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Sustainable and Resilient Agrifood Systems (SARAS). A Leibniz Position

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ABSTRACT

Current agrifood systems fail to provide healthy, affordable food for all while also damaging the environment, contributing to climate change, reducing biodiversity, and increasing inequality. Given these compounding crises, it is crucial to transition towards sustainable and resilient agrifood systems (SARAS). This paper synthesizes perspectives from multiple disciplines on SARAS, incorporating consensus statements, current research positions, and actionable measures comprising ecological, economic, social, and political dimensions. Achieving a balance between global and local solutions is paramount to address the complexities inherent in agrifood systems. Moving forward, diversifying consumption patterns, production systems, and value chains depending on local conditions can support the realization of SARAS. Adopting a holistic system approach that covers both global and local dimensions of agrifood systems minimizes trade-offs, leverages synergies, integrates international agreements, and mitigates unintended impacts on other countries and vulnerable groups. Nevertheless, several unsolved issues persist, including matters of scaling, applicability of effective policy instruments, and securing funding for this transformation.

Claudia Hunecke, Ferike Thom are shared first authorship.

1 | Introduction

Current agricultural production and nutrition habits cause substantial negative externalities on climate, environment, and human health. For instance, greenhouse gas (GHG) emissions associated with the agrifood system contribute one-third of global GHG emissions (Crippa et al. 2021). Expansion of croplands leads to biodiversity loss and habitat destruction (IPBES 2019). Nitrogen (Kanter et al. 2020; Sutton et al. 2013) and phosphorus surpluses in soil (Beusen et al. 2016) result in environmental pollution. Inadequate diets are a major contributor to the global burden of disease through non-communicable diseases, including type-2 diabetes, cancer, and cardiovascular diseases and related premature deaths (GBD 2017 Diet Collaborators 2019; Murray et al. 2020). While two billion people (29% of the global population) are overweight and obese (Bodirsky et al. 2020; NCD-RisC 2017), undernourishment is rising despite previous advancements. In 2021, between 702 and 828 million people suffered from hunger, and approximately 2.3 billion faced food insecurity (FAO et al. 2022). In 2020, 3.1 billion people could not afford a healthy diet (FAO et al. 2022). Avoidable healthcare costs associated with unhealthy diets are estimated at 7% of global healthcare expenditures (Springmann 2020).

The food on people's plates plays a pivotal role in shaping the future (Rützler and Reiter 2022). Addressing the aforementioned negative effects, the concepts of Sustainable Diet and Sustainable Food Systems (FAO 2018a; FAO and Bioversity International 2012), Planetary Health Diet (PHD) (Willett et al. 2019) and Healthy Diets (Neufeld et al. 2023) have been developed (Box 1).

However, considering only health and sustainability is insufficient. Current environmental and economic crises, exacerbated by climate change, pandemics, and trade restrictions, intensified by the war in Ukraine, reveal the need for agrifood systems to also be resilient against disruptions of various kinds. In this article, we highlight the role of resilience as a complementary aspect to sustainability. We propose the concept of sustainable and resilient agrifood systems (SARAS) as a means to achieve greater stability for the planetary agrifood system.

Resilience and sustainability are interconnected concepts that are paramount in addressing present challenges and ensuring a prosperous future (Maleksaeidi and Karami 2013). Sustainability is the foundation for the long-term functionality of agrifood systems, providing healthy and affordable food while safeguarding economic, social, and environmental aspects (FAO 2018a). Complementing this, resilience describes the ability of a system to absorb and overcome disruptions and to adapt and transform while maintaining functionality (Constas et al. 2021; OECD 2020; Tendall et al. 2015). Only a global agrifood system that integrates both concepts will benefit present and future generations in the long run and in the presence of disturbances.

