Sustainable agrifood systems for a post-growth world

McGreevy, S.R.; Rupprecht, C.D.D.; Niles, D.; Wiek, A.; Carolan, M.; Kallis, G.; ... ; et al.

nature sustainability

PERSPECTIVE

https://doi.org/10.1038/s41893-022-00933-5

Check for updates

Sustainable agrifood systems for a post-growth world

Steven R. McGreevy[1,2,3,30] ✉, Christoph D. D. Rupprecht[4,30], Daniel Niles[3,30], Arnim Wiek[5,30], Michael Carolan[6], Giorgos Kallis[7,8], Kanang Kantamaturapoj[9], Astrid Mangnus[10], Petr Jehlička[11], Oliver Taherzadeh[12], Marlyne Sahakian[13], Ilan Chabay[14], Ashley Colby[15], Jose-Luis Vivero-Pol[16], Rajat Chaudhuri[17], Maximilian Spiegelberg[2], Mai Kobayashi[18], Bálint Balázs[19], Kazuaki Tsuchiya[20], Clara Nicholls[21], Keiko Tanaka[22], Joost Vervoort[10], Motoki Akitsu[23], Hein Mallee[24], Kazuhiko Ota[25], Rika Shinkai[3], Ashlesha Khadse[26], Norie Tamura[27], Ken-ichi Abe[3], Miguel Altieri[28], Yo-Ichiro Sato[24] and Masashi Tachikawa[29]

Sustainable agrifood systems are critical to averting climate-driven social and ecological disasters, overcoming the growth paradigm and redefining the interactions of humanity and nature in the twenty-first century. This Perspective describes an agenda and examples for comprehensive agrifood system redesign according to principles of sufficiency, regeneration, distribution, commons and care. This redesign should be supported by coordinated education and research efforts that do not simply replicate dominant discourses on food system sustainability but point towards a post-growth world in which agroecological life processes support healthy communities rather than serving as inputs for the relentless pursuit of economic growth.

Global agrifood systems—contemporary knowledge, institutions, infrastructures, practices and crops that define the predominant patterns of food production and consumption—are major forces of climate change, ecological degradation and rural decline[1]. Tackling these challenges requires the reimagination and re-creation of circuits of food production, processing, distribution, consumption and governance on the basis of humankind's best experience in agriculture as an immediate source of community well-being and fundamental field of interaction with nature[2]. Such profound reconfiguration exceeds much scientific discussion of sustainable agriculture, which, with notable exceptions, has for several decades centred on maintaining principal patterns of consumption while reducing negative environmental impacts of production[3,4]. Just as in the fossil fuel sector, much agricultural sustainability discourse has focused on incremental gains in energy efficiency and the disproven logic of green growth[5], rather than system-wide transitions to new energetic regimes. Fortified by the ideology of economic growth, this 'conventional' sustainability logic plays an outsized role in science and policy agenda-setting, as it maintains the legitimacy of dominant agrifood system players (and their influence within societal processes such as United Nations Food Summits) that obstruct the pursuit of post-growth agrifood solutions[6].

As a consequence, most change strategies presented to date are insufficient to achieve agrifood system transformation to sustainability. Reducing the consumption of meat and shifting to plant-based diets, reducing crop loss and food waste, and making technological and managerial improvements to food production[4,7] are indeed vital elements in substantial agrifood system change. Yet, such measures fail to address the underlying institutional, policy and economic structures at the roots of agrifood system unsustainability[8]. Decades-long concentration in the agrifood industry has created massive agri-industrial clusters whose business models drive unsustainability[9]. These clusters have developed and continue

[1]Faculty of Behavioural, Management, and Social Sciences, Section of Governance and Technology for Sustainability (CSTM), University of Twente, Enschede, the Netherlands. [2]FEAST NPO, Kyoto, Japan. [3]Research Institute for Humanity and Nature, Kyoto, Japan. [4]Faculty of Collaborative Regional Innovation, Department of Environmental Design, Ehime University, Matsuyama, Japan. [5]College of Global Futures, School of Sustainability, Arizona State University, Tempe, AZ, USA. [6]Sociology Department, Colorado State University, Fort Collins, CO, USA. [7]Catalan Institution for Research and Advanced Studies (ICREA), Barcelona, Spain. [8]Institute of Environmental Science & Technology, Universitat Autònoma de Barcelona, Barcelona, Spain. [9]Faculty of Social Sciences and Humanities, Mahidol University, Nakhon Pathom, Thailand. [10]Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, the Netherlands. [11]Institute of Sociology, Czech Academy of Sciences, Praha, Czechia. [12]Institute of Environmental Sciences (CML), Leiden University, Leiden, the Netherlands. [13]Department of Sociology, University of Geneva, Geneva, Switzerland. [14]Institute for Advanced Sustainability Studies, Potsdam, Germany. [15]Rizoma Field School, Nueva Helvecia, Uruguay. [16]Université Catholique de Louvain, Louvain-la-Neuve, Belgium. [17] Calcutta, India. [18]Center for the Promotion of Interdisciplinary Education and Research, Asian Studies Unit (KUASU), Graduate School of Economics, Kyoto University, Kyoto, Japan. [19]Environmental Social Science Research Group, Budapest, Hungary. [20]Social Systems Division, National Institute for Environmental Studies, Tsukuba, Japan. [21]Department of International Area Studies, University of California Berkeley, Berkeley, CA, USA. [22]Department of Community and Leadership Development, University of Kentucky, Lexington, KY, USA. [23]Graduate School of Agriculture, Division of Natural Resource Economics, Kyoto University, Kyoto, Japan. [24]Faculty of Letters, Kyoto Prefectural University, Kyoto, Japan. [25]Department of Policy Studies, Nanzan University, Nagoya, Japan. [26]Amrita Bhoomi Agroecology Center, Hondarabalu, India. [27]Graduate School of Project Design, Osaka, Japan. [28]Department of Environmental Science, Policy, and Management, University of California Berkeley, Berkeley, CA, USA. [29]Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan. [30]These authors contributed equally: Steven R. McGreevy, Christoph D. D. Rupprecht, Daniel Niles, Arnim Wiek. ✉e-mail: s.r.mcgreevy@utwente.nl

