevitable path to be followed. As discussed in Chapter 3, the goals of ‘alternative’ and justice-based food movements are often strictly opposed to the food security agenda’s objective of increasing food production and integration of agriculture into international markets. As such, the dystopian imaginary in the FIAN and ETC Group documents display the anthropological fixes and social approach to food security that stand in opposition to the technological fixes and rational approach. This more generally, as we have mentioned, is the frequent dividing line between the two opposing understandings of food security and of food itself. By integrating into the wider discourse and conflict on international food systems and security, the documents in this analysis resist, or reverse the discourse on Agriculture 4.0 for food futures. This illuminates further the powerful position of actors like CGIAR and the FAO.

There is something that has been left out of the discussion until this time: the Pragmatic frame. Visible primarily in one FAO document and one CGAIR document, it does not fit into the utopian nor the dystopian imaginaries, because it does not totalize predicted benefits nor concerns. It does not, I would argue, fall into this pattern of binary opposition. Since it still assumes the current structure of the food system, but with significant *reforms*, it does reflect the hegemonic power of the actors within the utopian imaginary. However, it also demonstrates a departure. Given that these documents are on the more recent end of the sample (from 2022 and 2024), their frame employed could be understood as a step towards integration; integrating concerns over the dystopian future of Agri 4.0 with the development of its technologies and projects. This is especially potent for the CGIAR document, which itself is a critical assessment of digital agriculture. Given that CGIAR is most thoroughly ingrained in the neoliberal ideology of agriculture and exhibits power in relation to philanthrocapitalists like Gates, its production of a more critical frame than is the norm is significant and telling of the potency of non-dominant ideologies (and perhaps non-dominant actors) in more recent years. The FAO document indicates a similar sentiment, though its history has been steadily more cooperative with non-dominant actors and civil society. What is most telling, perhaps, is that this frame represents a departure from the inevitability; the inevitable rise and contributions of Agri 4.0 in the utopian imaginary, and the inescapable demise of society through Agri 4.0 in the dystopian imaginary. Instead, as it is quoted

in the FAO document: “The main learning from this report is that the future of agrifood systems is not predetermined” (Alexandrova-Stefanova et al., 2024, p. xx).

This frame seems to reflect the ways in which civil society and international organizations have worked together, and the progress towards food security they have brought about. Take the example of how the work of food sovereignty advocates, like La Via Campesina, resulted in the reform of the Committee for Food Security (CFS), and the inclusion of Civil Society and Indigenous Peoples’ Mechanism (CSIPM) into a mainstream international body (Nicholson & Borras Jr., 2023, p. 2). What this manifests is an imaginary where Agri 4.0 is not something revolutionary, but just another tool, another discovery which use must now be decided upon; this vision of the future can be seen as a *protopia*. This concept is preceded by Booth’s (1991) idea of ‘Utopian Realism’, which argues that utopianism as a view of what is possible in the future is extremely useful for realist International Relations, albeit primarily through small incremental steps (Booth, 1991). This fostered further debate on the utopian/realist nexus, like from Brincat (2009) who has argued ‘Utopian Realism’ lacks large imagination of what is possible, conceding too much to the status quo (Brincat, 2009, p. 600). They go on to tweak the idea into a ‘open-dialectical utopianism’, which “remains aware of its embeddedness in the world – with all of its limiting conditions” while also faithful to utopia’s reach for possibilities (Brincat, 2009, p. 605). It is a form of ‘betterment’ that is not rigid, but adaptable to context and time and not limiting in its radical imagination (Brincat, 2009, p. 606). Protopia has been emerging, mildly introduced in the last two decades, with projects like Monika Bielskyte’s “Protopia Futures” (Post Growth Institute, 2022) and Kevin Kelly’s 2009 book *What Technology Wants* (Needelman, 2023). Boehnert et al. (2024), in their discussion on techno-utopian ideas of the future that exclude ‘the ecological’ from society in their design, present instead an idea of ‘Ecocene Protopias’ as “places of continuous ecological transition” (Boehnert et al., 2024, p. 6). In this sense, the authors consider protopias as an approach to a better future through a focus on *process* rather than preferred worlds (Boehnert et al., 2024, p. 9).

