Challenging high-tech solutionism in an era of polycrisis: A commentary on claims for novel foods and on building an alternative narrative[1]

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Abstract

Considering the contemporary global landscape of interlocking environmental, economic and political challenges - labelled as a polycrisis - the paper takes issue with an influential narrative of technological solutionism. Both within the rapidly digitalizing agricultural sector that is reshaping industrial farming and across the novel foods category engaged in scaling protein production, there is a tendency to proclaim new technologies as providing singular remedies to existential problems. While conceding that new technologies may have an important role to play as we navigate uncertainty in striving for healthy, sustainable diets, this commentary argues that such efforts ought to be informed by a wider vision embracing complexity and scientific humility and capable of scrutinising the purpose of such innovations while ensuring the inclusion of valued social and cultural attributes of food. Ultimately, challenging dominant narratives of technological solutionism requires civil society to develop alternative discourses that speak to human and ecological wellbeing above purely technocratically defined objectives.

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[1] The conception of this paper was a Rapporteur's report closing the one-day conference, 'Novel Foods and Novel Food Production: A solution to food systems sustainability?' held at the American University of Rome on 10 March 2023.

Introduction

We are living through a time of multiple and interlocking existential challenges – having recently emerged from a global pandemic – and confronted by a range of environmental problems that have been highlighted by scientists' warnings (Ripple et al. 2022; Albert et al. 2020; Garcia-Gonzalez et al. 2024; Wiedmann et al. 2020; Richardson et al. 2023). Yet these concerns have been further exacerbated by a variety of economic, social and political issues – financial system instability, cyber terrorism, choke-points in global supply chains, large-scale migration, and rising social and political discord including increased military conflict – that demonstrate our enmeshment in a global polycrisis marked by the 'amplification, acceleration, and synchronisation of systemic risks' (Homer-Dixon et al. 2022: 3; Lawrence et al. 2022). That these challenges are conceivably connected in ways that we may not fully understand is a consequence of a reductionist mindset not well placed to accommodate holistic thinking in an era of complex causation, nonlinearity and post-normal science that may be vulnerable to unexpected tipping points (Morin 2008; Montuori 2022; Byrne 2017). This is the predicament of the contemporary human condition where a global population of eight billion people is differentiated by enormous social and economic inequalities and where the basic material needs for existence – let alone those required for a dignified life free of hunger and preventable disease – are denied to so many. Yet there is an assumption that a series of 'techno-fixes' are in the pipeline that will deliver us from catastrophe and allow us to continue to maintain our existing levels of consumption despite evidence to suggest that we are in advanced ecological overshoot[1] (Merz et al. 2023; Rees 2023).

One of the key challenges facing the global community is the ways in which we produce and make available food for human consumption. The global food system has become an increasing focus of attention, given the ever-widening chorus of voices that argue it is no longer fit for purpose (Sachs, 2021; GLOPAN 2020; Sage 2022a). Its contribution to the global climate crisis – accounting for more than 30% of greenhouse gas emissions, biodiversity loss, and disturbance of global nutrient cycles (Sage 2022b, 2022c) – is most especially evident in regard to human consumption of animal products, which exerts a higher impact than any other major aspect of human ecology (Coimbra et al. 2020). Yet, at the same time, there is a growing realisation that the food system is also failing to feed people adequately. With numbers of chronically hungry and malnourished people remaining stubbornly high, while those suffering from diet-related diseases continue to rise, the food system is increasingly regarded as the cause of a global public health crisis (Swinburn et al. 2019; Scrinis 2020). It is in this context of overshoot, polycrisis and complexity that we have witnessed the inexorable rise of 'techno-solutionism' (Morozov 2013; Milan 2020; Sætra 2023). The term is used here not only to profess a *faith* in technology but also embodies how we frame social phenomena to make them more amenable to the technological solutions proposed by their advocates. Solutionism takes us beyond techno-optimism which presumes that technology will deliver beneficial outcomes, and where it is even demonstrated that the good outweighs the bad (Danaher 2022). Solutionism possesses a rhetorical dimension whereby it takes the pursuit of scientific idealism and genuine problem resolution into a realm that privileges its narrative and potentially hinders opportunities to examine alternatives. As Digital Rights Watch have pointed out, 'techno solutionism is problematic because its roots run deep and it's incredibly hard to weed from public discourse once it has been introduced' (DRW 2021).

Drawing on this notion of technological solutionism, the paper examines elements of the narrative surrounding the development of novel foods and of digitalisation processes in agriculture. While 'novel foods' has been used as an umbrella term for this special issue, within the EU it refers to any food that had not been consumed to a significant degree by humans in the EU before 15 May 1997. Novel foods is therefore a capacious, even ambiguous, category and extends well beyond the often synonymous 'alternative proteins' label. The latter term is better understood as comprising a new and diverse technology sector utilising

[1] Anthropogenic ecological overshoot is defined by Merz et al. as 'the human consumption of natural resources at rates faster than they can be replenished, and entropic waste production in excess of the Earth's assimilative and processing capacity' (Merz et al. 2023: 2-3).

advanced scientific techniques that are engineering plants, micro-organisms, fungi, algae, insects or animal cells to deliver products that will largely replicate the experience of eating meat, dairy or fish. Given the diversity of developments in this category, the paper focusses upon precision fermentation to illustrate aspects of the narrative surrounding novel foods.