Table 1 | Principles by which growth and post-growth metabolisms operate arranged by category

	Economic principles	Social–ecological principles	Allocative principles	Institutional principles	Relational principles
Growth metabolism	Efficiency	Extraction	Accumulation	Private ownership	Control
Post-growth metabolism	Sufficiency	Regeneration	Distribution	Commons	Care

to promote industrial livestock production, in tandem with the overproduction of feed cereals and widespread conversion of intact forestlands[10]. This process is often subsidized by nation-states, facilitated by international trade law and underwritten by the capitalist logic of efficiency, economies of scale and externalization of real costs[11].

If such actors, networks, and scientific and economic logic are left unchallenged, ecological value will continue to be converted into 'foods from nowhere', rural lands will continue to be appropriated and rural peoples dispossessed, and exploitative labour relations and abuse of animals will continue, while the responsibility for such unhealthy and unjust agrifood systems is assigned to individual and societal choice[12]. In addition, just as did the global food crises of 2008 and 2010, the war in Ukraine highlights the need to rethink the ways in which, at field, local, national and international levels, the dominant agrifood systems and food security discourse are predicated on continued easy access to cheap fossil fuels, the majority of which need to remain unextracted to avert dangerous climate change[13]. This realization underscores the importance of the IPCC's first-ever discussion of degrowth in 2022 and its grave summary of contemporary global environmental change. To be true to its name, the science of sustainable agrifood systems must address the structural social inequities and ecological exploitation existing at the core of industrial agrifood systems and the insinuation of their underlying logics into the food security and wider sustainability discourse.

Post-growth agrifood system principles

Transforming global agrifood systems for sustainability means moving beyond the growth paradigm. It requires reconceptualizing human food metabolisms according to values, food practices and lifestyles that strive for sufficiency over efficiency, regeneration over extraction, distribution over accumulation, commons over private ownership and care over control (Table 1). These principles have been identified by Indigenous, feminist, degrowth and post-development communities as essential to food sovereignty, food justice, social equity, cultural survival and ecological integrity, but they remain absent within most sustainability discourses, including the Sustainable Development Goals[14–16].

Sufficiency. The principle of sufficiency has profound ethical, political and philosophical meaning. Most immediately for our purposes, it means producing enough healthy food for those who need it and doing so in ways that promote the welfare and stewardship practices of those who produce it. If sustainability is the overarching challenge of our time, sufficiency supersedes the growth-driven logic of efficiency, which prioritizes agricultural yields and economic profit over land access and stewardship, while externalizing real costs (such as ecological damage and negative health impacts) or shifting them to the future[17]. Sufficiency addresses the bodily physiological and psychological needs for sustenance, asking what amounts and kinds of foods are nutritionally and culturally appropriate, and how this food can be produced and shared to eliminate undernourishment and control overconsumption[18]. Sufficiency engages social–ecological limits that are linked to community health and well-being, to field-level agroecologies and to their 'nested' positions within wider ecologies. Sufficiency involves the recognition of nonhuman agencies on their own terms (for example, the 'rights of a river'), recognition that also extends to the real action of billions of agencies in keeping life on the planet at play[19]. While traditional societies around the world have long insisted on the interconnectedness of life and planet, the principle of sufficiency obliges modern societies to conceptualize and institutionalize new forms of non-anthropocentric juridical thought concerned with the comprehensive rights of life.

Regeneration. The principle of regeneration requires producing food at rhythms compatible with the creative and recuperative processes of ecosystems and people, now and in the future. This principle highlights the value of bio-culturally diverse agroecological food systems that generate fertile soils and agrobiodiversity, management practices that ensure the quality of life of farm animals, and landscape practices that maintain habitat for wild species and ecological interactions[20]. When related to human communities, the principle of regeneration involves the recognition and support of diverse traditional food systems, while also drawing attention to the position of human labour within these as well as to entrenched historic agri-environmental and social injustices (such as insecure land tenure and asymmetric power labour relations) that have usurped community capacity for social reproduction and undermined community well-being.

Distribution. The principle of distribution prevents concentration and overaccumulation. It addresses historic injustices underlying and still perpetuated through contemporary agrifood systems, including the continuing usurpation of Indigenous lands and the legacy of colonialism and imperialism[21,22]. It addresses the international trade and domestic policies undermining family- and community-scale production and facilitating industry concentration around the world[23]. Regionally, the principle of distribution emphasizes localized food economies rooted in the landscape and seascape, often facilitated by direct links between producers and consumers. Distribution is a key concern of hybrid worker–consumer cooperatives[24], in which farmers, retail entities and consumers act as co-producers of food products and related services, developing policies to ensure mutual benefit and the redistribution of excess gains. The principle of distribution also concerns agricultural and environmental knowledge[25], as greater engagement in agrifood endeavours also invites closer attention to seasonality, the quality of local landscapes and seascapes, the lives of individual farm animals, and other place-making features of particular food cultures and agricultural systems.

Commons. The principle of food as a commons rather than a commodity already informs many approaches to land management and access to food. It exists alongside diverse similar notions found across cultures and reflects food's many dimensions, from necessity for human life to expression of cultural identity. "The end-goal of a food commons system should not be profit maximization but rather increasing food access in ways that are fair to producers and consumers, build community and shorten the distance from field to table…all the while stewarding natural resources for future generations"[26]. Communal stewardship of food systems allows people to experience natural abundance, helping unlearn damaging

patterns of behaviour driven by the experience of artificial scarcity under private ownership[27]. Re-commoning—reversing the process of "accumulation by dispossession"[28]—literally and conceptually opens access to space required for post-growth food systems. Land, soil, water, seeds, equipment, techniques, knowledge and skills—each of these resources can be managed through commoning as a way of being[29] practised by humans and non-humans alike. This principle is applied in the various contemporary attempts to advance the governance of agrifood systems through practices of 'food democracy'[30].