The existing concepts can be considered to cover the aspects of health and sustainability well, both at the level of individual diets and for (agri)food systems at the systemic level (Figure 1). However, these concepts have only some implicit implications for the aspect of resilience, mainly because the reduced resource use of the suggested diets contributes to resilience on the systemic level. The concept of sustainable food systems from FAO (2018a) includes food security, which can be understood as an outcome of resilience. The healthy diet, as defined by Neufeld et al. (2023) considers food safety and availability, which is an implicit health aspect on the systemic level, hence expanding beyond the individual scope of a dietary recommendation.

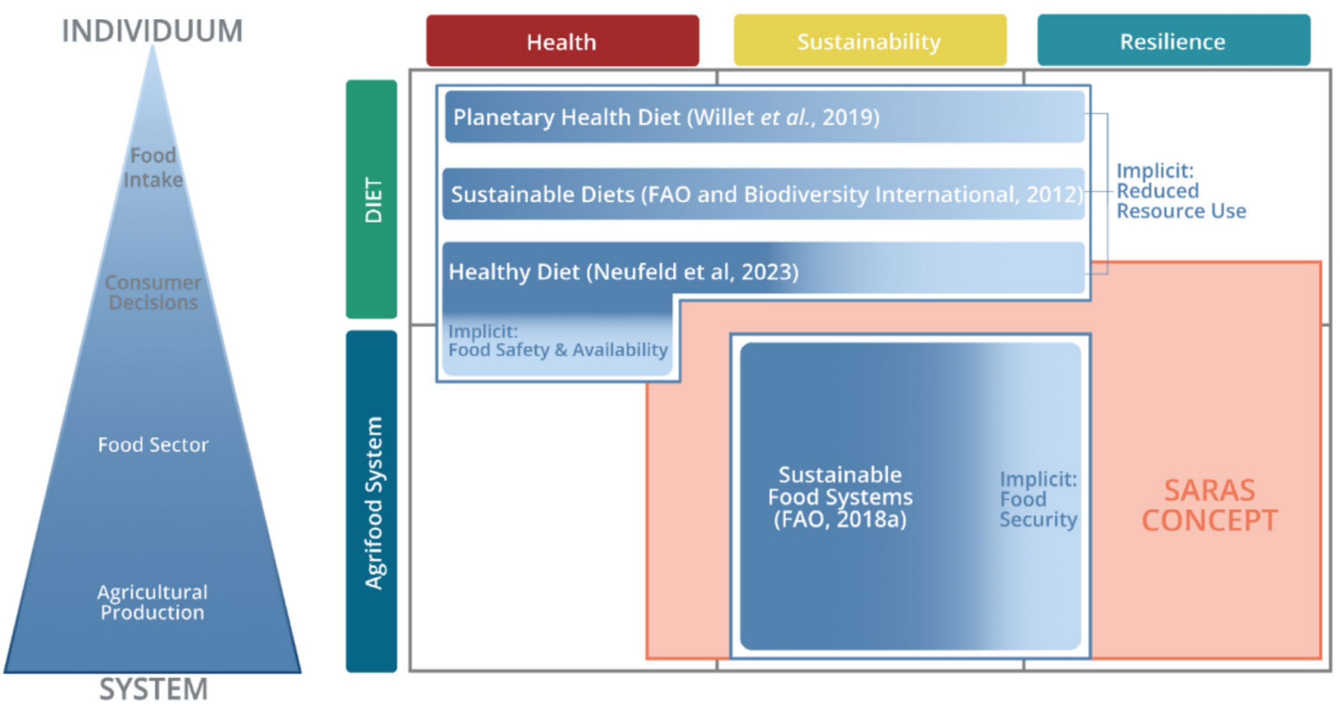

FIGURE 1 | SARAS concept in the context of existing concepts from Box 1.

BOX 1 | Relevant existing concepts and the novelty of SARAS.

Sustainable Diet (FAO and Bioversity International 2012): "Sustainable diets are those diets with low environmental impacts that contribute to food and nutrition security and healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources."

Sustainable Food Systems (FAO 2018a): "A sustainable food system is a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised. This means that it is profitable throughout (economic sustainability), it has broad-based benefits for society (social sustainability), and it has a positive or neutral impact on the natural environment (environmental sustainability)."