In doing so, the paper seeks to sidestep description of the technology and its products, and rather to attend to the discourse of solutionism which has come to prevail both within this sector and in the wider agri-food system. For without under-valuing the *potential* contribution of new technologies, it would seem that some of our most treasured attributes around food – its cultural significance, the act of eating with others (commensality), the deeply-rooted territorial dimensions of food production (farming) systems, its life-giving and nutritional properties – are in danger of being swept aside in pursuit of novel products that appear to be designed more to solve professed singular problems (the need for more protein) than to improve global dietary health and human wellbeing.

The paper embarks from the position that underpinning contemporary food system vulnerabilities has been the pursuit of a reductionist, growth-driven, wealth accumulating paradigm now largely in the hands of powerful corporate interests (Clapp 2022; Howard 2016; Carolan 2018). If food systems are to recover greater resilience in the face of polycrisis, then it seems vitally important to make the case for a more holistic, transdisciplinary and socially equitable approach in addressing how we are to feed ourselves. Indeed, if we genuinely wish to improve global food security and dietary health, it might be more appropriate to strike out on a path that embodies greater public engagement and transparency, rather than the pursuit of a strategy of enclosure that enshrines intellectual property rights over seeds and other food organisms in the hands of private corporations. Thus, in contrast to much solutionist rhetoric that makes claims to 'feeding the world' (as will be outlined below), this paper makes the case for a different approach, one rooted in humility and a more expansive mode of thinking.

Following Jasanoff (2007), this paper argues that we need to look beyond science for possible solutions to our current predicament of polycrisis. As she argues, humility compels us to think harder on ways to reframe problems so that their ethical dimensions are better revealed, to focus on known causes of people's vulnerability, to pay attention to the distribution of risks and benefits, and to reflect on the factors that promote or discourage learning. Humility is about defending modes of knowing often pushed aside in the expansion of technological capacities and re-engaging with the moral foundations for acting in the face of scientific uncertainty (Jasanoff 2007). This means embracing complexity, contingency and continuous learning through feedback loops, where positive outcomes are measurable not only in financial terms but also in terms of human flourishing (Ehrenfeld 2024, Mullally et al. 2017). As Cilliers notes, "'In order to open up the possibility of a better future we need to resist the arrogance of certainty and self-sufficient knowledge' (Cilliers 2005: 265). That means having regard for the precautionary principle, for prudent action and, as concerns the topic here, for the need to engage on a deeper level with a wide range of issues surrounding the production and consumption of food.

Consequently, underpinning the paper is a belief that the extent of our planetary predicament and our capacity to address the polycrisis requires a profound change in our values and expectations that have been so significantly shaped by neoliberal capitalism. In this regard, the first objective of this paper in approaching the question of technological solutionism is to challenge the singular, often rather simplified, narrative that it promotes. This means not only asking questions about the technologies and their ownership but also about whether the products being promised are as necessary for our wellbeing as their proponents insist. It also means establishing the identity of those likely to carry a disproportionate share of these products' externalised costs and risks.

The second objective for the paper is to make a case for an alternative narrative. This may certainly appear both less coherent – comprising divergent themes and aggregating a discordant polyphony of voices engaged

in dialogic opposition (Gruber 2023) – and undoubtedly 'messier' to operationalise than the alternative promulgated by technological solutionism. Yet in challenging the latter's promised universality where all are proclaimed as 'beneficiaries', an alternative approach establishes the situational, contextual and ecological basis of narrative construction and, embracing complexity, works to recover greater individual and collective agency on food matters across society. This raises important questions about modes of governance capable of ensuring participation and the integration of different forms of knowledge into effective policymaking (Van Assche et al. 2024) while guarding against utilitarianism aimed at 'solving' market-defined problems or developing technologies that control rather than anticipate societal needs (Mullally et al. 2017).

Drawing upon a wide range of literature, this paper offers a commentary arguing that the pace and power of technological change not only poses a challenge to consumers by widening the knowledge deficit (what, precisely, are we eating, how was it produced and how are we to know?) but threatens to overwhelm many of the social and cultural attributes of food. Thus, the paper seeks to make the case that technological innovation should proceed in such a way that nutrition and wellbeing, taste and enjoyment, cultural meaning, conviviality and social identity are not driven from consideration as we chart a course toward a more sustainable, resilient and equitable food system.

Technology as solution. But for whose benefit?

While innovation has been a feature of food production throughout human history (Mazoyer and Roudart 2006), there would surely be widespread agreement that the pace of technological change has accelerated with digitalisation (Bronson and Knezevic 2016; Guthman and Butler 2023). As the biosciences and chemistry meet new data gathering and management tools, most especially with the development of machine learning in complex data analysis, new processes executed through advanced engineering techniques have emerged to deliver novel food products. Such efforts are regarded by many as breathtaking in their scope and ambition, and demonstrate the capacity for human ingenuity (CATO Institute 2015). The claimed ambition of their proponents – in the 'move quickly, break things' language of Silicon Valley – is to disrupt the current model and design solutions for how we might eat in the future (Guthman and Biltekoff 2021). Indeed, it is argued that "'Disrupting the legacy food system is a global imperative if we are to have a thriving society… we are on the precipice of seismic shifts in how our food is produced and delivered' (Rethink Food 2024; see also Reboot Food). Yet the development of such radical innovations carries with it important cultural consequences, given that technologies are invariably embedded with human values, biases and privileges. That digital technologies have become central to a reimagination of the food system speaks to the materialist and cultural power of scientific innovation, particularly when backed by billions of dollars of new financial investments (Fasler 2024). As Guthman and Butler (2023) argue, claims to be solving the structural problems of the food system have however not been matched by their capacity to address the fundamental biophysical challenges of food and farming. Indeed, the promotion of solutions may precede problem definition where existing technologies are looking for new applications and many Silicon Valley 'solutionaries' lack a basic familiarity with the challenges facing food production.

