Agriculture and Human Values (2023) 40:913–928
https://doi.org/10.1007/s10460-023-10454-2

SYMPOSIUM/SPECIAL ISSUE

Ag-tech, agroecology, and the politics of alternative farming futures: The challenges of bringing together diverse agricultural epistemologies

Summer Sullivan[1]

Accepted: 13 March 2023 / Published online: 21 April 2023

Abstract

Agricultural-technology (ag-tech) and agroecology both promise a better farming future. Ag-tech seeks to improve the food system through the development of high-tech tools such as sensors, digital platforms, and robotic harvesters, with many ag-tech start-ups promising to deliver increased agricultural productivity while also enhancing food system sustainability. Agroecology incorporates diverse cropping systems, low external resource inputs, indigenous and farmer knowledge, and is increasingly associated with political calls for a more just food system. Recently, demand has grown for the potentially groundbreaking benefits of their convergence, with the University of California, Santa Cruz (UCSC) attempting just such a union. Building on its combined expertise in engineering and agroecology, as well as a longstanding reputation as a socially progressive institution, university administrators believe that UCSC could produce a unique, socially just form of ag-tech designed for small, low-resource farmers—a rare contribution given ag-tech's tendency to cater primarily to large-scale agribusiness. This paper examines the complexities of uniting agroecology and ag-tech through interviews with agroecologists, engineers, and social scientists involved in UCSC's ag-tech initiative. Within the setting of a historically radical yet neoliberalizing university, I find that significant epistemic and structural barriers exist for agroecology and ag-tech to come together on an even playing field. This case study contributes to broader discussions of the future of food and farming by focusing on the contours and challenges of a widely called-for agricultural collaboration, highlighting its difficulty but also areas of possibility in a particularly rich, contested context.

Keywords Ag-tech · Agroecology · Epistemology · Neoliberalizing university · Social justice

Across a variety of sectors and geographies, many scholars and researchers agree that the global food system is unsustainable. Amid mass environmental destruction and social inequalities caused by the twin crises of capitalism and climate change, calls to make agricultural practices more environmentally sound are becoming urgent (Tomich et al. 2011). How the food system should be fixed, however, is a highly contested matter. Recently, two approaches have received prominent attention: agricultural technology (ag-tech) and agroecology. Ag-tech seeks to improve the food system through the development of high-tech tools such as sensors, digital platforms, and robotic harvesters. In line with Silicon Valley's penchant for pairing economic disruption with positive social change, many ag-tech start-ups promise to deliver increased agricultural productivity while also enhancing food system sustainability (Fairbairn et al. 2022). Agroecology, meanwhile, is often viewed as an alternative to conventional agriculture. Incorporating diverse cropping systems, low external resource inputs, indigenous and farmer knowledge, agroecology is increasingly associated with political calls for a more just food system (Guzmán and Woodgate 2013). Recently, momentum has grown in support not just of these two approaches, but of the potentially groundbreaking benefits of their convergence (Bellon Maurel et al. 2022; Bonny 2017; Ditzler and Driessen 2022).

The University of California, Santa Cruz (UCSC) is currently attempting just such a union. Building on its combined expertise in engineering and agroecology, as well as its longstanding reputation as a socially progressive institution,

✉ Summer Sullivan
summer_sullivan@ucsc.edu

1 Environmental Studies Department, University of California, Santa Cruz, Natural Science 2 Main Building Room 467, Santa Cruz, CA 95064, USA

university administrators believe that UCSC could produce a unique, socially just form of ag-tech designed for small, low-resource farmers—a rare contribution given ag-tech's tendency to cater primarily to large-scale agribusiness (Bronson 2019). However, such aspirations for merging agroecology and ag-tech may be easier said than done given their divergent epistemological underpinnings. Further, the definitions of both agroecology and ag-tech are themselves unsettled, with different interpretations leading to distinct outcomes (Bellwood-Howard and Ripoll 2020). It is therefore crucial to not only examine their epistemological roots, but also the unique context in which their union is proposed—in this case the neoliberalizing university (Giroux 2014). This article, therefore, does not seek to determine whether the union of agroecology and ag-tech is possible or desirable, but rather explores a specific attempt to bring these dissimilar agricultural epistemologies together during a moment of increased urgency in calls for their synergy.

In what follows, I examine the complexities of uniting agroecology and ag-tech through an empirical analysis of interviews with agroecologists, engineers, and social scientists involved in UCSC's ag-tech initiative. I find that there are significant epistemological divergences and some synergies which I organize into three groups (scope, scale, and social impact) described below. This case study contributes to broader discussions of the future of food and farming by focusing on the contours and challenges of a widely called-for agricultural collaboration, highlighting its difficulty and, to a lesser extent, areas of possibility in a particularly rich, contested context.

Calls for complementarity: the possibility of combining ag-tech and agroecology

Agroecology is a recognized but contested field, with different interpretations supporting divergent agricultural and social outcomes (Bellwood-Howard and Ripoll 2020). Dating back to the 1920s (Wezel and Soldat 2009), agroecological science has supported whole and diversified farming systems utilizing practices that foster complex species interactions to enhance biodiversity and support beneficial ecosystem services such as nutrient cycling and weed, disease, and pest management (Kremen et al 2012), meaning it does not rely on synthetic implements. Agroecological science is also "placed-based," or rooted in and attuned to the particular agroecosystem that it occurs (Bocchi 2020; González de Molina & Lopez-García and 2021). Scholars have argued that indigenous peoples and peasant communities have been practicing place-based, ecological agriculture for centuries (Carlisle et al. 2019; Vandermeer and Perfecto 2012), something that a more recent, transdisciplinary, and "transformative" interpretation of agroecology has embraced (Levidow et al. 2014; Pimbert 2015). A transformative approach to agroecology goes beyond sustainability on the farm to include a broad vision of social, economic, and political change with food sovereignty at its core (Dale 2021; Gliessman et al. 2019; Pimbert 2018; Wach 2021). It is now widely argued that agroecology is a science, practice, and social movement (Isaac et al. 2018; Méndez et al. 2013).

The meaning of ag-tech has similarly shifted over time. Unlike agroecology, however, ag-tech has long been geared toward large-scale production of monocultures, minimizing human labor through automation, and maximizing output, goals that have been reinvigorated through the promise of advanced digital technologies (Ditzler and Dreissen 2022). Digital agriculture, or the increased use of digital technologies in the sector (Shepherd et al. 2020), has foregrounded the present association of ag-tech with "high tech" devices such as drones, robots, microbials, and all manner of data-driven agriculture (Lajoie-O'Malley et al. 2020). Many engineers and entrepreneurs argue that ag-tech presents the best path to sustainably feeding a growing population (Biltekoff and Guthman 2022; Clapp and Ruder 2020; Constance 2009). However, some have argued that rather than enhancing sustainability and disrupting conventional agriculture, ag-tech is a continuation of its intensive practices that benefit large agri-food corporations (Bronson and Knezevic 2016; Fairbairn et al 2022). Further, there has been asymmetry in funding and legitimacy between ag-tech and agroecology. While ag-tech has benefited from capital investment and support from lucrative agribusiness, agroecology has often been overlooked as a viable agricultural approach, often due to its political and social commitments (DeLonge et al. 2016). Due to these dynamics, calls to unite agroecology and ag-tech are highly aspirational given agroecology's normative underpinnings, even if these are indeed not fully embraced by all.

The desire to feed the world more efficiently and sustainably has hastened calls for the union of agroecology and ag-tech. Some scholars argue that combining agroecology and ag-tech can result in superior agricultural outcomes if ag-tech can adhere to agroecological principles and support the scaling of diversified farming systems, farmer decision making, and complex data collection (Bellon Maurel et al. 2022; Bonny 2017). Bellon Maurel and Huyghe (2017) assert that ignoring potential synergies is ludicrous, stating, "putting agro-equipment and digital technology at the service of agroecology is not a straightforward route, but it is absurd… to oppose agroecology and technology." Literature in agricultural sociology and development economics has argued that farming practices and perspectives exist on a continuum rather than in a binary (Beus and Dunlap 1991), suggesting that it is possible to combine conventional and alternative practices (Plumecocq et al. 2018). Ditzler and Driessen (2022) argue that while ag-tech has indeed been traditionally geared toward conventional agriculture, "there appears to be no fundamental reason why automated tools could not be designed to progress agroecological aims." Daum (2021) imagines an "ecological utopia" where fleets of small robots co-exist with diverse agroecosystems.

Critical social scientists approach the compatibility of agroecology and ag-tech with more skepticism, but many are open to the possibility of enhanced environmental and social outcomes. For these scholars, compatibility becomes both more possible and more equitable if changes occur in the control, design, accessibility, values, and ownership of ag-tech, necessitating a shift away from corporate principles and practices (Hilbeck and Tisselli 2020; Klerkx et al. 2019; Wittman et al. 2020). Rotz et al. (2019) assert that agroecology and ag-tech "are not *necessarily* mutually exclusive" (emphasis theirs) and advocate for proactive policy, open-source technology, and data sharing. However, these contributions often focus on potential means to and outcomes of obtaining their union more equitably, without directly addressing questions of what Montenegro de Wit (2021) calls their "epistemic and structural compatibility." In tracing the epistemic compatibility of agroecology and the gene editing technology CRISPR, she argues that "the dovetailing of CRISPR and agroecology is hard to fathom without a significant shift in the core scientific tenets of one field or the other." Similarly, my findings indicate that while there is potential for agroecology and ag-tech to come together, substantial epistemological and structural challenges exist for them to do so evenly. Still, calls for their union abound. The pressure to combine agroecology and ag-tech, and the attendant epistemic tensions, is further heightened within the university context where there is an ever-growing emphasis on academic-industry collaboration. In many ways, the neoliberalizing university is fixated on interdisciplinarity collaboration between dissimilar entities to solve complex, real-world problems while also generating funding opportunities.