The Pragmatic frame embodies these aspects of utopian realism, open-dialectical utopianism, and protopia. I would argue that a *protopian imaginary* is focused on the process of betterment, but heavily grounded in current contexts. The protopian sociotechnical imaginary of Agriculture 4.0 presented in the pragmatic frame does not work in rejection of proposed solutions, only in

inclusion, presenting a ‘yes and-’ approach to the future of food systems that works with visionary possibilities of practical, tangible changes. In the typical utopian sense, it aims to ‘think big’ on how the future of food could be, but acts upon existing structures. Though clearly rooted in the status quo, it is not beholden to it. It is not neutral in its stance but evokes less emotional response than the imaginaries of techno-food utopia or dystopia. In the face of growing neoliberal dominance in the food systems and policy arena, the pragmatic frame shows there is potential for change, that power relationships are not immovable.

It seems that there exists a “productive dialectical relationship” (Jasanoff, 2015, p. 4) between the sociotechnical imaginaries of Agriculture 4.0 of international food security actors, that function through the protopia; utopia and dystopia are mediated through the protopia, where binaries are dispossessed and conceding visions of the future are promoted. These conceptions that so often seem mutually exclusive (Borghini et al., 2020, p. 2) are brought together. Understanding how Agriculture 4.0 is understood by international actors, and how this understanding fits into wider discourses on food security and visions of the future, are telling about the influences directing policy and agenda setting. However, as Jasanoff writes, it is still up “to legislatures, courts, the media, or other institutions of power to elevate some imagined futures above others, according them a dominant position for policy purposes” (Jasanoff, 2015, p. 4). Identifying these imagined futures is the first step, understanding who elevates them and how must come subsequently. By including not just dominant, mainstream influential food security policy actors, this thesis has taken a stride in elevating different visions of how technology and agriculture might affect one another, and the possibilities for molding food systems toward different values. If there is contestation over what constitutes a utopia and a dystopia of food, then perhaps it is a protopia that can ground ideological debates and make contributions towards action.

7.2 Limitations

Although this thesis conducted methodological research into the topic of international conceptions on Agriculture 4.0 and food security, it has several limitations. Firstly, as the work conducted was for a master’s thesis, time and capacity were severe constraints on the scope of the research. Thirteen documents were analyzed, however some organizations (FAO and CGIAR and ETC Group) had many that fit the search criteria, which could have been used in a more extensive study

that would require a longer timeline. Additionally, the sample size for FIAN documents was much smaller, which is why ETC Group documents were also included, but makes it more difficult to compare between each group individually. A lack of previous research on NGO and civil society oriented international organizations, in comparison to large mainstream organizations characterized as influential policy actors (Montenegro de Wit & Canfield, 2024, p. 383), also meant that the selection and interpretation of the non-dominant actors require a new typology, and was novel and challenging.

Further research is needed to fully address the gap in knowledge on the landscape of sociotechnical imaginaries on Agriculture 4.0, particularly in relation to food security. This would require samples from additional international organizations, including non-dominant ones, as well as from civil society groups and localized organizations. Through this diverse sample set, one could use comparison to both understand the international landscape, as well as its relationship to local contexts over which it influences. Additionally, utilizing other research methods, like surveys and interviews would provide insight into both how these topics are framed and the imaginaries that surround them; this would be particularly fruitful when engaging with civil society actors, given the limitations of publications that would be available for framing analysis.

In sum, this thesis demonstrates that Agriculture 4.0 is not a neutral or purely technical project but a contested arena where divergent imaginaries of food futures are negotiated. By revealing how organizations frame Agriculture 4.0 through competing frames, the analysis highlights the power relations and interests embedded in these visions. Utopian, dystopian, and emerging protopian imaginaries each illuminate both possibilities and limitations for food systems transformation, underscoring the need to move beyond entrenched binaries. Ultimately, the study contributes to a more critical understanding of how technological change is imagined and governed, and whose voices shape the trajectory of global agrifood systems.

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