The promise of delivering 'magic bullet' solutions, framed by promiscuous deployment of such concepts as 'sustainability', 'regenerative', and 'climate smart' production, has consequences, of course, not only in diminishing their meaning but in distracting policy and funding from engaging in the kinds of structural changes that are truly needed to effect a necessary food system transformation (IPES-Food 2022). Moreover, while moving at speed to ensure scientific breakthroughs are translated into proprietary patented technologies and achieve regulatory approval, powerful commercial interests work to exercise influence over policy processes and institutions.[2] This raises questions around how society can respond, given the privileged position

[2] At the time of writing there is considerable concern amongst non-governmental, civil society and environmental organisations about the pace of roll-back of proposed measures within the EU to protect nature. The 'great backtracking' includes diluting some of the provisions of the Nature Restoration Law, abandoning measures to reduce pesticide use, exempting cattle production from the EU's industrial emissions rules, and shelving a proposed strategy to improve Europe's freshwater resilience.

that scientific innovation enjoys in societies where governments are supportive in pursuit of competitive economic growth. Moreover, while recognising the legitimacy of claims to protect the rights of scientists over their technological innovations, this cannot extend to the wholesale exclusion of civil society when the precautionary principle demands an agreed level of transparency and accountability.

Before looking more closely at precision fermentation as one strand of novel foods, it is useful to consider the solutionist narrative that has established itself in the agricultural sector, hitherto the sole source of primary foods, where the digitalisation of farming has been proceeding at rapid pace, constituting what has been termed a 'Fourth Agricultural Revolution' (Rose et al. 2022, Klerkx et al. 2019). Leading technologies here include sensors and other data capture tools (wearable and implanted devices for animals, cameras using the visible, multispectral, and thermal imaging elements of the electro-magnetic spectrum on drones and satellites) providing a continuous stream of information that can be processed by Artificial Intelligence and other machine learning capabilities in order to deliver actionable outputs. Combining remotely sensed images of soil or crop conditions using Global Navigation Satellite Systems with enhanced granularity (i.e., sub-centimetre spatial resolution) provides precise coordinates capable of determining the application of chemicals and the performance of other field tasks using driverless and other robotic machinery.

Paying attention to such technological developments within the agricultural sector reveals the increasingly interconnected web of corporate interests where, 'Big Ag giants such as Bayer, Deere & Company, Corteva, Syngenta and Nutrien are restructuring their entire businesses around Big Data platforms. Bayer's "Field View" digital platform, for example, extracts billions of datapoints from farmland in 23 countries and funnels it into the cloud servers of Microsoft and Amazon'(ETC 2022: 10). Characterising them as the new Food Barons, the ETC Group[3] report alerts us to the ways that the assemblages of the new digital agri-technologies are enabling greater corporate control over the entire food system and, without vigilance, this might as easily unfold in the field of novel foods (Howard 2022). Being alert to – and challenging – the solutionist narrative that is used to justify path-dependent technologies is therefore critically important. For example, perhaps the most persistent trope that is used to justify and indeed to insist upon the imperative of rapid and far-reaching technological innovation is that of neo-Malthusianism. Most frequently amongst the promotional output of the agri-tech sector, one will find the rhetorical question posed, 'How will we feed a population of ten billion by 2050?'. This question is asked regularly throughout a video series available on the BBC World News platform funded by Corteva Agriscience,[4] the company formed by the merger of two already large seed and agrochemical companies, Dow and Dupont. What this series makes clear is how the 'chemicals plus seeds' model first developed under the Green Revolution is now an integral part of a deeper digitalisation of the entire food system all the way through processing and distribution to retail. It is as if digitalisation and the sophistication of the algorithms were designed to conceal what continues to be a chemically driven productivist model dominated by a handful of mega corporations that together exercise oligopolistic control of key sectors.[5]

This is believed to be a consequence of lobbying efforts by farming and agri-food interests www.euractiv.com/section/agriculture-food/news/ngos-unite-against-eus-rollback-of-green-policies-for-the-agrifood-sector/
See also 'The EU's great green retreat benefits the far right. For the rest of us, it's a looming disaster' https://www.theguardian.com/commentisfree/2024/apr/02/eu-green-deal-far-right-environment-agribusiness-extremists#comment-167097992 (accessed 13/05).
See also 'The global power of Big Agriculture's lobbying' Financial Times, 22 August 2024.
On the power of lobbying on behalf of biotech companies this piece on Jack Bobo makes for interesting reading: https://gmwatch.org/en/106-news/latest-news/20445-american-biotech-lobbyist-drives-gmo-deregulation-discussions-in-uk-eu

[3] The ETC Group is a think-tank that monitors the impact of emerging technologies and corporate strategies on biodiversity, agriculture and human rights. https://www.etcgroup.org/
[4] Follow the Food: https://www.bbc.com/future/bespoke/follow-the-food/
As James Wong pronounces in the first episode of Season Two, 'With our current global population growing at current rates, it's been estimated that we will have to produce more food in the next 30 years than we have in the entire history of humanity.'
[5] According to Clapp (2022) approximately 60% of the global seed market was held by the top four firms in 2018, while around 70% of the global agrochemical market was controlled by those same four firms. Corporate consolidation and concentration

Seizing control of the solutionist narrative appears to require claims for the highest stakes, that is, to establish the existential challenge which their technologies will resolve. Thus, in a digital newsletter on European food and agriculture which carries promoted content, the Regional Director of Syngenta Europe writes:

> *We are poised on the brink of a golden opportunity to redefine European agriculture. The questions we face are pivotal: How do we support agriculture within our planet's limits? How can we unlock the potential of knowledge and technological innovation? Our planet's health and our agricultural practices are intertwined, and the challenge, though immense, is within our grasp. (Hill 2024).*

The issue, of course, is that we do not all share the same vision for European agriculture. Syngenta, it might be noted, was created by the merger of the agricultural divisions of Novartis and AstraZeneca and was then bought by ChemChina, making it one of the world's largest pesticide manufacturers. So, if, as they suggest, our 'planet's health and agricultural practices are intertwined', it may be that their vision also includes the need to conceal from European regulators the results of brain toxicity studies arising from exposure to their chemicals (Carrington 2023a, b).

It is important to note how the language of 'precision', 'climate-smart' and 'sustainable' farming underpins the proposed solutions to our environmental predicament. Yet we might ask: what are the implications of such high-level technological developments for users? (Bronson and Knezevic 2016). If AI is to support farmer decision-making with algorithmic rationality, what are the implications for those who have previously enjoyed a high degree of autonomy drawing upon more empirical knowledge? Will we witness a new generation of cyborg farmers? This question has become increasingly prescient in light of the Right to Repair movement that has sought to challenge the capacity of companies such as John Deere to exert rights over machines purchased and owned by farmers (National Agricultural Law Center 2023, Farm Action 2024). In this respect, the deepening penetration of such technologies into agri-food production raises profound questions regarding the practice of surveillance capitalism and digital colonialism (Zuboff 2019), and demonstrates the urgent need to build a collective, democratic and open-source response (Maschewski and Nosthoff n.d). It also generates uncertainties about the future of rural areas where the likelihood of increasing farm size in order to meet the new economies of scale set by robotics may lead to a loss of population and changing cultural landscapes. Arguably, this is precisely an outcome desired by many supporters of precision fermentation as we see below, and it raises profound questions about how we are to navigate a socially just technological transition.

Precision Fermentation

The Silicon Valley-led digitalisation of food, underpinned by biotechnology and utilising tissue engineering, precision fermentation, gene editing and other related technologies, is bringing to market a range of plant, cellular, insect and fermented proteins. The professed objective in developing these novel foods is to produce substitutes for animal protein since this is an area widely and correctly regarded as the principal source of biodiversity loss, climate disruption, and land utilisation by agricultural activities (Xu et al. 2021; Clark et al. 2020; Coimbra et al. 2020). Besides their putative environmental and animal welfare benefits, novel foods are also often represented as a way of extending consumer choice, developed to accommodate changing 'lifestyle' considerations and healthier bodies (Sexton et al. 2019).

Precision fermentation is one of the novel food technologies currently being developed. Given that the first keynote address at the 2023 Rome Conference on Novel Foods was given by George Monbiot[6] on the topic of precision fermentation, it seems appropriate to look more closely at the claims being made for this technology, and leave aside other novel food processes. Fermentation of foodstuffs is, of course, a long-

continues in other parts of the agri-food system, for example with four firms controlling around 70% of global grain trade.

[6] George Monbiot, for those who may not be familiar with this name, is a UK based, award-winning journalist, author, and environmental and political activist. He writes a regular column for The Guardian newspaper and was the first invited Keynote speaker at the Rome Conference on Novel Foods. Further details about him and his work can be found here: www.Monbiot.com.

established practice that provides a sense of familiarity given its use to process raw materials into stable products such cheese, yoghurt, kimchi, bread and beer. Biomass fermentation may utilise algae or fungi to yield high protein food products, such as Quorn, as well as biofuels such as ethanol. Precision fermentation, on the other hand, uses microbes as 'cell factories' in order to produce a wide range of functional ingredients such as protein, enzymes, flavouring agents, vitamins, natural pigments, and fats (GFI 2024). Precision fermentation can use a wide range of feedstocks including food waste, by-products from food processing industries (e.g. whey from cheese-making), while algae offer a particularly promising option (Augustin et al. 2024). The process takes place in brewery-style fermentation tanks, or bioreactors, which are very 'space-efficient', and when "scaled up, fermentation can produce many tons of biomass every hour' (GFI 2024).

Monbiot began his talk[7] by insisting that the use of land around the world ought to be one of our key environmental metrics, one matching the climate emergency, yet it receives too little consideration. Drawing on land use statistics (Ritchie and Roser 2019), he argued that livestock production worldwide was the major driver of biodiversity loss and agricultural sprawl, and that it was imperative to get out of animal farming. Fortunately, for Monbiot, single cell organisms offer an exit route while also supplying high levels of protein, and so for him represent 'the most important environmental technology ever developed'. Indeed, as he has written, 'It might be all that now stands between us and Earth systems collapse' (Monbiot 2022a).

Significantly, Monbiot is not alone in this view, given work underway on the development of single cell proteins that could be produced from hydrogen or other cheap and abundant feedstock. Such proteins could potentially support human survival in the event of a global catastrophe such as a super-volcanic eruption, asteroid impact, or nuclear winter causing global agricultural collapse due to reduced sunlight reaching the Earth's surface (Pham et al. 2022; Garcia Martínez et al. 2022). One might consequently assume that these new technologies are pitched at the highest level of existential solutionism yet are made more miraculous by their claim to dematerialise the production of nutritionally comparable protein. This inevitably raises more sceptical doubts around 'magical thinking' (Guthman and Biltekoff 2021). In his talk, for example, Monbiot extolled Solar Foods, a Finnish company, that produces a high protein powder using a hydrogen-oxidising bacterium and which the company states is 'a protein out of thin air' (Solar Foods 2024). Yet making such claims for precision fermentation is a high stakes game and necessarily invites scrutiny of the data, methods and assumptions that support the case, let alone evaluation of the implications arising from the technology's widespread implementation.