Interdisciplinarity and impact within the neoliberalizing university

U.S. public universities have undergone significant structural shifts in recent decades, with the North American public university system acutely embodying this transition (Pelly and Boje 2019). As many public universities have reoriented their academic missions in service of the market, the long-held virtue of education as a public good has deteriorated (Giroux 2014; Newfield 2008). Traditional measures of academic research have shifted to equate its value with economic promise and possibility for impact, while funding to the arts, humanities, and social sciences has been systemically cut (Rhodes et al. 2018). A body of scholarship theorizes these market-oriented turns as the "neoliberal university." However, many of these arguments lend themselves to a premature conclusion that neoliberalism has consumed the public university system, often overlooking neoliberalism as an ongoing, contested, and uneven project (Harvey 2005; Peck and Tickell 2002) and the pockets of resistance that often exist within institutions of higher education (Davis 2010). It is more appropriate to situate this case study as a unique public university grappling with the politics of neoliberalization as a process, not a foregone conclusion.

This framing is not meant to diminish the impacts of neoliberalization in public universities, which are acutely exemplified within interdisciplinary collaborations. Proponents believe that the complexity of real-world problems requires multiple perspectives (Stephenson et al. 2010), resulting in increased demand for interdisciplinary collaborations to solve them (Frodeman and Mitcham 2007; Klein 1990). Framed as a mutually beneficial crossing between two or more disciplines, interdisciplinarity is argued to produce superior research outcomes, becoming the standard research model in U.S. universities (Cooper 2013) and receiving significant prioritization by national funding bodies (Gardner 2014; Jacobs and Frickel 2009). Within the neoliberalizing university, interdisciplinarity is also championed for the economic opportunities it generates.

The dovetailing of interdisciplinarity and real-world problem-solving within the neoliberalizing university has resulted in increased industry partnerships, the development of research parks, and offices dedicated to patenting new technologies (Philpott et al. 2011). Industry-oriented research was woven into the university's structural fabric through the Bayh-Dole Act of 1980, which enabled universities to patent and license technologies developed through publicly funded research. It led to a steep increase in university patent activity (Renault 2006) and encouraged faculty to "spin-off" their inventions into startup companies (McGuire 2011). Bayh-Dole also encouraged increased university interest in commercialized agricultural research like biotechnology (Glenna et al. 2007).

Funding and institutional support has especially been given to lucrative STEM-industry partnerships (Etzkowitz and Leydesdorff 1995; Welsh et al. 2008) seen to "increase the brand and reputation of the institution" (Scricca 2006). Indeed, the outsized funding awarded to STEM collaborations is in large part due to the propensity for problem-solving and the economic opportunity, and thus prestige, that such impact-oriented research generates. Critical engineering literature has found that engineering, in particular, encourages an "exclusive technical focus," resulting in decreased engagement with social and political questions and a streamlined approach to problem solving (Riley 2008). Such a profit- and impact-oriented approach to research has led to a hierarchy of academic disciplines with STEM at the top (Giroux 2010; Slaughter and Rhodes 2000).

Interdisciplinarity has been critiqued because of the asymmetrical power dynamics within interdisciplinary collaborations. Literature examining interdisciplinarity typically understands its challenges through the limitations of epistemic boundaries, or the different ways disciplines understand and approach their work (Brewer 1999). STS literature on responsible innovation suggests that difficulties of interdisciplinary collaboration can be lessened with time, effort, and commitment (Conley and York 2020; Stilgoe et al 2013). Others acknowledge the messy work of interdisciplinarity and the time it takes to get on the same page within an increasingly neoliberalizing university setting (Gannon et al. 2016; Serpa et al. 2017). In addition to epistemic differences, some have indeed attended to the "impossibility" (Albert and McGuire 2014) and "incompatibility" (Bergland 2018) of interdisciplinarity within the neoliberalizing university, pointing to the outsized funding and value given to STEM fields. Given its rich history of alternative agricultural and social commitments, UCSC appears as an exemplary setting for studying the union of ag-tech and agroecology. However, what sets this case further apart is that despite its unique reputation, UCSC has not been immune to neoliberalization nor is it a perfect example of a university subsumed by neoliberalism. Instead, what follows is a case study detailing processes of negotiation and contestation among epistemically diverse actors within a university struggling to maintain its uniqueness in the face of neoliberalizing forces.

Alternative agriculture and radical politics at UCSC

Emerging in opposition to public universities accused of serving the interest of big agribusiness, UCSC created what is widely known as a radically alternative agricultural program. Imagined as an experimental campus, UCSC was organized around colleges rather than standard disciplines (Kerr and Jarrell 1989) and did not issue letter grades until 2000. Since its founding, UCSC has become widely known for "its foundation in radical politics and its support of student activism" (Renda 2015). One of UCSC's most renowned and lasting alternative experiments was its student-run garden. Founded in 1967 and cultivated only with hand tools and organic inputs, the project eventually grew into an 11-acre campus farm by 1971. Responding to increased interest and demand, in 1980 UCSC hired Stephen Gliessman who led the field of agroecology to world-renowned prominence (Reti 2010). Under Gliessman, UCSC officially created an Agroecology Program—the first University of California (UC) initiative centered on sustainable and organic agriculture (Brown 2000).

With its engaged students and practitioners, agroecology at UCSC emphasized food systems transformation and included social justice in its mission. Despite the evolution of agroecology that took place on its campus, notably, UCSC has not been part of the University of California's land grant system until its recent inclusion in November 2022. Land grant universities were established in every state in 1862 by the US Morrill Act, in which the federal government granted 30,000 acres to every state in the union, acres which could be sold to establish and finance colleges of "agriculture and mechanic arts." It was at the land grant universities like UC Davis that massive research was undertaken to support almost wholly conventional agriculture. Indeed, the extent that the land grant has come to serve chemically-intensive agribusiness has not only drawn sociological critique (Glenna et al. 2007; Henke 2008); it also led to a lawsuit against UC after its development of a mechanical tomato harvester in the 1960s,[1] catalyzing a legal battle between the UC and a group of small farmers and farmworkers who argued the harvester device displaced them. Ag-tech was thus the province of large agricultural universities, not UCSC.

Absent from UCSC's founding was an engineering school. Starting in 1983, UCSC began offering engineering degrees in Computer Engineering, but it was not until 1997 that the Jack Baskin School of Engineering was officially established, accelerating UCSC's recognition in the field. UCSC engineers helped pioneer the Human Genome Project in the 1980s, with the department now home to the world-class Genomics Institute. Baskin Engineering has since produced numerous successful "spin-offs and start-ups," or companies originating from departmental research (engineering.ucsc.edu). In addition, UCSC was the first university in the nation to offer a graduate degree in Serious Games. Now boasting six departments, eleven distinct research centers, and hundreds of faculty, the Jack Baskin School of Engineering is one of UCSC's premier assets. Contributing at least in part to engineering's distinguished campus strength is its proximity to Silicon Valley, where UCSC began operations of a satellite campus in 2016. Notably, UCSC does not have agronomics or agricultural engineering departments, meaning all engineers involved in UCSC's ag-tech initiative had no previous agricultural experience.

Like the campus itself, UCSC's ag-tech initiative was imagined as unique for its intention to build ag-tech for smaller, less-intensive growers that the Center for Agroecology has traditionally supported. The initiative sought to capitalize on the campus' proximity to both the Silicon Valley

[1] See Martin, Philip L., and Alan L. Olmstead. 1985. "The Agricultural Mechanization Controversy." *Science* 227(4687):601–6. Langdon Winner's *Do Artifacts Have Politics?* (1980) is also excellent.

and the Salinas Valley—the latter a major "big ag" region with some of the highest values for crops such as lettuce, berries, and broccoli in the nation (Langholz 2021)—as well as an opportunity to develop UCSC's Monterey Bay Education, Science, and Technology (MBEST) Center. Owned by the UC, MBEST sits on about 1000 acres of land in the Monterey Bay Peninsula south of UCSC. The momentum of the ag-tech initiative reinvigorated its development plans of a STEM-oriented research park concept with ag-tech, drones, and coastal sustainability as its themes. Such an initiative that aims to combine social impact, interdisciplinary collaboration, and economic opportunity is a hallmark of the neoliberalizing university.

Methods

Between January and March 2021, I conducted 23 semi-structured interviews via Zoom. Interviewees were recruited primarily through their involvement in the ag-tech conversations and projects, but also included those with pertinent practice-based and/or research backgrounds. In line with the intent of the initiative to build on campus strengths (agroecology, engineering, and social justice), I interviewed faculty and staff from all three areas. The division of interviews was: agroecologists ($n=11$), engineers ($n=7$), and social scientists ($n=5$). All but one participant was employed by UCSC. Interview request emails were sent to 42 relevant people: 18 engineers, 17 agroecologists, and 6 social scientists. The by-field response percentages leading to an interview were: engineers 38%, agroecologists 65%, and social scientists 83%. These categories are imperfect, with many people doing cross-cutting work or holding multiple campus roles. With consent, I recorded interviews, transcribed them with a web-based transcription software, and coded them. Social scientists were not asked to join the collaboration as early as the engineers and agroecologists. Instead, the few involved heard about it from colleagues and asked to be included. Additionally, no engineers interviewed were agricultural engineers.