Care. The principle of care replaces the techno-scientific ideal of control in agrifood system sustainability and the neoliberal tinge of 'food security'. Care supports commons; it lies at the heart of the post-growth metabolism, enabling and guiding inter- and intra-species relations[31] and establishing the ethical foundation of food sovereignty[23]. Care recognizes the role of women, children, migrants and many others, whose indispensable contributions to food production are often neglected[32]. It emphasizes mutual producer–consumer interests in agrifood systems and interconnectedness and interdependencies within local and even global food networks. Care brings attention to the need to establish multispecies sustainability policies based on the recognition of the multitude of animal, vegetal, fungal and microbial agents shaping shared landscapes[33], even as these are co-constructed and co-stewarded across large geographical and relational distances[34]. The principles of care and commons are often grounded in diverse syncretic forms of traditional agricultural knowledge and spirituality, including an awakened sense of belonging to the 'spirited' web of living beings[35,36].

Post-growth agrifood systems in action

Fortunately, these principles are already instantiated in many creative and inspiring endeavours around the world, including in food production (for example, agroecological farming and gardening), food businesses (for example, business model innovation, cooperatives, alternative (direct) trade arrangements and circular economy), food culture (for example, narratives, rituals and traditions) and food governance (for example, food policy councils, policy integration and anticipatory governance). Such 'real utopias' developed across Indigenous, feminist, degrowth and post-development communities[14–16] offer guidance for the transformation towards sustainable agrifood systems, as illustrated in the remainder of this Perspective.

Food production. Agroecological food systems apply the principles of sufficiency, regeneration, distribution, commons and care through the observation of and engagement with the complex relationships between plants, soils and pollinators. For decades, agroecology has demonstrated how at field and landscape levels agriculture can provide abundant high-quality foods as it enhances agrobiodiversity and nutrient cycling, creates and maintains fertile soils, and improves agrifood system resilience to social and ecological shocks[37,38]. Diversified small farms can produce higher yields while using land and water more efficiently than industrial agriculture[38–40]. Such small-scale production is often absent from national accounts, however, leading to enduring controversy about the actual and potential impact of small-scale agriculture to food security: credible estimates range from 30% to 70% depending on how production is calculated and how farm size is defined[41,42].

Despite these data disputes, the endurance of small-scale agroecological production systems around the world is evidence of their continuing importance to household consumption, community livelihood and cultural identity as well as surrounding landscapes and ecologies. The survival of these farms also signals the continuing potential of family, community, cooperative and various other solidarity-based food production arrangements and institutions often undermined by government subsidization of monocrop production on the one hand, and privatizations and land-grabbing on the other. The international peasant movement Vía Campesina has spearheaded the call for food sovereignty, reclaiming the roles of smallholder and agrarian communities within viable national food economies, and defending the labour of rural women and the rights of peasant communities to the seeds inherited from their ancestors[43]. Aside from such mass-based peasant movements, there are many experiments linking small farms within networks of bioregional foodsheds, shortening food circuits and increasing consumer–producer transparency and solidarity while also prioritizing local and regional self-sufficiency[44,45]. While there are no easy panaceas[46], these new food endeavours take various forms, offering multiple niches to a range of actors within complex food economies[47]. In Japan, practitioners of the *han-nou han-x* ('half-farming, half-X') lifestyle, in which livelihoods combine food production and some other ideal work or job, have grown substantially in recent years, increasing gardening and farming among young and old people in both rural and urban areas[48]. Establishing equitable labour arrangements and legal regimes is critical to the long-term success of these endeavours—especially for women, migrants, landless workers and other vulnerable populations often employed in the agrifood sector[43,49].

Home and urban gardening represents another viable yet underestimated component of sustainable agrifood systems[50]. A rich body of research on traditional home gardens, especially demonstrating their relevance to agrobiodiversity, household nutrition, gendered labour and poverty alleviation, is not yet widely recognized or activated in policy. Gardens exemplify the multifunctional character of agriculture: in addition to their direct contributions to food security, they often produce medicinal plants, fodder for domestic animals and other non-food-related household goods, and their role in in situ biodiversity conservation and the provision of supporting and regulating ecosystem services (including carbon sequestration) is also well established[51].

Intensive urban and peri-urban gardening and horticulture have been essential in world history. As brief examples, the 'floating garden' *chinampas* provisioned the inhabitants in the basin of pre-colonial Mexico[52], while Tokyo was supported by small-scale intensive agriculture based on sophisticated systems of organic nutrient cycling, including the use of night soils, well into the mid-nineteenth century[53]. Even though the recycling of human wastes is not yet considered a priority, contemporary urban gardens often require few fossil fuel inputs and promote the recycling of organic food waste. Gardening is popular (for example, engaging 36% of the total population in Hungary, 40% in Czechia and 54% in Poland), and garden foods are often shared rather than exchanged within markets, accounting for sizeable portions of household consumption of fresh produce in countries as diverse as Czechia and Japan[54,55]. At the national level, home and community gardens produce more organic produce than the commercial sector in Czechia[54], while Cuba, in response to its fossil fuel crisis, relied on a coordinated switch to agroecological production, with strong reliance on urban gardening, to meet domestic consumption needs in recent decades[56–58]. Especially when enhanced by agroecological principles, urban agriculture shows great potential in post-growth agrifood systems[59].