In his talk, Monbiot placed particular emphasis on the 'land sparing' possibilities of single cell organisms and microbial fermentation, not only in comparison to livestock rearing but also in relation to crop plant proteins such as soy. Producing all of the world's protein requirements in contained bioreactors could be achieved, he suggested, in an area the size of Greater London. This would then enable a Great Rewilding of previously farmed landscapes to take place, a notion in line with the 'Half Earth' strategy, a conservation initiative which advocates that protecting half of the Earth's land and sea areas would likely conserve at least 80% of preindustrial species richness (Crist et al. 2021). Precision fermentation would then appear to be an ideal solution in achieving these aims if Monbiot's calculations are correct:

> *…using methanol (as feedstock) needs 1,700 times less land than the most efficient agricultural means of producing protein: soy grown in the US. This suggests it might use, respectively, 138,000 and 157,000 times less land than the least efficient means: beef and lamb production (Monbiot 2022a).*

Logically, this technology would also bring about radical reductions in water use and greenhouse gas emissions and avoid the spillover of waste and chemicals typically caused by farming. It would thus appear then that the technology offers a self-evident win-win solution and perhaps explains Monbiot's rather exasperated tone when responding to more sceptical questions.

[7] Available at https://aur.edu/node/4713. Monbiot's talk begins at 09 min17 and finishes at 1hr 11.30.

Clearly, new technologies do offer possible pathways to reduce livestock's environmental burden, provide malnutrition mitigation pathways and enhance food system resilience (Tzachor et al. 2021). Yet cautiously evaluating such possibilities, while recognising the serious technical and institutional challenges that exist, requires a broadening of perspective as well as the need for reliable data drawn from methodologically sound and systematic analyses. For example, a recent review paper has suggested that single cell protein bioreactors may not necessarily exhibit environmental benefits, and that various conditions such as the cultivation system, location, season, scale, microbial species and source of nutrients would considerably influence environmental impact (Smetana et al. 2023). It goes on to argue that 'the environmental impact of single-cell proteins is dependent on the use of renewable energy' given that the production of hydrogen for cell growth is so energy intensive (Smetana et al. 2023: 7). This is why detailed and transparent life-cycle assessments are necessary in order to evaluate the legitimacy of solutionist claims.

In his book, *Regenesis* (2022c), Monbiot sets out a broader case for the subject of his Rome talk, that of microbial protein production, but also takes to task agriculture more generally, regarding it as little more than an outdated – and highly inefficient – way of producing food. In a book-length rebuttal, Smaje (2023) offers something of a forensic analysis of Monbiot's book and, in particular, subjects the latter to detailed scrutiny around its treatment of energy. Highlighting the paradox of substituting free solar energy to grow plants by the need to supply large amounts of electricity needed to drive bioreactors, Smaje calls into question the feasibility of this shift. In a peer-reviewed publication (Järviö et al. 2021) reporting on the LCA study they conducted at Solar Foods (the same company visited by Monbiot), the authors calculate an electricity requirement of 18 kWh per kilogram of product output. Without appropriate attribution, this is the figure that Monbiot uses to suggest that meeting the global population's protein needs would therefore require just 11% of the world's installed electricity capacity.[8] Here Monbiot displays his ecomodernist credentials, for he argues that this additional energy could easily be supplied through new nuclear technology as well as through a massive expansion of renewables. Given the urgency – yet financial and regulatory challenges – of decarbonising electricity generation to meet current needs, let alone the controversial role of nuclear in the energy mix, Monbiot's position seems, at best, ingenuous.

In this respect, the enthusiasm for the technology of precision fermentation – which, it has to be said, borders on zealous advocacy in Monbiot's case – appears to overwhelm all other considerations, while the building and installation of thousands of fermentation tanks – a brewery in every town according to Monbiot – underplays the embedded resource investments in concrete and steel, let alone their operating energy requirements. Precision fermentation also potentially threatens many farmers around the world, and not just those engaged in livestock rearing. For example, Planet A Foods uses precision fermentation to create ChoViva, 'an indulgent, cocoa-free chocolate'. This means 'we can utilise local crops, which are harvested in a much more sustainable and people-friendly way, than crops like cocoa' (Planet A Foods 2024). Cocoa farmers in West Africa are already under severe pressure because of climate disruption, the spread of a viral infection and the growth cycle of cocoa plants, and are now likely to face increasing competition from a manufactured substitute that might promise environmental benefits but will come at a cost to livelihoods.