The contested convergence of agroecology and ag-tech

What follows is a narrative rooted in the diverse perspectives held by agroecologists, engineers, and social scientists, which I categorize into three groups for organization: scope, scale, and social impact. The three categories each highlight a group of challenges or, less frequently, convergences identified in uniting agroecology and ag-tech through interdisciplinary collaboration within a neoliberalizing university.

Scope

This section deals most heavily with epistemic and disciplinary concerns, or the instincts, approaches, and ways of knowing expressed by engineers, social scientists, and agroecologists summed up within the overarching category of scope. Within scope, there are three subsections. The first deals with scope of their research, the second describes scope of interdisciplinarity, and the final concerns the scope of solutions offered to solve agricultural problems.

Scope of research

Agroecologists, engineers, and social scientists approach their work in highly distinct ways. Agroecologists communicated a wide or "systems" lens through which they see and undertake research and practice. As one agroecologist said,

> [in agroecology] you need to understand the community that you're embedded in, and the impact that your agriculture has either on or within that community… from production to our use of resources, potential pollution, things like that… it is a very whole-systems perspective.

Agroecologists also maintain a systems-level perspective in their description of farming practices, rooting their approach in the complexity of biological organisms and the use of practices that further foster species diversity and "interactions between plants, soil, microbes," as one agroecologist described it. The fact that agroecologists take a wide ecological and social view of their work is consistent with a transformative understanding of the discipline (Francis et al. 2013). Conversely, engineers zoomed in on specific phenomena and processes. One engineer said that the largely unpredictable nature of complex biological systems—core to agroecology—is their biggest challenge, as it impedes their overarching goal of increasing systems efficiency. This person further described their research goal as wanting to "characterize every tidbit of a biological system individually" to better understand and predict its functions. This engineer also stated that their interest in the initiative was rooted in "efficiency and acceleration of science." This finding is echoed by Montenegro de Wit (2021) who found that scientists and engineers attribute problems food systems problems to "errors of efficiency and lack of scientific knowledge/data" that can be solved by gathering more intricate data in larger quantities.

Though no agroecologist thought of the engineers' approach as inherently wrong, some noted that the different lenses through which each group viewed their work affected their ability to find common ground within the initiative, as the object(s) of discussion were not the same. One agroecologist summed up the differences between the scope of the research lenses by comparing agroecologists to public health experts who are concerned with whole populations and communities, and engineers to medical doctors, concerned with individual people. Another noted that the engineers' expertise lies at the "cellular and individual organism level" whereas agroecologists are thinking about "the crop field level." Similarly, some critical scholars argue that engineering epistemologies tend to not include social and political factors in their research scope, often viewing those factors as not essential to their work (Leydens et al. 2012; Li 2007). This contributes to what Cech (2014) calls a "culture of disengagement" among many engineers.

Most social scientists also noted incompatibilities between their own and the engineers' approach. One social scientist said that "where social scientists are useful may not intersect with engineers very easily and obviously" in reference to the research concerns of each.

Like the agroecologists, this dynamic led to what another social scientist called a "mismatch" between their field and engineering. While one thought their skillset might be able to "help engineers be more ethical and thoughtful about their work and the unintended consequences and implications," other social scientists were more skeptical of such convergence, recalling conversations involving both engineers and social scientists where the word "epistemology" was introduced. In response to the social scientists' desire to engage in a discussion surrounding the varied epistemological foundations of their shared research within the ag-tech initiative, this social scientist recalled the engineer's reaction: "…the engineers are like, 'oh, my god.'" This social scientist concluded that such a dynamic among the fields "gets challenging." Some critical engineering literature has found that engineers tend to shy away from discussions that might reveal underlying biases, thus impacting their ability to do what many conceive of as "pure" science, or science not influenced by social structures or politics (Cech 2014). Noting the different lenses of engineers and agroecologists, one engineer said, "Social scientists are interested in the impacts of technology on farmers. But on the productive ag side, they're really concerned about efficiency. So, there's these two arenas, and depending on framing, this can create a sense of either common or opposing interests." While divergences in scope of research are not new among groups with different epistemological orientations, they draw attention to the foundational difficulties these differences present for the proposed union of ag-tech and agroecology.

Scope of interdisciplinarity

All interviewees had different understandings of and experiences with interdisciplinarity, in no small part because they incorporate and value different types of knowledge, ways of knowing, and knowledge-sharing practices. Described by one as the field's "epistemic plurality," agroecologists discussed the incorporation of a range of knowledges like ecology, sociology, economics, and agronomy. Many agroecologists further noted the necessity of wide, community-rooted engagement and sociality to their work, stating that agroecological knowledge is shared via farmer-to-farmer (*campesino a campesino)* and peer-to-peer networks, a practice that made one describe agroecology as "knowledge intensive," a common phrase within the discipline (Utter et al. 2021). Another agroecologist said, "You can't extract that social piece and community piece from agroecological systems, because they rely on those communities and connections in order to function." This finding is also consistent with the growing number of scholars who argue agroecology is inextricably linked to social processes and movements (Guzmán and Woodgate 2013), further supported by the frequent mention of indigenous, peasant, and local community knowledges as foundational to their work.

Most engineers also considered their work interdisciplinary, though in a different way than the agroecologists. One engineer stated that engineering is becoming increasingly interdisciplinary. They noted that funding structures have shifted to value collaborative projects, stating, "I just think that collaborative work is the future. I think single PI [Principal Investigator] research projects are a thing of the past." This person also identified challenges to meaningful interdisciplinarity, saying, "a lot of it is just lack of communication… Sometimes building those bridges is 50% of the work." However, when other engineers spoke of interdisciplinarity, they largely referenced collaborations between themselves and other types of biological or natural scientists, or other kinds of engineers. One listed the areas of mathematics, machine learning, statistics, and dynamic modeling as essential to their work. Further, one engineer noted, "There's a balance between too many perspectives, [because] then it's difficult to get actionable items. In the beginning, it's always easier to start small and then see how things work out." In an examination of an interdisciplinary collaboration between social and biophysical scientists, Gardner (2014) found not only that academics from STEM fields are most interested in collaborating with others in STEM, but also that "many interdisciplinary endeavors are conducted within similar paradigmatic fields, meaning that these disciplines will share assumptions about the nature of reality and how to observe it." As such, this engineer's hesitation to invite more people into the ag-tech collaboration suggests an awareness of the challenges that ensue when working with people not just from other STEM fields, but from fields with different ways of constructing and understanding knowledge (Gardner 2014).

Social scientists were perhaps the most reticent about interdisciplinary projects, with some citing first-hand experiences that had not gone well (see Manifesto in this issue).

One imitated how non-social scientists think about interdisciplinary collaborations, saying, "'Oh, we need to study people, so we'll have a social scientist do that,'" further noting that this inclusion is "in the service of somebody else's research project." Another voiced awareness that social scientific criticism in interdisciplinary collaborations is often unwelcome and dismissed as overly negative rather than offering a possible corrective, saying, "We're always seen as complaining and pointing out the flaws and risks and potential problems, like that irritating fly in the room." They added that their attitude is not one of "being cynical and skeptical about everything… I am critical, but it's not a predisposition towards being a pessimist. It's actually the radical optimism that there are other ways of doing things." This, for most social scientists, was what meaningful collaboration might entail: doing things differently and questioning the collaborative process itself, not just its outcomes and impacts. Within the neoliberalizing university context, such interests tend to be viewed as slowing down and even impeding the forward progress of the ag-tech initiative, and thus, impacting its economic promise (Stengers 2011). These inquiries also are not marketable in their own right, earning them less value and resources (Stengers 2011). In sum, the fact that most social scientists felt dismissed within the collaboration is not surprising given the prioritization of STEM research—and therefore its higher institutional standing—at UCSC and other neoliberalizing universities.

Scope of solutions

Different disciplinary norms around research manifested in divergent approaches to defining problems and identifying how to solve them, going to the very core of what an ag-tech initiative could do. One engineer laid out their discipline's approach by saying, "As an engineer, if there's a problem somebody has, and I have a technology that can provide a solution, that's what I do." This engineer gestures toward the "technological fix," or the belief that "technological innovation could confidently resolve any issue" (Johnston 2018), a foundational principle in engineering pedagogy (Riley 2008). Another engineer said that within their field, "If you aren't solving problems, you're just in the frickin' mud." Largely stemming from roots in Western science, this streamlined approach to problem-solving was held by of most engineers interviewed and is indeed helpful in many of the technical contexts they encounter. However, some engineers offered a different explanation of how they approach problems and solutions. One engineer emphasized the need to understand agricultural problems before attempting to offer solutions, saying,

> A lot of the initial phase [of the ag-tech initiative] has been really trying to understand what the necessities are in agriculture. It's not like me coming in and saying, 'you're not doing things right, or you're not moving the right direction.' We've been in discussion about what are the things that people in agriculture care about, because as an engineer, it's easy to get caught up in the theory and the equations for just for the sake of the math with no real applications, or applications and no real interest from other communities.