Planetary Health Diet (Willett et al. 2019): The Planetary Health Diet is based on recommended intake ranges of different food groups that together constitute a dietary pattern that is both healthy and in line with planetary boundaries, for example, of climate change and biodiversity loss. It can be flexibly adapted in different contexts and emphasizes a plant-forward diet where whole grains, fruits, vegetables, nuts, and legumes comprise a greater proportion of foods consumed. Meat and dairy can be part of the diet but in significantly smaller proportions than currently consumed in high-income countries.

Healthy Diet (Neufeld et al. 2023): "A healthy diet is health-promoting and disease-preventing. It provides adequacy, without excess, of nutrients and health-promoting substances from nutritious foods and avoids the consumption of health-harming substances." The authors emphasize that food safety, affordability and availability of foods, as well as cultural and other preferences need to be considered when deducting food-based recommendations.

Sustainable and Resilient Agrifood Systems (SARAS): Rather than a dietary recommendation, SARAS is a concept for agricultural and food systems, taking resilience against crises and disruptions into account. SARAS includes a systemic view of ecological, environmental, social, economic, and political dimensions and considers trade-offs and synergies between different goals. It recognizes interlinkages between the global and regional scope, as well as between the different stages within the agrifood system spanning from production to final consumption of a healthy diet.

The contribution of SARAS is to expand the systemic view beyond sustainability and to explicitly include the resilience aspect, while ensuring healthy diets. An additional novelty is the multidimensionality of the SARAS concept. In this article, we include five different perspectives on sustainability and resilience in the context of agrifood systems, that is, the ecological, economic, political, social dimension as well as the global–local scale. To ensure diversity and interdisciplinarity of scholars involved in the development of the SARAS concept, the Leibniz Research Network "Green Nutrition—Healthy Society" organized a workshop in Berlin on June 6th and 7th, 2022, assembling experts from different scientific disciplines to discuss the multiple dimensions of sustainability and resilience in the context of healthy human nutrition.

While recognizing the diversity in agrifood systems and dietary preferences across regions and localities, we specifically focus on the imperative actions needed in high-income countries. This emphasis stems from the acknowledgment that agrifood systems, particularly dietary choices, in high-income countries have a disproportionately greater negative impact on the global environment than other nations. The concept of SARAS considers these disparities and underscores the importance of implementing policies that promote fairness and sustainability within the agrifood system, ultimately benefiting all stakeholders. It is essential to highlight that actions taken by high-income countries are crucial not only for their own benefit but also for achieving SARAS on a global scale.

To achieve SARAS (Table 1 in the discussion section), it is crucial to minimize ecological and economic trade-offs associated with current dietary habits, particularly in high-income regions. Robust and targeted policies, coupled with global adoption, are necessary to ensure the long-term realization of SARAS. The experts formulated consensus statements, representing their shared positions and forming the foundation of this paper. The consensus statements encompass the definition of SARAS, as well as all relevant dimensions of sustainability such as the ecological, economic, social, and political dimensions associated with SARAS and the balance between local and global solutions. Based on these statements, we identify lessons learned, research gaps, and limitations of current approaches in implementing SARAS.

2 | Current Evidence

2.1 | What Are Sustainable and Resilient Agrifood Systems (SARAS)?

2.1.1 | Leibniz Consensus

To ensure the security of healthy nutrition now and for future generations, agrifood systems have to be sustainable and resilient to economic, political, and ecological crises. This requires the transformation of food production.

SARAS refers to healthy eating within environmental limits and within fair food environments. Such environments support socio-cultural identification, participation, and self-determination. The SARAS concept comprises healthy, physiologically balanced, predominantly plant-based nutrition and can include new and re-introduced species and varieties. Innovative technologies, management, and political institutions are tailored to suit the context (e.g., production site) and goals (e.g., ecosystem services (ESS) improvement).