Such developments reveal the highly complex, interconnected issues of technological, ecological and social change driven by the pursuit of financial returns by corporate interests. Yet this complexity is reduced to simplistic tropes by companies – such as by Planet A Foods – declaring 'A new era of sustainable food ingredients is here' without fully considering what this might mean for small farmers in West Africa. Likewise, Monbiot's enthusiasm to rewild land spared from livestock agriculture has simply enormous consequences for temperate upland farmers with limited options for arable crop cultivation. Perhaps Montenegro de Wit

[8] Smaje, drawing on studies from elsewhere, arrives at a figure nearly four times this – 65 kWh/ kg of product – and extrapolates that this would require around 43% of the world's electricity consumption or 89% of its low-carbon electricity supply. Smaje blogs on these and other issues. See 'The energetic implausibility of manufactured food revisited' at https://chrissmaje.com/2024/01/the-energetic-implausibility-of-manufactured-food-revisited/

(2022) poses this dilemma best when interrogating the assumptions about nature that distinguish the 'saving-land-from-people discourse' of gene editors and ecomodernists, as opposed to the 'saving-land-with-people' discourse of agroecology. Above all, the solutionist narratives emerging from the novel foods sector reveals the ways in which problems are framed to match the solutions they can provide, but appear to disregard the wider consequences, such as the livelihoods of livestock or cocoa farmers. Surely any claim to be feeding the world sustainably must embrace a more holistic and inclusive perspective as well as some degree of scientific humility about the technology's limitations and consequences.

Technological solutionism and sustainable, healthy diets

It has been noted that a consequence of media interest in the novel foods sector is that it skews to the celebratory and thus overshadows a broader debate on what these developments might mean for food and agriculture more generally (Sexton and Goodman 2022). Indeed, maintaining a focus on the *technology* rather than the *outcomes* of that technology serves to deprive society of a voice, an opportunity to question the desirability of the products being developed (Nerlich 2021). A preoccupation with the 'heroic' efforts of laboratory scientist-entrepreneurs invariably circumscribes the opportunity for wider societal debate around the pursuit of alternative strategies that take social inequality, nutritional security and ecological integrity seriously (McGreevey et al. 2022). It therefore seeks to maintain a top-down approach seeking global solutions to ostensibly meet consumer *wants* (continued availability of cheap and convenient protein) rather than enabling more localised food systems that engage with helping citizens to achieve their nutritional *needs* while preserving the social, cultural and ecological importance of those systems. It certainly does not challenge consumerism nor provide any restriction on freedom of choice. Simply extending a range of options in the supermarket might assuage a moral dilemma for flexitarians but is unlikely to keep us within 1.5°C of global atmospheric heating (Clark et al. 2020).

This is, of course, not disconnected from the extraordinary economic power and influence exercised by those businesses emerging as leaders in the field. The consolidation of corporate power in the food system through merger and integration as well as through extending market reach and product diversification is well documented (Clapp 2022; Howard et al. 2021; ETC 2022; IPES-Food 2017). Some of the big investors in novel foods are also some of the largest meat and dairy processing firms, and reconciling their involvement in plant-based substitutes while their core business remains in slaughtering animals appears to be resolved by relabelling themselves as 'protein' companies (Howard et al. 2021). This positioning around a charismatic macro-nutrient regarded as indispensable to human health serves to obfuscate those companies' continued activities in meat. At the same time, spreading risks in the event of regulation- or climate-driven destocking rules enables the co-existence of novel foods with business-as-usual livestock operations and crowds out alternative solutions for just, equitable dietary solutions (Guthman et al. 2022).

It is clear how the discursive power of solutionism is underpinned by a wide portfolio of products and technologies capable of utilising a range of interchangeable materials (microbial enzymes, algae, plant biomass, animal cells, secretions and tissue) as feedstock to deliver a diverse set of building blocks for food, energy and other industrial applications. Given the urgency to transition from fossil fuels, biorefineries, in addition to meeting the demand for protein, are likely to be processing growing volumes of agricultural raw materials into biofuels and biopolymers.[9] The entanglement of novel food production with the energy, transport and chemical sectors is therefore bound to increase and, depending upon market conditions, greater volumes of commodity crops hitherto regarded as primary foods might yet find themselves being used as feedstock in bioprocessing operations rather than feeding people directly.

In this respect it is necessary to ask if novel foods will facilitate or hinder the encouragement of consumers to move toward more whole plant-based eating in the interests of sustainability and dietary health, as proposed

[9] Currently an estimated 40% of the US corn crop is converted into ethanol.

by the planetary health diet (Willett et al. 2019)? While these new products may achieve comparability in terms of protein and other essential nutrients, the use of ingredients to provide flavour, colour, edibility, digestibility and binding agents has raised concerns about levels of sodium and other markers characteristic of ultra-processed foods (Lumsden et al. 2024; Monteiro et al. 2019). Moreover, it is worth reminding ourselves that the majority of these novel food products are presented in the form of burgers, nuggets, meatballs, hot dogs and other processed, extruded and printed shapes symptomatic of fast-food eating. Invariably served with potato fries and within a white bread bun, the dish is not a testament to healthy eating. We might also ask how novel foods fit within existing culinary traditions and associated agri-food culture, given their tendency to mimic conventional fast-food analogues. What does the increasing prevalence of such products mean for more territorially specific and healthier foodways such as the Mediterranean Diet?

Ultimately, novel foods' preoccupation with protein should remind us that any nutrient is not consumed in isolation but rather ingested as an element within complex dietary patterns that, depending on their society and geography, can display significant daily, weekly, and seasonal variability (Lumsden et al. 2024). Moreover, the complementarity of different foods and the ways they work in combination has provided the basis for nutritionally adequate diets (rice and lentils, corn and beans) for hundreds of generations. Plants contribute almost two-thirds of global dietary protein compared to one-third for animal products, though this ratio is reversed amongst the richest countries where the incidence of diet-related non communicable diseases (NCD) is most marked. Consequently, while novel foods are likely to find space on future plates within a continuum of flexitarianism (Kanerva 2022), the role of whole-plant farmed foods surely remains central to dietary well-being.