This gestures toward an engaged form of engineering practice that could overlap more readily with other disciplines. However, they went on to state that their understanding of agri-food systems issues surrounds "concerns about food shortages because we're becoming very overpopulated." Similar to what Montenegro de Wit (2021) found, this engineer's understanding of agri-food systems problems tends to uphold a Malthusian orientation of mass agricultural production to feed the world. This framing draws much critique in agroecological literature, which argues that overpopulation and food shortages are misnomers for social, political, and economic issues rooted in systemic inequality and racism (Chappell and LaValle 2011). Gesturing toward social complexities, a different engineer addressed the potential pitfalls of focusing on technological solutions:

> There are two important sides to our responsibility. As engineers… we have to understand what the inherent, accidentally, or intentionally damaging things technology can do. It's our responsibility to look for those and try to get rid of those kinds of effects of technology. But on the other side of the coin, we can use technology to improve society, to remove inequities, or limit them.

This engineer expressed a clear awareness that technologies often cause harm and viewed it as in their epistemological purview to anticipate such issues. At the same time, they still held technology as a net positive intervention and means of social improvement. This outlook is akin to what Cech (2014) calls the technical/social dualism of engineers, or their "cognitive separation of 'technical' and 'social' competencies [that] devalues 'social' competencies, such as those related to public welfare." In other words, social concerns are often made secondary to problem solving through technology.

Nearly all agroecologists interviewed saw agri-food systems problems as inherently complex and questioned the extent to which ag-tech could provide the needed solutions. One agroecologist said,

> A lot of the persistent problems that we have within the agricultural and food system are things that can't be easily solved. Thinking about issues of food access, hunger and distribution, and equal access of wealth… Those

> are the real persistent and wicked problems, and none of those are going to be solved by a technological fix.

Instead, most advocated for historically embedded approaches that centered local and marginalized communities. As one agroecologist put it, "So much of our society is just designed to make a technology or a solution to fix the problem, rather than changing the system so that it isn't a problem." Another pointed to the different approaches to problems and solutions as the fundamental conflict between engineering and agroecology. Noting this dynamic, one engineer identified what they called "distance" and "lack of a shared language" between their approach to problems and solutions and that of the agroecologists, agreeing that finding common ground in this area would be difficult. For their part, social scientists generally agreed with the agroecologists. While one said that engineers and social scientists might be able to come together to work on a "specific problem," other social scientists took issue with this approach. As one said,

> Social scientists have a very different set of methodological tools to think about individuals, communities, politics, ethics and systems. Instead of just coming up with a tool…social scientists deal with the contradictions and paradoxes, the gray areas that too often get erased or ignored… it's one thing to come up with a better tool, but we can ask, are people actually going to use it? Why? How might they reinvent it for themselves?

Aware of the epistemological distance between themselves and engineers when it came to identifying and solving problems and solutions, social scientists were thus skeptical of the potential for common ground in this area.

Scale

Scale is used as an organizational term and deals mostly with epistemological orientations toward market forces and external university actors, both of which are influenced by the neoliberalizing university context. The first subsection deals with the varying scale(s) of distribution and application of ag-tech described by different actors. The second concerns the scale of involvement, or the level of interest across social scientists, engineers, and agroecologists in engaging other, often non-academic actors in the ag-tech initiative. The final subsection details the varying funding scales revealed throughout interviews and their impact on the initiative's collaborative dynamics.

Scale of ag-tech's distribution and application

Most participants expressed diverging views both of whether the ag-tech could be scale-neutral in regard to farm size and if it could be scaled up to reach wide markets. Regarding the objective of the ag-tech initiative, one engineer said, "To me, it's a question of scale," which they elaborated upon by saying,

> Who gets into sustainable ag? I think there's the real and there's the ideal… and then there's the issue of scale. It's one thing to have a little patch of lettuce in my backyard, and it's another thing to need to feed the world… For the UCSC ag-tech thing, there needs to be a clearer vision of the intervention.

This engineer expresses a skepticism that small-scale agriculture can feed the world and notes that different conceptualizations of scale have led to lack of clarity about the initiative's goal. Other engineers emphasized the imperative to scale up markets for developers and funders to make a return on investment. After acknowledging the shared goal of producing cheap and accessible ag-tech, one engineer noted the distinction between "the research side of technology, and those who need to make it. In order to make it, they need to make money out of it." Connecting the imperative to make a return on investment with the need to work with larger-scale growers, this engineer said it would be difficult to produce a small-scale or scale-neutral ag-tech application because "the market is cruel." Another engineer explained this point further,

> I think this is true in industry in general. Companies usually have a certain way of doing things. Even if there's better ways to do it, the fact that they've been doing it for decades means that they'd rather just continue doing things the way they're doing them. It costs a lot of money to change your business model to change your methods, to change your approach, and to change protocols. It's a huge shift. So, if the method you're using isn't a problem, that you just keep doing whatever you're doing before.

This engineer addressed the fact that almost all ag-tech is made for large-scale agricultural operations because this is the most profitable business model. Further, there is little incentive to change these dynamics because the market rewards those who continue business as usual (Goldstein 2018). Since many agroecologists believe that food systems transformation also requires a transformation of economic systems, most saw the engineers' market concerns as a basis for skepticism about the initiative's claims to produce a more socially just, scale-neutral ag-tech. Expanding on their wariness, one agroecologist recounted another, similar project in which they were involved that had begun with intentions to develop an accessible, scale-neutral technology:

> In the second or third conversation, they're talking about, what's the scale? What's the price point? How are our numbers going to add up? And as soon

as you're in that conversation, it's going to direct the technology in a certain direction… because as soon as you rely on these things that aren't in some ways indigenous to the area, there's going to be that power exchange.

This agroecologist links scale to price and market concerns, which they state inherently changes the direction of ag-tech away from small-scale or scale-neutral to one that fits more profitably within existing food and power structures.

Questions of scale were also expressed in terms of the potential applicability of any given technology. One engineer noted that the discipline takes a "universalized" approach to the application of technologies saying that "context rarely matters." In contrast, for the agroecologists, context, or what each of them called agroecology's "place-based" nature, was an essential part of their practice. As is widely noted in the literature, a place-based approach meant attuning practices to "both the biophysical complexities, but also the socio-economic complexities" of a particular location, as one agroecologist said. Another said:

> When we're talking about agroecology, we're talking about deep place-based knowledge systems. They're very specific place to place. I'm not sure how that reconciles with ag-tech. If you pick up this technology and put it in another place in the country or another place in the world, how will that enhance it? Or how will it be difficult to integrate?

Social scientists were intrigued by the initiative's proposal to create scale-neutral ag-tech but expressed skepticism of this goal by referencing the Green Revolution. As put by one:

> One of the prominent discourses surrounding [Green Revolution technologies] was that they would equally benefit large farmers and small farmers. Because [the] technology is scale neutral, all you need is for a USAID [U.S. Agency for International Development] to go and disseminate these around the world… [Agrarian scholar] Henry Bernstein wrote about this and he was like, 'scale neutrality does not mean resource neutrality.' Compared to the small farmers, larger-scale, wealthier, better capitalized farmers… risked less adopting the seeds, had more access to irrigation, and had more access to farm credit.

For this social scientist and most others interviewed, the initiative was not taking seriously the well-documented histories of ag-tech that have demonstrated the perils of scale neutrality. As the quotation states, the Green Revolution promised scale-neutral seed technologies, only to promote chemically-intensive, mechanized approaches that displaced many peasant farmers in practice (Patel 2013). Even though most social scientists believed the goal of scale neutrality was well-intentioned, their knowledge of the Green Revolution led to a general feeling of doubt that such an achievement could be reached within the current food system. As Montenegro de Wit (2021) also argues, the Green Revolution represented an inflection point whose history bears heeding by all involved in the ag-tech initiative.

Scale of involvement

One area in which there was significant agreement was the opacity through which various people were invited into campus ag-tech discussions. Agroecologists and engineers both noted that they had been asked to join by university administrators, yet as mentioned in the Methods section above, initially no social scientists were asked to participate. Moreover, virtually all who were eventually brought in by university administration stated that they neither generated nor sought out the collaboration on their own, leading each group to communicate a sense that the initiative—despite being a collection of mostly faculty—was not faculty-driven. One engineer said they "just happened to be in the same room" with people involved in ag-tech discussions and was invited to join. Despite the fact they did not initiate their own involvement, two unique engineers articulated that ag-tech was a "natural progression" for their research. On the other hand, most social scientists felt largely left out of the ag-tech initiative and even confused by it. One said that when they joined a conversation regarding the initiative, they were struck by people asking questions of dissemination before a technology had been developed, saying, "I feel like we're at step ten. And we forgot step one through nine." In describing the nature of the collaboration, agroecologists used descriptors such as "ad hoc," "slapped together" and "a forced marriage."

Across all interviewees, many also expressed concern about the lack of participation from off-campus communities. Multiple agroecologists mentioned that few, if any, practicing farmers and agroecologists had been invited to the ag-tech discussions, though they also expressed reservations about the ways they are typically asked to engage. One agroecologist shared that they have frequently been approached by people from Silicon Valley, saying,

> There's always a couple a year. I'm like, look, if you're gonna take eight hours of my time and then disappear, which is almost always what happens… Tell me what I get out of this. They come in, and they flitter out.

An engineer also noted the importance of off-campus community connections, yet expressed the difficulty of cultivating such relationships, saying, "Connecting with the community is not easy… There are times when I'm like 'oh, I'm ready to offer my help and services.' I don't even know where to start." However, this engineer expressed the importance of such an engaged process in order to produce relevant ag-tech, stating, "We can pretend that we're solving equations that people in agriculture care about. But the reality is unless we communicate directly with them, we won't really know what is relevant."