Gardening also contributes to a sense of well-being in urban areas, as people are outdoors, physically active and directly engaged in creative stewardship of their home places, creating communities in the process[60]. Gardens complement and extend urban green spaces and corridors, benefiting human and multispecies health, while parks and vacant lots can serve as edible urban commons[61]. Informal food practices such as hunting, fishing, gathering, small-scale animal husbandry and gleaning further diversify the potential of post-growth food provisioning, even though their benefits are largely unnoticed by researchers and government officials[62].

Food business and trade. Many alternative community-based business and investment models support post-growth food commons. When food is a public good, food businesses become partners in polycentric governance of a common-pool resource[63]. Without the profit-seeking motives and shareholder interests of their market counterparts, social businesses and benefit corporations anchor sustainability in their business models by prioritizing the long-term health and well-being of the environment and the public, also in the food sector[64]. Employee-owned businesses and cooperative enterprises composed of consumers, producers and mixed groups of food actors ensure that the needs of people are met first and generate wealth in a transparent and equitable manner[63]. There is a suite of tools and methods in alternative finance and investment that jump-starts and maintains diverse, alternative food economies, such as transparent, ethical, cooperative and community-scale trusts, loans and in-kind contributions, administered through crowdfunding schemes, ethical banks, credit unions or impact investors.

Food trade is essential to any post-growth sustainable agrifood system. Yet, within the current global economic regime, trade has become a primary source of environmental and social risks[65,66]. Of paramount importance is ending the current state of unequal exchange (estimated to exceed a US$10 trillion drain from the global South to the global North) followed by ecological reparations for past harm[21]. New terms of trade should be based on consensus, fair distribution, social protection and capacity building[67], rather than the crude logic of trade theory[68]. Transparency, enabled by participation and by active and open dialogue and cooperation, can recognize, empower and show care for marginalized agrifood system actors[69]. Post-growth agrifood systems are socially and ecologically sensitive to the throughput of food trade, respecting the carrying capacities of local markets and their environments, prioritizing sufficiency and avoiding overdependence on trade[70]. Redistributing organic resources and nutrients to eliminate waste and reconnecting eaters and growers in circular economic relationships reinforce food as a regenerative commons[71].

Food culture. Food narratives can create a culture of care. Rejecting narratives of scarcity and costly sacrifice as necessary for sustainability, narratives of sufficiency and regeneration enable self-limitation as an act of care "since limitless expansion inevitably colonizes and assimilates the lifeworld of others, human and nonhuman alike"[27]. In re-embracing caring agrifood system relationships, a multispecies approach to sustainability focuses on "meeting diverse, changing, interdependent, and irreducibly inseparable needs of all species of the present, while enhancing the ability of future generations of all species to meet their own needs"[33]. Such connections between microbiomes, diets and physical and emotional well-being are easy to grasp in agrifood systems[72]. Rural and urban edible landscapes cared for by more-than-human landscape stewards, who tend to their multispecies commons on the basis of agroecological principles, thus provide food that allows for mutual flourishing[33]. Relationships of this kind, often grounded in forms of spirituality and traditional ecological knowledge, have been the backbone of highly persistent traditional food cultures and agricultural heritage from around the world that protect agrobiodiversity and provide human nutrition[73]. Post-growth food narratives feature such real social–ecological collectivities involved in sustainable agrifood endeavours, demonstrating collective agency rather than focusing on lone farmer, corporate or scientist heroes[74].

Food governance. Cross-sectoral, multi-level and multi-actor agrifood system governance and institutions bridge the institutional silos of agriculture, public health, education, development planning and so on, in pursuit of sustainable post-growth agrifood systems. Food policy councils are one example of such new governance structures[75,76], offering platforms for food policy development and interventions of collective agency. Ideally, food policy councils are inclusive and representative of diverse public and private stakeholders and cut across multiple sectors of policy expertise related to food. Varying in scale and organizational arrangements, they form linkages to facilitate the scaling up of novel forms of food governance while avoiding domination by specific governmental or business interests. Integrative food policy making links environment, health and education by considering the social norms and meanings of food, the material and institutional mechanisms that make some foods more available than others, and people's skills and competencies in relation to food[77]. Policymaking processes that incorporate practical contextual factors such as time availability, social relations and practices, and the links between practices (such as food provisioning and mobility) contest the default assumption that individual behaviour is ultimately responsible for system-level sustainability problems[78]. Experimental and experiential approaches to the future allow for co-creation, creativity and "practicing with the future", which can avoid risk and lead to more optimistic, innovative and broadly supported food futures[79]. Food policy development processes using immersive foresight methods with diverse groups of food stakeholders build consensus among decision makers on pathways for sustainable food governance that avoid path dependency[76,80]. Adapting and shaping uncertain futures highlights the need to build anticipatory capacities and futures literacy for policymakers and agrifood system actors at large[81]. For organizing viable distributed agrifood systems and networks under such circumstances, best practices from cybernetics and related fields will prove vital to help the coordination of governance and integrative policies across scales.

Post-growth education and research

Transformation begins with rethinking what and how we learn and teach about agrifood systems. In light of deeply held beliefs in unlimited economic growth, pervasive even in sustainability research, degrowth scholars call for 'decolonization of the imaginary'. Feola develops this call into a theory of unmaking, "a multilevel (individual, social, socioecological) and multidimensional (temporal, spatial, symbolic, and material) range of situated processes that can be used strategically to make space for sustainable alternatives"[82]. From early childhood through life-long learning, education is essential in the evolution of knowledge. Creative pedagogies are essential in transforming how future agrifood system professionals, including agrifood researchers, are educated—especially in relation to transformational policies, practices and infrastructures necessary for sustainable post-growth agrifood systems[83].