Finally, while this paper has sought to critically evaluate the solutionist claims for novel foods, it is recognised that it faces challenges from the incumbent meat lobby. Reactions to the EAT-*Lancet* publication (Willett et al. 2019) – amongst a deluge of other scientific studies highlighting the problems of industrial meat production – are testament to the power of livestock interests not engaged in the protein transition to resist such initiatives, including building alliances with university academics in order to establish a science-based rebuttal (Morris and Jacquet 2024; Garcia et al. 2019).[10] Consequently, challenging technological solutionism and its promissory narratives should not distract us from remaining vigilant to incumbent interests anxious to protect the status quo centred upon productivism and consumerism. Creating an alternative narrative capable of supporting food system transformation in the interests of human and planetary health at a time of polycrisis thus requires an enormous collective, collaborative, and creative effort across civil society and beyond.

Building an alternative narrative

The paper has argued that the food system has become particularly susceptible to narratives of solutionism in which neo-Malthusian, environmental or animal welfare tropes are deployed to demonstrate the critical – even existential – contribution that its technology plays in overcoming the issue. Here the multi-dimensional attributes of food as the basis for social cohesion, cultural meaning, nourishment for wellbeing throughout the life-course, and ecological equilibrium begin to disappear. This is why it is important to create new narratives of food system transformation that can address the diverse challenges highlighted at the beginning of this paper, and do so in a way that recognises complexity, contingency and the need for collective and continuous learning. Embarking on such a task requires the rejection of reductionist metaphors of food ('food as protein, fuel for the body as machine') and the creation of new metaphors that span food's cultural and social domains (Sage et al. 2022). It also requires the identification of key concepts around which to mobilise – ideally words that have not yet been completely (mis)appropriated by defenders of 'business-as-usual'.

[10] See also the Dublin Declaration of Scientists on the societal role of livestock (https://www.dublin-declaration.org/) as an example of this pushback where it is stated that livestock systems 'are too precious to society to become the victim of simplification, reductionism or zealotry'.

Agroecology is one such term that has gained real traction in offering a focus for an alternative paradigm for food systems. That it has largely emerged from subaltern usage, especially in Latin America (Altieri and Toledo 2011) and its association with La Via Campesina, provides it with a legitimacy denied to other more tainted concepts. Agroecology is however not simply a technical roadmap for low-external input agriculture; it comprises a more holistic, transdisciplinary, epistemological framework through which to understand the multiple shortcomings of the existing food system and the place of various actors within it. While encompassing a wide portfolio of farm and landscape-level 'best practices' that need to be evaluated and implemented as place-specific operations, it builds upon principles of stakeholder participation, the co-creation of knowledge and transformative efforts to establish a more resilient, equitable and socially just food system (Bezner Kerr et al. 2023).

Incrementally, then, an agroecological paradigm has taken shape and gained legitimacy in policy circles in recent years, not least as a consequence of the UN Committee on World Food Security (CFS) High Level Panel of Experts (HLPE) report (HLPE. 2019), the FAO's creation of an agroecological knowledge hub (Barrios et al. 2020), and a growing academic literature inspired by the work of Miguel Altieri, Steve Gliessmann and others.[11] Yet the agroecology movement has pushed back against attempts to co-opt the narrative by agri-food corporations (Bless et al. 2023) and has worked hard to maintain its tripartite definition as comprising science, practice and social movement. It is this pragmatic epistemological framework of agroecology that could provide the basis for promoting an alternative narrative that can also be taken up by other social actors engaged with food system transformation.

It is now clear that there exists a relatively well-organised and interconnected global social movement around food which, in contrast to first-generation alternative food networks (Goodman et al. 2012), is now demonstrating greater ecological and social justice awareness and capability for action. This 'second generation' food movement (Sage et al. 2021), while largely comprising civic food initiatives, is increasingly well-connected both within national jurisdictions and through international networks. These initiatives, thinking critically about the food system, recovering a territorial dimension to production systems, and finding ways to recover the materiality of endogenous foods and culinary traditions, present one opportunity through which to start a wider conversation around alternative 'food futures' (IPES-Food and ETC Group, 2021).

While many of these initiatives, seeking to co-design their urban spaces in collaboration with municipal government, reveal a wide variety of practices, one expression of this new civic collaboration has been the creation of food policy councils[12] (Schiff et al. 2022; Giambartolomei et al. 2021). These provide a platform for engaging citizens within a quasi-legitimate framework, not only to devise local strategies but potentially to enable a wider civic dialogue around food. At a time of polycrisis marked by growing polarisation, populism, and pessimism, the application of representative deliberative processes to improve public policy outcomes is being more widely considered. These include citizens' assemblies, citizens' juries and other consultative and consensus building models (OECD 2020). There is consequently an emerging epistemological framework involving civil society actors, local government, deliberative methodologies and a growing sense of urgency that could provide the basis for developing new narratives around the food system.

Yet challenging technological solutionism raises the issue of knowledge deficit: how can the public better understand – and trust – novel foods, recognising their societal usefulness, ethical acceptability and sustainability rather than accepting their existence under a barrage of solutionist marketing? Broad and Biltekoff argue that achieving such trust requires engaging the public through multi-stakeholder dialogue, enabling them to

[11] This paper cannot do justice to the range and scope of published work or to the efforts of activists working in the field of agroecology. However, useful entry points, besides the work of Altieri and Gliessman, are provided by Anderson and Anderson (2020) and Tomich (2011).