Social scientists echoed the need to engage communities in advance of developing technologies. At least one advocated for including small farmers and community members whom the initiative may impact, yet as cautioned by another, this had to be more than performative. Referring to the often-used metaphor of having a seat at the table, they said, "I don't want to have a seat at the table, I want to decide if we want the table at all, what materials we're going to use, what is the design and structure of this table? Or do we want to chop it up and build a fire?".

Scale of funding

Another point of agreement was that divisional funding is uneven at UCSC, although such agreement did not ameliorate the tensions that arose from these differences. There was a general sense among agroecologists that their work, practice, and research was "resource-limited" and noted the opportunities that often accompany interdisciplinary STEM partnerships. Some agroecologists felt compelled to join the ag-tech initiative despite their concern that "high-tech" ag-tech has not been a central feature of their work. Without such opportunities, "we have no money," as one agroecologist said. Another described a hierarchical campus dynamic of "political and social capital" that did not favor agroecologists largely due to the uneven funding dynamics. Some agroecologists even expressed resentment toward the initiative, stating they would rather work on their own research projects.

Engineers expressed less concern about funding for themselves but were clearly aware that other disciplines were not so fortunate. Some engineers described various channels through which they had direct access to funding and support, notably from the Office of Research. However, they recognized that funding disparities between departments could dampen collaboration. One engineer said of the uneven campus funding dynamics, "There's just so many reasons it becomes politically challenging for true interdisciplinary work to happen," and went on to note that while certain on- and off-campus funding bodies have been trying to promote this type of collaboration, UCSC's funding infrastructure itself presents multiple barriers to meaningful interdisciplinarity. This was echoed by other engineers, who noted that the university should dedicate more funding to foster meaningful interdisciplinarity. Despite their funding advantage, some engineers also shared the concerns of agroecologists that they were spread thin between the ag-tech initiative and their own research projects.

Social scientists felt particularly frustrated with campus funding mechanisms, with one expressing that the campus "de-prioritized" their work. One social scientist described the prioritization of engineering projects on campus, saying, "If anything goes through campus, unless it comes out of the School of Engineering, it gets dinged." They further noted that while funding models differ across disciplines, funding norms favor STEM projects because they are expansive, often supporting Principle Investigators, graduate student researchers, travel expenses, and more. On the other hand, social science grants "look puny compared to other disciplines because it's not funding my salary, it's just funding my research." Insufficient funding for social science research also affects faculty ability to participate in collaborations. One described their experience with campus funding discrepancies and made specific note that insufficient financial support affects their bandwidth and the number of projects they pursue:

> There's always challenges. A lot of it is me being the fundraiser, me being the facilitator... I'm the one making the website, I became the director… It also means we would only be able to do two to three projects a year, so it keeps it small. This is what I can handle until the administration wants to give me more.

As exemplified by the findings in this section, all three groups were aware of uneven funding dynamics, as well as how such an economic asymmetry might affect achieving equitable interdisciplinarity. Despite such awareness, differences in funding were mainly a source of tension for social scientists and agroecologists who felt that the campus did not materially or symbolically value their work in the same way as the work of engineers. This highlights an often-overlooked challenge of interdisciplinarity within a neoliberalizing university: even though calls for interdisciplinarity abound, funding was systemically tilted in favor of the engineers, giving them more influence over the direction of the initiative and calling into question what true academic collaboration can look like when capital is shaping it (Hackett 2014).

Social impact

This section deals with social impact, or the consideration given by each group to how the ag-tech initiative might engage broader societal questions and/or affect the local community. It details the contested processes of UCSC's attempt to brand the ag-tech initiative in line with its historical commitments to social justice and the possibilities for social justice within a neoliberalizing university. The first subsection concerns the question of how different fields viewed the question of social justice in relation to the ag-tech initiative, and the second details the potential social impacts related to partnerships the initiative could seek.

Social justice

The question of how social justice would be incorporated into the ag-tech efforts generated particularly animated responses, with engineers and agroecologists noting—to various degrees—increased conversations about such issues. Many agroecologists said that the campus's approach to agroecology emphasizes social justice and distinguishes it from other modes of sustainable farming, noting that UCSC agroecology "encompasses political change and social movements." One said that many of UCSC's agroecological practitioners are "really focused on sovereignty, building connections with the [local indigenous] tribal band, thinking about Black Lives Matter and how that intersects with agroecology." As such, most expressed a "transformative" vision of agroecology (Pimbert 2015). Importantly, not all agroecologists saw social justice as central to the work. As described by one,

> The way I was raised through agroecology is applying ecological principles into agricultural management. I certainly appreciate the extent that the Santa Cruz school of agroecology really embraces the human community aspects of agroecology, as well.

Even though most agroecologists agreed that agroecology at UCSC uniquely centered social justice, they were simultaneously skeptical of the university's goal to create ag-tech with such values. One said,

> [it's] a little awkward because right now [we are] so focused on building up equity in the food system… We have all this sustainable agriculture and it's gonna blend with ag-tech, but there isn't any real involvement, even of the farmers that we have here on campus, which doesn't necessarily bode well for how the initiative is gonna impact farmers out in the world.

Such a trepidation about the incorporation of social justice into university-led initiative has precedent in critical literature. Rhodes et al. (2018) argue that "activism" and "social justice" can be understood as having market value within the neoliberalizing university. In a similar way, most agroecologists viewed the social justice rhetoric as an administrative attempt to brand the initiative and make it attractive to potential funding partners, citing lack of engagement with those who might be able to help successfully shape such an outcome.

Social justice was not central in most conversations with engineers, although one reported increased reflection about social issues spurred by the murder of George Floyd in May 2020. This engineer said that since the campus is "thinking about social justice," UCSC could produce ag-tech for social good. When asked about who might benefit from UCSC's ag-tech initiative, one engineer said they had not thought about it. Noting their interest in the initiative lay mostly in academic curiosity, they said, "I like the challenge. I like learning about different fields. If it helps somebody, that's great." This is consistent with literature on engineering pedagogy. Clearly, it is not the case that any engineer interviewed wanted to create ag-tech that would produce social harm or inequality, but the tendency toward "depoliticization" meant social good was an afterthought (Cech 2014), or as the previous quotation exemplifies, a fringe benefit. The neutral stance toward social justice expressed by the engineers maintains the status quo of ag-tech, which currently serves powerful corporations (Bronson and Sengers 2022). Similarly, Montenegro de Wit (2021) details the myth of technological neutrality commonly held by scientists and engineers. Technological neutrality is the belief that technology is not inherently good nor bad but is determined by its application. This myth, also employed by the engineers above, "reduce[s] compatibility to techniques" while obscuring the systems, politics, and power dynamics into which technologies are both produced and used (Montenegro de Wit 2021). Indeed, some have argued that engineering and social justice are incompatible in many contexts due to their incongruous epistemologies (Leydens et al. 2012).

Social scientists were particularly troubled by the presumption that an ag-tech initiative would incorporate social justice simply because UCSC has historically pursued such values. As one put it, UCSC's goal to produce socially just ag-tech could "be really distinct and provide some major contributions," but they and others asserted that if the campus wants to achieve such an outcome, it should make the effort to meaningfully engage those who might make it a reality. Moreover, some expressed reservations about this goal altogether, citing the longstanding social concerns surrounding ag-tech regardless of its intentions. One social scientist summed up their position by saying they were aware of the initiative's "intention to be mindful of both ecological sustainability and social justice," but continued,

> I have a lot more questions when it comes to grappling with the structural constraints into which technology enters. We can say that a technology is going to be socially just, but how you do that in the absence of economic policy change or land reform? ... I have a hard time taking the rhetoric seriously.

The reference to economic policy change and land reform indicates broader social transformations that many social scientists and agroecologists believe are necessary for ag-tech to serve socially just ends. In a similar way, attempts by UCSC administrators and some interviewees to brand and legitimize the ag-tech initiative within its alternative campus framework is insufficient, as interviews reveal that the reality of the initiative is a contested process among groups with different levels of social engagement baked into their discipline. In other words, epistemological divergences among social scientists, agroecologists, and engineers do not disappear under the auspices of a social justice label, nor is social justice guaranteed because of historical reputation.

Social impact of partnerships

All interviewees agreed that for the initiative to be successful, outside partners should be involved. Who those partners might be and how they should influence the distribution of ag-tech to broader publics, though, were questions attracting greatly different responses. Engineers were generally interested in working on ag-tech-related projects to advance and expand their research. For them, that entailed developing industry partnerships with the possibility of patenting a technology or obtaining funding for a campus ag-tech facility. Engineers thus assumed the natural progression of an ag-tech initiative would be to partner with incumbent industries in Silicon and/or Salinas Valley. As one engineer said, "You have to engage with industry to be relevant." Some agroecologists said that larger partners can take on a lot of the risk that comes with developing a new technology—risks smaller operations often cannot afford.

Most agroecologists, however, expressed discomfort with industry partnerships. Often assuming that the ag-tech initiative was propelled by "the Chancellor's interest in potential funding and research partnerships with Silicon Valley," they questioned the presumption that the initiative could simultaneously engage with or serve the small or diversified farmers that have been the Center for Agroecology's historic collaborators. Agroecologists were particularly concerned that the "drive for innovation" was too tied "to privatization and profit." Most emphatically, they felt that any ag-tech developed at the university should be publicly owned and made widely available, not subject to intellectual property right protections that industry partners often seeks. One agroecologist connected their perspective to UCSC's standing as a public university, saying:

> There's a huge push in the university to patent so that the university can benefit economically. To what extent will that get in the way of sort of creating more sort of scale neutral, low-cost approaches? I don't think that's appropriate for a public university. I think we're meant to provide information free of charge. But I know that's not a philosophy that holds anymore in the current funding situation for the university.