Transformation to a post-growth world has already begun. The examples given above are merely the tip of the iceberg. Despite the abundance of diverse post-growth agrifood system innovations and solutions existing around the world, studies about them are easily overshadowed by the vast number of studies focusing on the sustainability problems of conventional, exploitative and growth-driven agrifood systems. Sustainable agrifood system solutions are complex phenomena that include outcomes, drivers and change actions. They are embedded in historical, social, political and cultural contexts. Below, we offer a pragmatic and programmatic framework for structuring solutions research in support of sustainable post-growth agrifood systems.

Understanding existing solutions. Diverse actors currently develop and implement agrifood system solutions around the world (see the previous section). To substantiate how these solutions were generated, how they are maintained or lost, what these solutions entail, how they work and how sustainable they are is the goal of the first solution research stream. This includes analysing outcomes, drivers, change actions and contexts, as well as assessing outcomes against a comprehensive set of criteria for sustainability, overall effectiveness

and alignment with post-growth metabolism principles. The pool that represents this type of solution research includes, for example, studies on land access strategies for direct-market food farmers in Oregon[84]; on the services provided by sustainable food forests in Europe, North America and South America[85]; on the agroecological transformation in Latin America[86]; or on the structure of alternative food networks in China[87]. Advancing our understanding of existing agrifood system solutions helps stakeholders identify innovative solution options, support maintaining present solutions, test solution plans, optimize implementation efforts and verify solution outcomes before, during and after implementation. This type of evidence can directly inform agrifood system programmes, policies, funding and other important decisions.

Adopting and transferring existing solutions. Many sustainable agrifood system solutions relevant to a post-growth world have been successfully tested and implemented, and offer valuable opportunities for learning and transfer. However, while understanding a viable agrifood system solution creates a good base of knowledge, it does not automatically translate into successful transfer and implementation, due to specific context conditions. Dedicated studies should thus support the adoption and transfer of sustainable agrifood system solutions aligned with post-growth metabolism principles. Adoption and transferability studies include the reconstruction of implementation pathways to identify success factors, the analysis of contexts and similarities, and experiments to test transfer plans. The pool that represents this type of solution research includes, for example, studies on the transfer of water-efficient irrigation schemes in New Zealand[88]; on the transfer of agroecological practices in Nicaragua[89]; or on the transfer of various agrifood system solutions from around the world ("seeds of a good Anthropocene") to Kyoto, Japan, through a food policy council[76,90].

Supporting the creation of new solutions. Finally, some situations may require creating a new agrifood system solution due to a lack of precedence, low transferability of existing solutions or misalignment with post-growth metabolism principles. Considering the urgency of timely actions as well as limited resources and experience, research should generally support agrifood system transformation efforts through reviewing existing solutions and then exploring their transferability. When these options do not suffice, supporting the development and testing of new agrifood system solutions can be done through combining evidence-oriented visioning, creative strategy building and experimentation[91]. The pool that represents this type of solution research includes, for example, studies on responding to COVID-19 challenges through the adoption of sustainable business practices and models for small and medium food enterprises[92]; on testing a small but comprehensive sustainable coffee supply chain between Arizona and Mexico[69]; or on shifting people's perceptions and behaviour towards empathy and inclusiveness through joint food experiences[93].

As a whole, these three streams of research and the real-world experiences from which they are drawn provide important coordinates for system-wide transformation[94]. Further research should aim to understand what strategic actions are effective beyond the immediate solution level. Such analysis would pay explicit attention to the political, economic and scientific power dynamics that facilitate or impede the kinds of sweeping changes implied in agrifood system transformation and transition as well as be wary of 'one-size-fits-all' upscaling[95] and explore the full range of amplification options[96].

Transformation to post-growth sustainability

Assuring the social, economic and ecological future of human and non-human life depends on changing dominant agrifood systems as well as dominant agrifood systems research and education. Food practices are intimately cultural, socially ubiquitous and at the same time embedded in nature. Food has historically linked everyday cultural practices into landscapes, seascapes and ecological rhythms. At its best, agriculture is an agroecological practice modelled on the cycles of nature itself. Such qualities and interactions require further study in themselves and can also aid understanding of complex human–environmental interactions found in sustainability challenges in general.

We no longer have the luxury of ignoring viable, successful options when it comes to agrifood system sustainability, and we must question the reliance on economic growth as the dominant paradigm[97,98]. Researchers must take sustainability challenges seriously, first by overcoming ideological blindness to the profound practical and theoretical meaning of already existing agrifood system solutions[40]. While there might be strong positions held for or against certain types of solutions, the challenges of sustainability in general and agrifood systems sustainability in particular are so complex and urgent that all types of solutions with real potential for post-growth transformation are needed. These efforts must not perpetuate discourses of delay[99] and should go beyond the Sustainable Development Goals[100]. The principles, examples and research agenda presented here are intended to sketch out a sustainable post-growth agrifood system pluriverse to which all can find ways to contribute. Dig in!