[12] Food policy councils may exist under a different nomenclature, such as food partnerships or food advocacy coalitions, but generally they hold in common an organisation that brings together diverse stakeholders sharing a common interest in advocating on local food issues.

explain what they want from the food system, the ethical principles to which industry should conform, and the questions they have about the new technologies (Broad and Biltekoff 2022). If this means upstream involvement of citizens able to examine the innovation process – and not simply to offer thoughts on near-to-market improvements – it will require the building of public capacity to ask the kinds of penetrating questions posed by Schweizer (2022). Armed with such knowledge, would that then permit a more generous openness to new tools and techniques that give rise to novel foods?

In an intriguing paper, Montenegro de Wit (2022) examines the contrasting ontologies of agroecology and the gene editing technology known as CRISPR which, for most of us familiar with the regulatory struggles over first-generation GMOs, would be regarded as entirely incompatible. Given her natural and social scientific education, as well as cultural background, the author offers an argument for complementarity – even synergy – for the two. Stripping away the economic and political advantages and protections that corporate biotechnology enjoys, she poses important questions about ownership and control, considering whether open-source and commoning arrangements could overcome the IP lock-in that CRISPR and other techniques enjoy. Here, she outlines six principles for technology sovereignty which ultimately come down to establishing people's right to make decisions about and co-create 'technologies that reflect, respond to, and mobilise communities' collective knowledge and power' (Montenegro de Wit 2022: 750).[13]

Building an alternative narrative, then, invites us to reconsider the role of technology but stripped of its solutionist hubris, freed from the chains of corporate hegemony, and carefully unrolled with due regard for precaution, the capacity for collective learning, and the sharing of benefits. However, at the heart of this narrative must lie a foundational objective that can mobilise communities and drive a strategy for transformation, particularly at a time of polycrisis. The concept of resilience, for example, might serve this purpose. Though long used as a desirable property of systems – the capacity to withstand shocks, stress and risks, underpinned by robustness, adaptive capacity and recovery (Folke 2006) – its application to food systems establishes the central importance of equitable access to food, nutritional security and social justice. Building adaptive capacity within food systems for producers means prioritising local diversity of culturally appropriate foods, using agroecological principles that reduce reliance on external inputs and exposure to their fluctuating market prices (Schipanski et al. 2016). Above all, however, food systems need reorientation, moving them gradually away from short-term and resource-intensive productivism delivering cheap food that increases vulnerability to a host of risks for producers and consumers alike. A just and lasting reduction in vulnerability will involve 'changing societal expectations and the demands of system outcomes in order to enhance food system resilience'[14] (Zurek et al. 2022: 521).

Reorientation of food systems involving changing societal expectations would therefore seem to be an inescapable part of strengthening resilience; it implies going beyond a gradualist reduction in levels of food waste, meat consumption, adoption of novel food products and other such 'nudged' behaviours in the hope that consumers make informed choices and that these lead to reduced environmental impacts. Building a more democratised and socially just food system could mean reorientation toward a broadly agroecological structure, involving a reimagination and re-creation of food production, processing, distribution, consumption and governance (McGreevey et al. 2022). As Montenegro de Wit (2022) observes, technology has an important role to play but it depends upon the social, political and economic ecosystem around it to guide it towards desirable, democratic and more equitable outcomes. Above all, this requires the engagement of citizens to reclaim agency and voice, challenging dominant narratives of technological solutionism in the service of profit accumulation and corporate control, and creating an alternative discourse that speaks to human and

[13] These six principles of technology sovereignty – closely following those of food sovereignty – focus on: technology for people; valuing food providers as tech providers; localising tech systems; putting control in local hands; building knowledge and skills; and working with nature (Montenegro de Wit 2022).

[14] It should be noted that the High-Level Panel of Experts on Food Security and Nutrition of the FAO's Committee on World Food Security (CFS) has been charged with producing a report on 'Building resilient food systems' to be presented at the 53rd plenary session of the CFS in October 2025.

ecological wellbeing, social justice, and planetary stability.

Conclusions

This paper has sought to offer a critical commentary on technological solutionism especially as it is emerging in the realm of novel foods. Utilising the notion of polycrisis as representing a multidimensional and interconnected set of contemporary challenges, it argues that if we are to live within planetary boundaries and ensure nutritional security for all, we need to look beyond mainstream science and the invention of technical fixes, and develop a new mode of thinking that embraces complexity and greater scientific humility. Following a brief examination of precision fermentation, outlining George Monbiot's belief that single cell proteins represent 'the most important environmental technology ever developed' – though with enormous uncertainties around its energy demand – the paper considered how novel foods might contribute to the achievement of sustainable, healthy diets. Asking questions about the technology not only reveals a scarcity of uncontested scientific evidence able to establish its case for superior performance – whether environmental or nutritional – over existing products, but also raises concerns about possible impacts from scaling production on other groups of people far removed from the sites of bioreactors. The narrow framing of problems ('a future protein shortage') is therefore designed to match the solutions the technology can provide but critically at the cost of disregarding wider consequences.

This demonstrates the need to develop alternative narratives capable of drawing together – and energising – a much wider range of stakeholders than the corporate interests that lie behind technological solutionism. It was suggested that agroecology might provide a suitable framework given its holistic, transdisciplinary and knowledge co-creating epistemology, as well as the importance attached to participation in building a more resilient, equitable and socially just food system. The role of technology will be critical, and we have to closely consider how it can best support civil society to exercise greater agency, perhaps through pressing for more collective, open-source tools in resistance to digital colonialism. This will require challenging dominant narratives of technological solutionism in the service of profit accumulation and corporate control, and creating an alternative discourse that speaks to human and ecological wellbeing, social justice, and planetary stability.

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