Tensions around industry partnerships were perhaps best indicated in varied levels of knowledge and buy-in regarding development of the MBEST facility. Engineers largely supported the idea of turning MBEST into a research park based on a P3 (public–private partnership) model. As one pointed out, the area's designation as an "opportunity zone," would additionally provide "tax benefits for investment development investment in that area." Engineers were particularly interested in the fundraising and research potential presented by MBEST, with some already seeking funding to help link ag-tech to its development. One shared that corporations such as Driscoll's—critiqued for their labor and environmental practices (Guthman 2019)—had already been contacted and expressed interest in a potential ag-tech partnership with UCSC, which, according to the engineer, could be "mutually beneficial." A contrasting opinion was shared by an agroecologist who stated that "the whole goal is to do this so that it can be done by the people, not by the giant industrial corporations." Other social scientists corroborated agroecologists' concerns about partnering with large incumbent corporations to obtain funding. As put by one,

> Is this meant to bring in money? Or is this meant to do to spend money to create research? Are we just going to become Monsanto's little playground? That's where the big social justice question comes in. Half the campus is going to go up in flames if we sign a partnership with Monsanto.

Social scientists more generally raised concerns about the beneficiaries of any developments in the ag-tech realm. One recalled a conversation where UC Davis, a large agricultural school, was frequently mentioned, which made them question whether the intent of UCSC's initiative was to compete with such a large agricultural school, saying:

> I'm not sure whether the interest is having more purchase or buy-in or legitimacy with the large-scale growers. That's going to be a very different framework than if we were specifically and intentionally going out to support farmers of color and marginalized communities. Those are very important questions. Who are we talking about?

More than one social scientist and some agroecologists also mentioned the UC's mechanical tomato harvester lawsuit which, as described above in the Alternative Agriculture and Radical Politics at UCSC section, displaced California farmworkers and set a precedent for ag-tech to be favored over labor. A social scientist summed up UC's ultimate victory by saying, "in fact, you can use public money to displace workers," adding that the suit "highlights the point that for many people, new tech or ag-tech is a threat."

Conclusion: the struggle for the future of food and farming

While most digital agricultural literature has focused on the means to and potential outcomes of agroecology and ag-tech's convergence, this paper approached their prospective union by tracing the epistemological orientations of those proposing it. This case study is not meant to showcase the divergent opinions of individual engineers, social scientists, and agroecologists. Rather, it attends to foundational epistemic divergences that allow specific challenges of uniting ag-tech and agroecology to surface. Such epistemic differences trouble the union of agroecology and ag-tech on a structural level by attending to the distinct ways that agroecologists, engineers, and social scientists approach fundamental questions. The contested context of a historically radical yet neoliberalizing university struggling to make itself legible to both industry partners and social justice advocates provides an important material backdrop for their union and makes clear that no single outcome of this initiative is a given.

The findings indicate that most engineer's saw the ag-tech initiative as the natural progression of their research and were compelled by the prospect of developing a scalable technology. Most did not express concern for social questions and viewed the market in a practical manner. In line with scholarship critical of engineering pedagogy, these findings indicate both an apolitical, or neutral, stance toward their role as ag-tech developers and a positive outlook on ag-tech's ability to solve problems (Cech 2014; Riley 2008). Such streamlined epistemic concerns are financially buttressed by the neoliberalizing university, which prioritizes the real-world problem-solving potential of STEM research, with UCSC engineers reporting greater access to funding and institutional support.

Alternatively, agroecologists saw ag-tech as one thread within a larger web of tools and approaches that were place-based and therefore not scalable or marketable in the way engineers conceived of those terms. Most agroecologists held what some literature calls a transformative vision for the food system with political concerns and social justice at its core (Levidow et. al 2014; Pimbert 2015). Unlike the engineers, agroecologists spoke almost unanimously of funding difficulties, with increased access to capital as a driver of their involvement in the ag-tech initiative. For their part, social scientists were interested in the nature of the collaboration itself—its social, economic, and epistemic dimensions—an inquiry which many said was dismissed by their engineering colleagues, drawing attention to the way they often feel "tokenized" within interdisciplinary STEM collaborations. Social scientists also questioned the extent to which ag-tech could be socially just and scale neutral, citing well-documented evidence from the Green Revolution. They also reported less institutional and economic support than engineers.

This case study challenges the increased calls for the union of agroecology and ag-tech by attending to the asymmetrical material and epistemic nature of their proposed union that threatens to dampen, if not negate, any positive social and environmental potential. These findings trouble the belief that only time and effort are needed to overcome interdisciplinary and epistemic challenges, pointing to the uneven ground upon which collaborations occur within the neoliberalizing university. Within these conditions, however, interviews reveal that the outcomes of ag-tech initiative are still undetermined. The initiative is thus a site of contestation about what the union of agroecology and ag-tech could or might be in this context and perhaps elsewhere. For it is not UCSC's history or reputation that can guarantee that the union of ag-tech and agroecology will result in socially just outcomes, but instead the everyday conversations among people with different epistemological concerns recognizing their uneven structural dynamics, persisting within them, and struggling to change them. This case study contributes to literature concerning the future of food and farming by highlighting that it is both uneven and not yet determined. The potential convergence of agroecology and ag-tech, and its stakes, is an ongoing process produced and shaped by epistemic, economic, and political struggle.

Acknowledgements This paper has benefitted tremendously from the deep engagement of many people. Fellow members of the University of California Agri-Food Technology (UC AFTeR) Project Julie Guthman, Madeleine Fairbairn, Charlotte Biltekoff, Kathryn De Master, Zenia Kish, Emily Reisman, Michaelanne Butler, and Sarah Ruth Sippel provided generative and thoughtful feedback throughout various stages of the writing process. Substantial insights were also shared by the Science and Technology Studies Food and Agriculture Network (STSFAN) including Mascha Gugganig, Samara Brock, Saul Halfon, Charles Mather, Susanne Freidberg, Sarah Martin, Mark Bomford, Barkha Kagliwal, Kristin Reynolds, Ritwick Ghosh, Lissa Caldwell, Erika Wagner, Sarah Cavallo, Sarah Marquis, Karly Burch, Garret Broad, Matthew Comi, and Chantal Gailloux. Fellow UCSC graduate students Halie Kampman, Edith Gonzalez, Indiana Reid-Shaw, Clara Qin, and Stefan Yong also contributed fruitful feedback. The editorial team of this special issue— Mascha Gugganig, Karly Burch, Kelly Bronson, and Julie Guthman—deserve a special thanks for their patience, guidance, and generosity. I am especially grateful to two anonymous reviewers who provided very helpful suggestions that improved the paper's quality and argument. Finally, my two advisors deserve additional thanks. Madeleine Fairbairn's methodical eye helped the paper achieve coherent organization and flow. Julie Guthman went above and beyond to provide immense support and advice throughout both the lengthy research and writing processes.

Funding Funding for this research was provided by National Science Foundation Grant #1749184.

Declarations

Conflict of interest No potential conflict of interest was reported by the author.

References

Albert, Mathieu, and Wendy McGuire. 2014. Understanding change in academic knowledge production in a neoliberal era. In *Political power and social theory*, ed. Scott Frickel and David J. Hess, 33–57. Emerald Group Publishing Limited.

Bellon Maurel, Véronique, and Christian Huyghe. 2017. Putting agricultural equipment and digital technologies at the cutting edge of agroecology. *OCL* 24: 1–7. https://doi.org/10.1051/ocl/2017028.

Bellon Maurel, Véronique, Bonnet, Pascal, Piot-Lepetit, Isabelle, Brossard, Ludovic , Labarthe, Pierre, et al. 2022. Digital technology and agroecology: opportunities to explore, challenges to overcome. *Agriculture and Digital Technology: Getting the most out of digital technology to contribute to the transition to sustainable agriculture and food systems,* White book INRIA, 978-2-72611310-3. hal-03606035v2

Bellwood-Howard, Imogen, and Santiago Ripoll. 2020. Divergent understandings of agroecology in the era of the African green revolution. *Outlook on Agriculture* 49: 103–110. https://doi.org/10.1177/0030727020930353.

Bergland, Brita. 2018. The incompatibility of neoliberal university structures and interdisciplinary knowledge: A feminist slow scholarship critique. *Educational Philosophy and Theory* 50: 1031–1036. https://doi.org/10.1080/00131857.2017.1341297.

Beus, Curtis E., and Riley E. Dunlap. 1991. Measuring adherence to alternative vs. conventional agricultural paradigms: A proposed scale. *Rural Sociology* 56: 432–460. https://doi.org/10.1111/j.1549-0831.1991.tb00442.x.

Biltekoff, Charlotte, and Julie Guthman. 2022. Conscious, complacent, fearful: Agri-food tech's market-making public imaginaries. *Science as Culture*. https://doi.org/10.1080/09505431.2022.2090914.

Bocchi, Stefano. 2020. Agroecology: Relocalizing agriculture accordingly to places. In *Bioregional planning and design: Volume II: Issues and practices for a bioregional regeneration*, ed. David Fanfani and Alberto Matarán Ruiz, 81–99. Springer International Publishing. https://doi.org/10.1007/978-3-030-46083-9_5

Bonny, Sylvie. 2017. High-tech agriculture or agroecology for tomorrow's agriculture? *Harvard College Review of Environment & Society* 4: 28–34.