Received: 28 July 2021; Accepted: 17 June 2022;
Published online: 4 August 2022

References

1. Campbell, B. M. et al. Agriculture production as a major driver of the earth system exceeding planetary boundaries. *Ecol. Soc.* **22**, 8 (2017).
2. Niles, D. in *Oxford Handbook of Heritage Studies* (eds Labrador, A. & Silberman, N.) 339–354 (Oxford Univ. Press, 2018).
3. Fedoroff, N. V. & Cohen, J. E. Plants and population: is there time? *Proc. Natl Acad. Sci. USA* **96**, 5903–5907 (1999).
4. Springmann, M. et al. Options for keeping the food system within environmental limits. *Nature* **562**, 519–524 (2018).
5. Haberl, H. et al. A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: synthesizing the insights. *Environ. Res. Lett.* **15**, 065003 (2020).
6. Canfield, M., Anderson, M. D. & McMichael, P. UN Food Systems Summit 2021: dismantling democracy and resetting corporate control of food systems. *Front. Sustain. Food Syst.* **5**, 661552 (2021).
7. Willett, W. et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *Lancet* **393**, 447–492 (2019).
8. Clark, M. A. et al. Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. *Science* **370**, 705–708 (2020).
9. Howard, P. H. *Concentration and Power in the Food System: Who Controls What We Eat?* (Bloomsbury, 2016).
10. Henders, S., Persson, U. M. & Kastner, T. Trading forests: land-use change and carbon emissions embodied in production and exports of forest-risk commodities. *Environ. Res. Lett.* **10**, 125012 (2015).
11. Neo, H. & Emel, J. *Geographies of Meat: Politics, Economy and Culture, Critical Food Studies Series* (Taylor and Francis, 2017).
12. Nestle, M. *Food Politics: How the Food Industry Influences Nutrition and Health* (UC Press, 2004).
13. *Another Perfect Storm? How the Failure to Reform Food Systems Has Allowed the War in Ukraine to Spark a Third Global Food Price Crisis in 15 Years, and What Can Be Done to Prevent the Next One* (IPES-Food, 2022).
14. D'Alisa, G., Demaria, F. & Kallis, G. *Degrowth: A Vocabulary for a New Era* (Routledge, 2015).
15. Kothari, A., Salleh, A., Escobar, A., Demaria, F., & Acosta, A. *Pluriverse: A Post-development Dictionary* (Tulika Books, 2019).
16. Nelson, A. & Edwards, F. *Food for Degrowth: Perspectives and Practices* (Routledge, 2021).
17. O'Neill, D. W., Fanning, A. L., Lamb, W. F. & Steinberger, J. K. A good life for all within planetary boundaries. *Nat. Sustain.* **1**, 88–95 (2018).
18. Fuchs, D. et al. *Consumption Corridors: Living Well within Sustainable Limits* (Routledge, 2021).
19. Latour, B. *After Lockdown: A Metamorphosis* (Polity, 2021).
20. Johns, T. & Sthapit, B. R. Biocultural diversity in the sustainability of developing-country food systems. *Food Nutr. Bull.* **25**, 143–155 (2004).
21. Hickel, J., Dorninger, C., Wieland, H. & Suwandi, I. Imperialist appropriation in the world economy: drain from the global South through unequal exchange, 1990–2015. *Glob. Environ. Change* **73**, 102467 (2022).