In doing so, SARAS promotes multiple Sustainable Development Goals (SDGs) including Sustainable Production and Consumption (SDG 12), Zero Hunger (SDG2) and Good Health and Well-Being (SDG 3), which in turn contribute to Climate Actions (SDG 13), Life below Water (SDG 14) and Life on Land (SDG 15).

TABLE 1 | Synthesis of measures and recommendations to achieve SARAS.

Ecological dimension	• Balancing land sharing and land sparing measures • Changes and diversification in consumption patterns • Diversification of land use patterns • Adoption of smart farming, digitalization and urban farming options
Economic dimension	• Measures for reducing food waste • Cost accounting of food to increase affordability of healthy and sustainable diets • Revision of trade policies prioritizing sustainability • Diversification of trade partners • Freeing up of financial resources through repurposing of subsidies
Political dimension	• Internalizing externalities, for example, carbon tax or emission trading system • Health targeting taxation of food • Prioritizing both sustainability and health aspects in national food-based dietary guidelines • Implementation of coherent policies and coordination between domains and stakeholders
Social dimension	• Building alliances for sustainable transformation (e.g., short supply chain solutions) • Empowering individuals through social learning and reliable and accessible information • Establishing fair food environments • Balancing bottom-up and top-down strategies to induce behavioral changes
Global–local balance	• Integrating agrifood systems emissions in NDCs • Enabling informed decisions based on global and national transformation pathways • Considering equal, fair, socially just and inclusive agrifood systems within and between countries • Improving international cooperation
Recommendations to achieve SARAS • Diversification of production and consumption, trade and political measures • International cooperation to establish a globally sustainable and resilient agrifood system • Selection and employment of all available instruments corresponding to the circumstances and context • Adoption of a multi-dimensional system approach	

2.1.2 | Background

The fragmented nature of agrifood systems (Rützler and Reiter 2022), along with the emphasis on increasing production, must be reassessed. To ensure SARAS, it is crucial to analyze the necessary transformations at each stage, considering the connections between stages, sectors, and actors. Transformation and achievement of SDGs 2, 3, 12, 13, 14, and 15 are supported by innovative technologies, like digital agriculture, innovative cultivation and processing methods, and gene technology that are employed at different stages of the value chain and should be considered together (Herrero et al. 2021).

Currently, rice, maize, and wheat contribute to over 50% of global calorie intake (Hendriks et al. 2023). The diversity of crops and crop species worldwide has decreased following the adoption of Westernized diets driven by consumer preferences, rising incomes, globalization, trade liberalization, international standards, and multinational food corporations (Khoury et al. 2014). Although productivity gains, subsidies, and other factors have enabled mass production of calorie-dense but partially unhealthy food (Balié 2020; Khoury et al. 2014), the concentration on a few crops and varieties must be eliminated. Re-focusing on underutilized, site-specific plant species and varieties (Baldermann et al. 2016; FAO 2020a) and exploring alternative food and protein sources, like insects, algae, and marine invertebrates (Ahern et al. 2021; NFS 2022; Preiss et al. 2022; Read et al. 2022; Weindl et al. 2020) can help achieve greater nutritional diversity, from which both the environment and dietary composition would benefit Also, resilience against phytosanitary shocks would be enhanced.

Greater crop diversity also benefits the promotion of health and resilience against nutrition-related diseases. Increased consumption of many different plant-based products with legumes (as the protein source, currently less than 2.5% share of the global diet), other vegetables, and fruits (FAO et al. 2020; Willett et al. 2019) provides important and essential nutrients and fibers. Additionally, combining terrestrial and aquatic food sources can further contribute to a greater diversity of food production and diets, thus promoting sustainability and health (Ahern et al. 2021; Crona et al. 2023).

Globally, approximately 25%–30% of food is lost during processing or wasted, resulting in significant environmental damage from avoidable resource exploitation (Cattaneo et al. 2021; Kuiper and Cui 2021; von Braun et al. 2023). Therefore, reducing food waste and losses (e.g., by shortening the distance between food production and consumption (FAO 2019)) is a crucial step towards sustainable production and consumption and ultimately achieving SARAS.