Brewer, Gary D. 1999. The challenges of interdisciplinarity. *Policy Sciences* 32: 327–337.

Bronson, Kelly. 2019. Looking through a responsible innovation lens at uneven engagements with digital farming. *NJAS—Wageningen Journal of Life Sciences* 90–91: 1–6. https://doi.org/10.1016/j.njas.2019.03.001.

Bronson, Kelly, and Irena Knezevic. 2016. Big data in food and agriculture. *Big Data & Society* 3 (1): 205395171664817. https://doi.org/10.1177/2053951716648174.

Bronson, Kelly, and Phoebe Sengers. 2022. Big tech meets big Ag: Diversifying epistemologies of data and power. *Science as Culture* 31: 15–28. https://doi.org/10.1080/09505431.2021.1986692.

Brown, Martha. 2000. The farm and garden projects at the University of California, Santa Cruz. *Chronicle of the University of California: West of Eden* 3: 29–41.

Carlisle, L., Montenegro de Wit, M., DeLonge, M. S., Iles, A., Calo, A., Getz, C., Ory, J., Munden-Dixon, K., Galt, R., Melone, B., Knox, R., and Press, D. 2019. Transitioning to sustainable agriculture requires growing and sustaining an ecologically skilled workforce. *Frontiers in Sustainable Food Systems*. https://doi.org/10.3389/fsufs.2019.00096.

Cech, Erin A. 2014. Culture of disengagement in engineering education? *Science, Technology, & Human Values* 39: 42–72. https://doi.org/10.1177/0162243913504305.

Chappell, Michael Jahi, and Liliana A. LaValle. 2011. Food security and biodiversity: Can we have both? An agroecological analysis. *Agriculture and Human Values* 28: 3–26. https://doi.org/10.1007/s10460-009-9251-4.

Clapp, Jennifer, and Sarah-Louise. Ruder. 2020. Precision technologies for agriculture: Digital farming, gene-edited crops, and the politics of sustainability. *Global Environmental Politics* 20 (3): 49–69. https://doi.org/10.1162/glep_a_00566.

Conley, Shannon N., and Emily York. 2020. Public engagement in contested political contexts: Reflections on the role of recursive reflexivity in responsible innovation. *Journal of Responsible Innovation* 7: 1–12. https://doi.org/10.1080/23299460.2020.1848335.

Constance, Douglas. 2009. Sustainable agriculture in the United States: A critical examination of a contested process. *Sustainability* 2: 48–72. https://doi.org/10.3390/su2010048.

Cooper, Geoff. 2013. A disciplinary matter: Critical sociology, academic governance and interdisciplinarity. *Sociology* 47: 74–89. https://doi.org/10.1177/0038038512444812.

Dale, Bryan. 2021. Food sovereignty and agroecology praxis in a capitalist setting: The need for a radical pedagogy. *The Journal of Peasant Studies*. https://doi.org/10.1080/03066150.2021.1971653.

Daum, Thomas. 2021. Farm robots: Ecological utopia or dystopia? *Trends in Ecology & Evolution* 36: 774–777. https://doi.org/10.1016/j.tree.2021.06.002.

Davis, Mike. 2010. Who will build the ark? *New Left Review.* 61: 29–46.

de González Molina, Manuel, and Daniel Lopez-Garcia. 2021. Principles for designing Agroecology-based Local (territorial) Agrifood Systems: A critical revision. *Agroecology and Sustainable Food Systems* 45: 1–33. https://doi.org/10.1080/21683565.2021.1913690.

DeLonge, Maricia S., Albie Miles, and Liz Carlisle. 2016. Investing in the transition to sustainable agriculture. *Environmental Science & Policy* 55: 266–273. https://doi.org/10.1016/j.envsci.2015.09.013.

Ditzler, Lenora, and Clemens Driessen. 2022. Automating agroecology: How to design a farming robot without a monocultural mindset? *Journal of Agricultural and Environmental Ethics* 35: 1–31. https://doi.org/10.1007/s10806-021-09876-x.

Etzkowitz, Henry, and Loet Leydesdorff. 1995. The triple helix—University-industry-government relations: A laboratory for knowledge based economic development. *EASST Review* 14: 14–19.

Fairbairn, Madeleine, Zenia Kish, and Julie Guthman. 2022. Pitching agri-food tech: Performativity and non-disruptive disruption in Silicon Valley. *Journal of Cultural Economy* 15: 652–670. https://doi.org/10.1080/17530350.2022.2085142.

Francis, C., Lieblein, G., Gliessman, S., Breland, T. A., Creamer, N., Salomonsson, L., Helenius, J., Rickerl, D., Salvador, R., Simmons, S., Allen, P., Altieri, M., Flora, C., and Poincelot, R. 2013. Agroecology: The ecology of food systems. *Journal of Sustainable Agriculture* 21
Frodeman, Robert, and Carl Mitcham. 2007. New directions in interdisciplinarity: Broad, deep, and critical. *Bulletin of Science, Technology & Society.* 27: 506–514. https://doi.org/10.1177/0270467607308284.
Gannon, Susanne, Giedre Kligyte, Jan McLean, Maud Perrier, Elaine Swan, Ilaria Vanni, and Honni van Rijswijk. 2016. Uneven relationalities, collective biography, and sisterly affect in neoliberal universities. *Feminist Formations* 27: 189–216. https://doi.org/10.1353/ff.2016.0007.
Gardner, Susan K. 2014. Bridging the divide: Tensions between the biophysical and social sciences in an interdisciplinary sustainability science project. *Environment and Natural Resources Research* 4: 70. https://doi.org/10.5539/enrr.v4n2p70.
Giroux, Henry A. 2014. *Neoliberalism's war on higher education*. Haymarket Books.
Giroux, Henry A. 2010. Public values, higher education and the scourge of neoliberalism: Politics at the limits of the social. *Culture Machine.* https://culturemachine.net/wp-content/uploads/2019/05/426-804-1-PB.pdf
Glenna, Leland L., William B. Lacy, Rick Welsh, and Dina Biscotti. 2007. University administrators, agricultural biotechnology, and academic capitalism: Defining the public. *The Sociological Quarterly* 48: 141–163.
Gliessman, Stephen, Harriet Friedmann, and H. Howard. Phillip. 2019. Agroecology and food sovereignty. *IDS Bulletin*. https://doi.org/10.19088/1968-2019.120.
Goldstein, Jesse. 2018. *Planetary improvement: Cleantech entrepreneurship and the contradictions of green capitalism*. Cambridge: The MIT Press.
Guthman, Julie. 2019. *Wilted: Pathogens, chemicals, and the fragile future of the strawberry industry*. University of California Press.
Guzmán, Eduardo S., and Graham Woodgate. 2013. Agroecology: Foundations in Agrarian social thought and sociological theory. *Agroecology and Sustainable Food Systems* 37: 32–44. https://doi.org/10.1080/10440046.2012.695763.
Hackett, Edward J. 2014. Academic capitalism. *Science, Technology, & Human Values* 39: 635–638. https://doi.org/10.1177/0162243914540219.
Harvey, David. 2005. *A brief history of neoliberalism*. Oxford Academic Press.
Henke, Christoper R. 2008. *Cultivating science, harvesting power: Science and industrial agriculture in California*. MIT Press.
Hilbeck, Angelika, and Eugenio Tisselli. 2020. The emerging issue of "digitalization" in agriculture. In Hans Herren and Benny Haerlin IAASTD+10 Advisory Group, *Transformation of our food systems: The making of a paradigm shift*. Berlin and Zurich: Foundation on Future Farming and Biovision. https://www.globalagriculture.org/fileadmin/files/weltagrarbericht/IAASTD-Buch/PDFBuch/BuchWebTransformationFoodSystems.pdf
Isaac, Marney E., S. Ryan. Isakson, Bryan Dale, Charles Z. Levkoe, Sarah K. Hargreaves, V. Ernesto. Méndez, Hannah Wittman, Colleen Hammelman, Jennifer C. Langill, Adam R. Martin, Erin Nelson, Michael Ekers, Kira A. Borden, Stephanie Gagliardi, Serra Buchanan, Sarah Archibald, and Gálvez Ciani. Astrid. 2018. Agroecology in Canada: Towards an integration of agroecological practice, movement, and science. *Sustainability* 10: 1–17. https://doi.org/10.3390/su10093299.
Jacobs, Jerry A., and Scott Frickel. 2009. Interdisciplinarity: A critical assessment. *Annual Review of Sociology* 35: 43–65. https://doi.org/10.1146/annurev-soc-070308-115954.
Johnston, Sean F. 2018. The technological fix as social cure-all: Origins and implications. *IEEE Technology and Society Magazine* 37: 47–54. https://doi.org/10.1109/MTS.2018.2795118.
Kerr, Clark, and Randall Jarrell. 1989. *Clark Kerr and the founding of UC Santa Cruz*. Regional History Project, UCSC Library. https://escholarship.org/uc/item/9bw645n9
Klein, Julie. 1990. *Interdisciplinarity: History, theory, and practice*. Wayne State University Press.
Klerkx, Laurens, Emma Jakku, and Pierre Labarthe. 2019. A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS—Wageningen Journal of Life Sciences* 90–91: 1–16. https://doi.org/10.1016/j.njas.2019.100315.
Kremen, Claire, Alastair Iles, and Bacon Christopher. 2012. Diversified farming systems: An agroecological, systems-based alternative to modern industrial agriculture. *Ecology and Society* 17 (4): 44.
Lajoie-O'Malley, A., Kelly Bronson, Simone van der Burg, and Laurens Klerkx. 2020. The future(s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents. *Ecosystem Services* 45: 101183. https://doi.org/10.1016/j.ecoser.2020.101183.
Langholz, Jeff. 2021. Monterey county crop & livestock report: Salad bowl of the world. https://www.co.monterey.ca.us/home/showpublisheddocument/113214
Levidow, Les, Michael Pimbert, and Gaetan Vanloqueren. 2014. Agroecological research: Conforming—or transforming the dominant agro-food regime? *Agroecology and Sustainable Food Systems* 38 (10): 1127–1155. https://doi.org/10.1080/21683565.2014.951459.
Leydens, Jon A., Juan C. Lucena, and Jen Schneider. 2012. Are engineering and social justice (in)commensurable? A theoretical exploration of macro-sociological frameworks. *International Journal of Engineering, Social Justice, and Peace* 1: 63–82. https://doi.org/10.24908/ijesjp.v1i1.3507.
Li, Tania. 2007. *The will to improve: Governmentality, development, and the practice of politics*. Duke University Press.
Maurel, Véronique B., Pascal Bonnet, Isabelle Piot-Lepetit, Ludovic Brossard, Pierre Labarthe, P. Maurel, and Jean-Yye Courtonne. 2022. Digital technology and agroecology: Opportunities to explore, challenges to overcome. *Agriculture and digital technology: Getting the most out of digital technology to contribute to the transition to sustainable agriculture and food systems.* White book INRIA, 76–97. https://hal.inrae.fr/hal-03606035v2
McGuire, Wendy L. 2011. Constructing quality in academic science: How basic scientists respond to canadian market-oriented science policy: A Bourdieusian analysis. PhD Thesis. University of Toronto. https://tspace.library.utoronto.ca/bitstream/1807/31862/6/McGuire_Wendy_L_2011_11_PHD_thesis.pdf
Méndez, V. E., Bacon, C. M., and Cohen, R. 2013. Agroecology as a transdisciplinary, participatory, and action-oriented approach. *Agroecology and Sustainable Food Systems*, 37(1): 3–18. https://doi.org/10.1080/10440046.2012.736926.
Montenegro Wit de, Maywa. 2021. Can agroecology and CRISPR mix? The politics of complementarity and moving toward technology sovereignty. *Agriculture and Human Values* 39: 733–755. https://doi.org/10.1007/s10460-021-10284-0.
Newfield, Christopher. 2008. *Unmaking the public university*. Cambridge: Harvard University Press.
Patel, Raj. 2013. The long green revolution. *Journal of Peasant Studies* 40: 1–63. https://doi.org/10.1080/03066150.2012.719224.
Peck, Jaimie, and Adam Tickell. 2002. Neoliberalizing space. *Antipode* 34: 380–404. https://doi.org/10.1111/1467-8330.00247.
Pelly, Duncan R., and David M. Boje. 2019. Neoliberalism in the North American University: Toward integrating divisions in agent orientation via a Follettian differentiated relational ontology. *Communication & Language at Work* 6: 28–41. https://doi.org/10.7146/claw.v6i2.116132.