22. Gilbert, J. *Indigenous Peoples' Land Rights under International Law* (Brill, 2016).
23. *The Right to Produce and Access to Land: Position of the Vía Campesina on Food Sovereignty Presented at the World Food Summit, 13–17, November, Rome* (Vía Campesina, 1996).
24. Cohen, M. J. *The Future of Consumer Society: Prospects for Sustainability in the New Economy* (Oxford Univ. Press, 2016).
25. Hess, C. & Ostrom, E. *Understanding Knowledge as a Commons: From Theory to Practice* (MIT, 2007).
26. Vivero-Pol, J. L. in *Routledge Handbook of Food as a Commons* (eds Vivero-Pol, J. L. et al.) Ch. 2 (Routledge, 2019).
27. Kallis, G. *Limits: Why Malthus Was Wrong and Why Environmentalists Should Care* (Stanford Briefs, 2019).
28. Harvey, D. in *The New Imperialism* (Oxford Univ. Press, 2003).
29. Bollier, D. & Helfrich, S. *Patterns of Commoning* (Commons Strategy Group and Off the Common Press, 2015).
30. Bornemann, B. & Weiland, S. New perspectives on food democracy. *Polit. Gov.* **7**, 1–7 (2019).
31. Puig de la Bellacasa, M. *Matters of Care—Speculative Ethics in a More Than Human World* (Univ. of Minnesota Press, 2017).
32. Barca, S. *Forces of Reproduction: Notes for a Counter-hegemonic Anthropocene* (Cambridge Univ. Press, 2020).
33. Rupprecht, C. D. D. et al. Multispecies sustainability. *Glob. Sustain.* **3**, e3 (2020).
34. Weber, H., Wiek, A. & Lang, D. J. Sustainability entrepreneurship to address large distances in international food supply. *Bus. Strategy Dev.* **3**, 318–331 (2020).
35. Orr, D. W. Four challenges of sustainability. *Conserv. Biol.* **16**, 1457–1460 (2002).
36. Chabay, I., Koch, L., Martinez, G. & Scholz, G. Influence of narratives of vision and identity on collective behavior change. *Sustainability* **11**, 5680 (2019).
37. Gliessman, S. R. *Agroecology: The Ecology of Sustainable Food Systems* 3rd edn (CRC, 2015).
38. Ricciardi, V., Mehrabi, Z., Wittman, H., James, D. & Ramankutty, N. Higher yields and more biodiversity on smaller farms. *Nat. Sustain.* **4**, 651–657 (2021).
39. McDougall, R., Kristiansen, P. & Rader, R. Small-scale urban agriculture results in high yields but requires judicious management of inputs to achieve sustainability. *Proc. Natl Acad. Sci. USA* **116**, 129–134 (2019).
40. IPES-Food *From Uniformity to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems* (International Panel of Experts on Sustainable Food Systems, 2016).
41. Ricciardi, V., Ramankutty, N., Mehrabi, Z., Jarvis, L. & Chookolingo, B. How much of the world's food do smallholders produce? *Glob. Food Sec.* **17**, 64–72 (2018).
42. Herrero, M. et al. Farming and the geography of nutrient production for human use: a transdisciplinary analysis. *Lancet Planet. Health* **1**, e33–e42 (2017).
43. Desmarais, A. *La Vía Campesina: Globalization and the Power of Peasants* (Pluto, 2007).
44. Cato, M. S. *The Bioregional Economy: Land, Liberty and the Pursuit of Happiness* (Routledge, 2013).
45. Smaje, C. *A Small Farm Future* (Chelsea Green, 2020).
46. Niles, D. & Roff, R. Shifting agrifood systems: the contemporary geography of food and agriculture; an introduction. *GeoJournal* **73**, 1–10 (2008).
47. Gibson-Graham, J. K. & Dombroski, K. *The Handbook of Diverse Economies* (Edward Elgar, 2020).
48. Shiomi, N., Katsuyama, K., Une, Y., & Sakakida, M. *Han-Nou Han X: Kore Made Kore Kara (Han-Nou Han-X: Past and Future)* (Soshinsha, 2021).
49. Calo, A. et al. Achieving food system resilience requires challenging dominant land property regimes. *Front. Sustain. Food Syst.* **5**, 683544 (2021).
50. Schupp, J. L. & Sharp, J. S. Exploring the social bases of home gardening. *Agric. Hum. Values* **29**, 93–105 (2012).
51. Gbedomon, R. C. et al. Functional diversity of home gardens and their agrobiodiversity conservation benefits in Benin, West Africa. *J. Ethnobiol. Ethnomed.* **13**, 1–15 (2017).
52. Rabiela, T. R. in *The Oxford Encyclopedia of Mesoamerican Cultures* (ed. Carrasco, D.) 200–201 (Oxford Univ. Press, 2001).
53. Tajima, K. The marketing of urban human waste in the early modern Edo/Tokyo metropolitan area. *Environ. Urbain/Urban Environ.* **1**, 1039 (2007).
54. Jehlička, P. & Daněk, P. Rendering the actually existing sharing economy visible: home-grown food and the pleasure of sharing. *Sociol. Ruralis* **57**, 274–296 (2017).
55. Kamiyama, C., Hashimoto, S., Kohsaka, R. & Saito, O. Non-market food provisioning services via homegardens and communal sharing in satoyama socio-ecological production landscapes on Japan's Noto peninsula. *Ecosyst. Serv.* **17**, 185–196 (2016).
56. Altieri, M. A. & Funes-Monzote, F. R. The paradox of Cuban agriculture. *Monthly Review* (1 January 2012).
57. Cederlöf, G. Low-carbon food supply: the ecological geography of Cuban urban agriculture and agroecological theory. *Agric. Hum. Values* **33**, 771–784 (2016).
58. Gerber, J. F. Degrowth and critical agrarian studies. *Peasant Stud.* **47**, 235–264 (2020).
59. Altieri, M. A. & Nicholls, C. I. Urban agroecology: designing biodiverse, productive and resilient city farms. *AgroSur* **46**, 49–60 (2018).
60. Balázs, B. in *Routledge Handbooks of Food as Commons* (eds Vivero-Pol, J. L. et al.) 296–310 (Routledge, 2020).
61. Sardeshpande, M., Rupprecht, C. & Russo, A. Edible urban commons for resilient neighborhoods in light of the pandemic. *Cities* **109**, 103031 (2021).
62. Colby, A. *Subsistence Agriculture in the US: Reconnecting to Work, Nature and Community* (Routledge, 2020).
63. Novkovic, S. & Webb, T. (eds) *Cooperatives in a Post-growth Era: Creating Cooperative Economics* (Zed Books, 2014).
64. Carvalho, B., Wiek, A. & Ness, B. Can B Corp certification anchor sustainability in SMEs? *Corp. Soc. Responsib. Environ. Manage.* **29**, 293–304 (2022).
65. Taherzadeh, O., Bithell, M. & Richards, K. Water, energy and land insecurity in global supply chains. *Glob. Environ. Change* **67**, 102158 (2021).
66. Shilling, H. J., Wiedmann, T. & Malik, A. Modern slavery footprints in global supply chains. *J. Ind. Ecol.* **25**, 1518–1528 (2021).
67. Porkka, M., Kummu, M., Siebert, S. & Varis, O. From food insufficiency towards trade dependency: a historical analysis of global food availability. *PLoS ONE* **8**, e82714 (2013).
68. Clapp, J. The trade-ification of the food sustainability agenda. *Peasant Stud.* **44**, 335–353 (2017).
69. Weber, H. & Wiek, A. Cooperating with 'open cards'—the role of small intermediary businesses in realizing sustainable international coffee supply. *Front. Sustain. Food Syst.* **5**, 663716 (2021).
70. Friel, S., Schram, A. & Townsend, B. The nexus between international trade, food systems, malnutrition and climate change. *Nat. Food* **1**, 51–58 (2020).
71. Jurgilevich, A. et al. Transition towards circular economy in the food system. *Sustainability* **8**, 69 (2016).
72. Manor, O. et al. Health and disease markers correlate with gut microbiome composition across thousands of people. *Nat. Commun.* **11**, 5206 (2020).
73. Koohafkan, P. & Altieri, M. A. *Globally Important Agricultural Heritage Systems: A Legacy for the Future* (FAO, 2011).
74. Admussen, N. Six proposals for the reform of literature in the age of climate change. *Crit. Flame* **42**, May–June (2016).
75. Schiff, R. The role of food policy councils in developing sustainable food systems. *J. Hunger Environ. Nutr.* **3**, 206–228 (2008).
76. Mangnus, A. C. et al. New pathways for governing food system transformations: a pluralistic practice-based futures approach using visioning, back-casting, and serious gaming. *Ecol. Soc.* **24**, 2 (2019).
77. Godin, L. & Sahakian, M. Cutting through conflicting prescriptions: how guidelines inform 'healthy and sustainable' diets in Switzerland. *Appetite* **130**, 123–133 (2018).
78. Walker, G. P. in *Social Practices, Interventions, and Sustainability: Beyond Behavior Change* (eds Strengers, Y. & Maller, C.) Ch. 3 (Routledge, 2015).
79. Guston, D. H. Understanding 'anticipatory governance'. *Soc. Stud. Sci.* **44**, 218–242 (2014).
80. McGreevy, S. R. et al. Learning about, playing with, and experimenting in critical futures through soft scenarios: directions for food policy. *Kankyou Kagaku Kaishi (Environ. Sci.)* **34**, 46–65 (2021).
81. Mangnus, A. C., Oomen, J., Vervoort, J. M. & Hajer, M. A. Futures literacy and the diversity of the future. *Futures* **132**, 102793 (2021).
82. Feola, G. Degrowth and the unmaking of capitalism: beyond 'decolonization of the imaginary'? *ACME Int. J. Crit. Geogr.* **18**, 977–997 (2019).
83. Chabay, I., Renn, O., Van der Leeuw, S. & Droy, S. Transforming scholarship to co-create sustainable futures. *Glob. Sustain.* **4**, E19 (2021).
84. Horst, M. & Gwin, L. Land access for direct market food farmers in Oregon, USA. *Land Use Policy* **75**, 594–611 (2018).
85. Albrecht, S. & Wiek, A. Food forests—their services and sustainability. *J. Agric. Food Syst. Community Dev.* **10**, 91–105 (2021).
86. Altieri, M. A. & Toledo, V. M. The agroecological revolution in Latin America—rescuing nature, ensuring food sovereignty and empowering peasants. *Peasant Stud.* **38**, 587–612 (2011).
87. Scott, S., Si, Z., Schumilas, T., & Chen, A. *Organic Food and Farming in China—Top-Down and Bottom-Up Ecological Initiatives* (Routledge, 2018).
88. Nicholas, G. et al. Transferring the impacts of pilot-scale studies to other scales—understanding the role of non-biophysical factors using field-based irrigation studies. *Agric. Water Manage.* **233**, 106075 (2020).
89. Wigboldus, S. et al. Systemic perspectives on scaling agricultural innovations—a review. *Agron. Sustain. Dev.* **36**, 46 (2016).
90. Bennett, E. M. et al. Bright spots: seeds of a good Anthropocene. *Front. Ecol. Environ.* **14**, 441–448 (2016).