2.2 | Ecological Dimension

2.2.1 | Leibniz Consensus

Current food production and consumption play a major role in overshooting planetary boundaries. Maintaining and improving ecosystem services and biodiversity (BD) is essential for the transformation towards SARAS. Changes in production systems and consumption patterns will support the sharing and sparing of valuable land for agriculture as well as nature protection.

Innovative land use practices can increase BD, improve ESS, and enhance the resilience and security of regional food systems. Many ESS are land-based. Urban farming and equitable, sustainable urban–rural interrelations are necessary to avoid the exploitation of rural natural resources. To achieve SARAS, management models considering multiple societal demands and technological solutions, like collaborative approaches, agro-ecology, efficient production systems, as well as agri-photovoltaics, offer great potential for new business models but also for integrated research, system design, and impact modeling. Both empirical research and quantitative data mining, along with the implementation of such innovations, as well as integrated modeling for scaling and scenario approaches for assessing cumulative effects, contribute to SARAS.

Spatially and functionally diversified production systems, innovative management models, and technologies can solve trade-offs among ESS and BD while increasing resource efficiency at a landscape level.

2.2.2 | Background

Agrifood production is a key contributor to climate change and loss of ESS and BD (Alexander et al. 2015; IPBES 2019; IPCC 2022; Willett et al. 2019), impacting biosphere integrity and phosphorus and nitrogen flows (Campbell et al. 2017; Gerten et al. 2020; Haines et al. 2014; Springmann et al. 2018a; Willett et al. 2019). Additionally, agriculture accounts for 70% of global freshwater withdrawals (FAO 2023, 2020b; Shiklomanov 2000) and occupies 38% of global land, with both figures expanding and exacerbating the strain on valuable resources (FAO 2021; FAOSTAT 2022).

The suitability of a method for transforming towards SARAS depends on the context (e.g., agro-climatic zone) and the goal (e.g., decreasing GHG emissions). To achieve SARAS, the adoption of integrated systemic management concepts that address diverse societal needs and leverage technological solutions (e.g., agroecology) holds significant potential. These approaches incorporate principles such as collaboration and system efficiency (e.g., agri-photovoltaics) to enable the development of innovative business models, as well as to advance integrated research, system design, and impact modeling (Blomkamp 2018; Ketzer et al. 2020a, 2020b; Wüstenhagen et al. 2007).

Efficient land use balancing agricultural yields, ESS, BD, and nature protection is crucial (Kleijn et al. 2011) and can be achieved by utilizing both land sharing and land sparing concepts (Grass et al. 2021). Land sharing involves less intensive agriculture, allowing for both agricultural production and nature conservation (Kremen and Merenlender 2018), whereas land sparing concentrates production, leaving valuable natural habitats untouched by agriculture (Balmford et al. 2012). Determining the suitability of a method requires appropriate quantification of its effect and comparison to potential alternatives. The choice of measurement is crucial. For example, expressing externalities like GHG emissions per unit of product instead of per area of farm land can yield different implications regarding whether land sparing or land sharing is more effective in reducing the externalities (Balmford et al. 2012). Consumption changes and adoption of alternative food sources, particularly protein sources, can help spare areas previously used for feed production and livestock farming or shift them to extensive practices like grazing, which can enhance biodiversity (Alexander et al. 2015; Klein et al. 2020).

Diversification of land use is necessary for achieving different ESS, for example, through agroforestry (Zhu et al. 2020), crop mixture, strip and intercropping (Ditzler et al. 2021; Pötzsch et al. 2019), and reintroduction of underutilized plant species and varieties (Hufnagel et al. 2020; Baldermann et al. 2016). Crop diversification increases resilience to climate change (Kurdyś-Kujawska et al. 2021), thereby enhancing food security. New cooperation models can generate synergies and address trade-offs between SDGs related to water, energy, and food supply (Fader et al. 2018; Martens et al. 2022).