Philpott, Kevin, Lawrence Dooley, Caroline O'Reilly, and Gary Lupton. 2011. The entrepreneurial university: Examining the underlying academic tensions. *Technovation* 31: 161–170. https://doi.org/10.1016/j.technovation.2010.12.003.

Pimbert, M. 2015. Agroecology as an alternative vision to conventional development and climate-smart agriculture. *Development* 58 (2): 286–298. https://doi.org/10.1057/s41301-016-0013-5.

Pimbert, Michael P., Ed. 2018. Food sovereignty, agroecology and biocultural diversity: Constructing and contesting knowledge. Routledge, Taylor & Francis Group.

Plumecocq, Gael, Thomas Debril, Michel Duru, Marie B. Magrini, Jean P. Sarthou, and Oliver Therond. 2018. The plurality of values in sustainable agriculture models. *Ecology and Society*, 23. https://www.jstor.org/stable/26799066

Renault, Catherine S. 2006. Academic capitalism and university incentives for faculty entrepreneurship. *The Journal of Technology Transfer* 31: 227–239. https://doi.org/10.1007/s10961-005-6108-x.

Renda, Matthew. 2015. How a radical university is abandoning its tradition of political activism. *The Atlantic*. https://www.theatlantic.com/education/archive/2015/05/the-betrayal-of-student-activism/392759/

Reti, Irene H. 2010. Stephen R. Gliessman: Alfred E. Heller professor of agroecology. UC Santa Cruz.

Rhodes, Carl, Christopher Wright, and Alison Pullen. 2018. Changing the world? The politics of activism and impact in the neoliberal university. *Organization* 25: 139–147. https://doi.org/10.1177/1350508417726546.

Riley, Donna. 2008. *Engineering and social justice*. Springer International Publishing.

Rotz, Sarah, Emily Duncan, Matthew Small, Janos Botschner, Rozita Dara, Ian Mosby, Mark Reed, and Evan D. G. Fraser. 2019. The politics of digital agricultural technologies: A preliminary review. *Sociologia Ruralis* 59: 203–229. https://doi.org/10.1111/soru.12233.

Scricca, Cherie. A. 2006. *University-industry research partnerships: Motivations for collaboration.* Dissertations available from ProQuest. AAI3210001. https://repository.upenn.edu/dissertations/AAI3210001

Serpa, Sandro, Carlos Miguel Ferreira, and Ana Isabel Santos. 2017. Fostering interdisciplinarity: implications for social sciences. *International Journal of Social Science Studies* 5: 44–49. https://doi.org/10.11114/ijsss.v5i12.2775.

Shepherd, Mark, James A. Turner, Bruce Small, and David Wheeler. 2020. Priorities for science to overcome hurdles thwarting the full promise of the 'digital agriculture' revolution. *Journal of the Science of Food and Agriculture* 100: 5083–5092. https://doi.org/10.1002/jsfa.9346.

Slaughter, Sheila, and Gary Rhoades. 2000. The neo-liberal university. *New Labor Forum* 6: 73–79.

Spinoffs and Startups. 2022. *Baskin engineering*. Santa Cruz: University of California. engineering.ucsc.edu

Stengers, Isabel. 2011. "Another science is possible!" A plea for slow science. Inaugural Lecture. Vrije Universiteit Brussel. https://threerottenpotatoes.files.wordpress.com/2011/06/stengers2011_pleaslowscience.pdf

Stephenson, Janet, Rob Lawson, Gerry Carrington, Barry Barton, Paul Thorsnes, and Miranda Mirosa. 2010. The practice of interdisciplinarity. *The International Journal of Interdisciplinary Social Sciences: Annual Review* 5: 271–282. https://doi.org/10.18848/1833-1882/CGP/v05i07/51789.

Stilgoe, Jack, Richard Owen, and Phil Macnaghten. 2013. Developing a framework for responsible innovation. *Research Policy* 42: 1568–1580. https://doi.org/10.1016/j.respol.2013.05.008.

Tomich, Thomas, Sonja Brodt, Howard Ferris, Ryan Galt, William Horwath, Ermias Kebreab, Jonah Leveau, Daniel Liptzin, Mark Lubell, Pierre Merel, Richard Michelmore, Todd Rosenstock, Kate Scow, Jonah Six, Neal Williams, and Louie Yan. 2011. Agroecology: A review from a global-change perspective. *Annual Review of Environment and Resources* 36: 193–222. https://doi.org/10.1146/annurev-environ-012110-121302.

Utter, Alisha, Alissa White, V. Ernesto. Méndez, and Katlyn Morris. 2021. Co-creation of knowledge in agroecology. *Elementa: Science of the Anthropocene* 9: 1–16. https://doi.org/10.1525/elementa.2021.00026.

Vandermeer, John, and Ivette Perfecto. 2012. Complex traditions: Intersecting theoretical frameworks in agroecological research. *Journal of Sustainable Agriculture* 37: 76–89. https://doi.org/10.1080/10440046.2012.717904.

Wach, Elise. 2021. Market dependency as prohibitive of agroecology and food sovereignty—A case study of the agrarian transition in the Scottish highlands. *Sustainability* 13: 1–23. https://doi.org/10.3390/su13041927.

Welsh, Rick, Leland Glenna, William Lacy, and Dina Biscotti. 2008. Close enough but not too far: Assessing the effects of university–industry research relationships and the rise of academic capitalism. *Research Policy* 37: 1854–1864. https://doi.org/10.1016/j.respol.2008.07.010.

Wezel, Alexander, and Virginie Soldat. 2009. A quantitative and qualitative historical analysis of the scientific discipline of agroecology. *International Journal of Agricultural Sustainability* 7: 3–18. https://doi.org/10.3763/ijas.2009.0400.

Wittman, Hannah, Dana James, and Zia Mehrabi. 2020. Advancing food sovereignty through farmer-driven digital agroecology. *International Journal of Agriculture and Natural Resources* 47: 235–248. https://doi.org/10.7764/ijanr.v47i3.2299.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Summer Sullivan is a PhD student in Environmental Studies at the University of California, Santa Cruz. Her current research interests include political economy, digital agriculture, and labor geographies.