91. Wiek, A. & Lang, D. J. in *Sustainability Science—an Introduction* (eds Heinrichs, H. et al.) 31–41 (Springer, 2016).
92. Habiyaremye, A. Cooperative learning and resilience to COVID-19 in a small-sized South African enterprise. *Sustainability* **13**, 1976 (2021).
93. Carolan, M. *The Sociology of Food and Agriculture* 3rd edn (Routledge, 2021).
94. Herrero, M. et al. Innovation can accelerate the transition towards a sustainable food system. *Nat. Food* **1**, 266–272 (2020).
95. *A Long Food Movement: Transforming Food Systems by 2045* (IPES-Food & ETC Group, 2021).
96. Lam, D. P. M. et al. Scaling the impact of sustainability initiatives—a typology of amplification processes. *Urban Transform.* **2**, 3 (2020).
97. Wiedmann, T., Lenzen, M., Keyßer, L. T. & Steinberger, J. K. Scientists' warning on affluence. *Nat. Commun.* **11**, 3107 (2020).
98. Keyßer, L. T. & Lenzen, M. 1.5 °C degrowth scenarios suggest the need for new mitigation pathways. *Nat. Commun.* **12**, 2676 (2021).
99. Lamb, W. F. et al. Discourses of climate delay. *Glob. Sustain.* **3**, E17 (2020).
100. Zeng, Y. et al. Environmental destruction not avoided with the Sustainable Development Goals. *Nat. Sustain.* **3**, 795–798 (2020).

Acknowledgements

This paper stems from research conducted in the FEAST Project (Lifeworlds of Sustainable Food Production and Consumption: Agrifood Systems in Transition) (no. 14200116), Research Institute for Humanity and Nature (RIHN). We thank RIHN and the organizers of the 15th International Symposium entitled 'Transitioning cultures of everyday food consumption and production: stories from a post-growth future', which served as a starting point for developing this paper. Additional research funding for this paper is from JSPS Kaken research grants no. 19K15931 and no. 20K15552. A.W. acknowledges funding from the Social Sciences and Humanities Research Council of Canada (TRANSFORM, grant no. 50658-10029). G.K. acknowledges support by the María de Maeztu Unit of Excellence (no. CEX2019-000940-M) grant from the Spanish Ministry of Science and Innovation. P.J. acknowledges support from the Czech Academy of Sciences, Lumina quaeruntur award (no. LQ300282103). This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 870759. The content presented in this document represents the views of the authors, and the European Commission has no liability in respect to the content. This paper is supported by the Dutch Research Council (NWO), who funded the NWO Vidi project ANTICIPLAY (project no. VI. Vidi.195.007) and its research team.

Author contributions

S.R.M., C.D.D.R., D.N., A.W., M.C., G.K., K.K., A.M., P.J., O.T., M. Sahakian, I.C., A.C., J.-L.V.-P., R.C., M. Spiegelberg, M.K., B.B., K. Tsuchiya, C.N., K. Tanaka, J.V., M. Akitsu, H.M., K.O., R.S., A.K., N.T., K.A., M. Altieri, Y.-I.S. and M.T. contributed to the framing and argumentation. S.R.M., C.D.D.R., D.N. and A.W. led the writing and revisions. M.C., G.K., K.K., A.M., P.J., O.T., M. Sahakian, I.C., A.C., J.-L.V.-P., R.C., M. Spiegelberg, M.K., B.B., K. Tsuchiya, C.N., K. Tanaka, J.V., M. Akitsu, H.M., K.O., R.S., A.K., N.T., K.A., M. Altieri, Y.-I.S. and M.T. contributed to the writing and revisions.

Competing interests

The authors declare no competing interests.

Additional information

Correspondence should be addressed to Steven R. McGreevy.

Peer review information *Nature Sustainability* thanks Molly Anderson and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.