Smart farming and the digitalization of the agrifood sector can play crucial roles in sustainability and resilience (Walter et al. 2017) by freeing up land, using resources more efficiently, integrating diverse knowledge in decision processes (Mouratiadou et al. 2023) and Supporting Information-based governance. Urban farming encompasses various concepts, including outdoor, vertical, and indoor farming and combinations. As long as energy is sourced sustainably, urban farming can facilitate SARAS by conserving land and reducing dependency on rural food production while featuring high water recovery, nutrient efficiency, and/or reduced space requirements (Edmondson et al. 2020).

Food systems are characterized by their complexity and diversity, functioning as telecoupled systems that interconnect urban and rural areas in terms of space, actors, functions, and ESS (Ernstson 2013). Acknowledging the explicit distal interactions and feedbacks enables improved regional integration of food production, urban development, and governance transformations (Eakin et al. 2017; Gren and Andersson 2018). Adopting a systems approach is generally more cost-effective in staying within the planetary boundaries compared to addressing each stage and abatement potential in isolation (Kennedy et al. 2016).

2.3 | Economic Dimension

2.3.1 | Leibniz Consensus

Healthy and sustainable diets can be affordable for all populations, subject to supportive regulatory frameworks and fair food environments. Healthy and sustainable, predominantly plant-based diets are more affordable than current diets in higher-income countries (with high amounts of animal products). Still, they are less affordable than status quo diets in lower-income countries (with high amounts of staple crops). The affordability of healthy and sustainable diets can be increased by dedicated agrifood system changes, including full-cost accounting, reductions in food waste, and socio-economic development.

SARAS need to account for global economic interlinkages, including emission leakage and a global allocation of production that ensures fair income opportunities from food and agriculture. Trade policies can be strategically used to make healthy nutrition more affordable and resilient against ecological and economic crises by diversifying the origins of production. However, there can be a trade-off between resilience through diversification of food origins and more equally distributed income opportunities on the one side and natural resource and economic efficiency on the other side.

2.3.2 | Background

Adopting healthy and sustainable diets is hampered if they are more expensive and unaffordable for some populations. Model estimates based on country-specific market prices (Springmann et al. 2021) indicate that compared to current diets, healthy and sustainable diets can cost up to 22%–34% less in upper middle and high-income countries on average but would be at least 18%–29% more expensive in lower middle and low-income countries. Among different dietary patterns, vegetarian and vegan diets were generally more affordable, while pescatarian diets were the least affordable. Affordability can be improved through various measures. Food waste reductions, socio-economic development, and a comprehensive cost accounting that includes diet-related costs of climate change and healthcare have been found to increase the relative affordability of healthy and sustainable diets. When combined, these measures resulted in cost reductions of 25%–29% in low and lower middle-income countries and up to 37% on average (Springmann et al. 2021). Hence, interventions encouraging the adoption of healthy and sustainable diets in high and upper middle-income countries can help consumers reduce costs while supporting climate change commitments and reducing public health spending. In low and lower middle-income countries, healthy and sustainable diets are substantially less costly than Western diets and can become cost competitive in the medium to long term, subject to beneficial socio-economic development and reductions in food waste. A comprehensive cost accounting would establish healthy and sustainable diets as the least costly option in most countries.

Around 25% of globally available food is traded internationally (D'Odorico et al. 2014), which plays a crucial role in overcoming local limitations to food production and diversifying food supply (Allouche 2011; Porkka et al. 2017), thereby increasing affordability and contributing to SDG 2, but also contributing to dietary risks and diet-related mortality in some cases, for example, by increasing the availability of red meat in a country (Springmann et al. 2023). International trade enhances the resilience of national agrifood systems by aiding adaptation to climate change and cushioning price shocks from harvest losses and yield decreases (Gouel and Laborde 2021; Puma et al. 2015; Stevanović et al. 2016; Zimmermann et al. 2018). Sourcing products from multiple countries, in addition to domestic production, makes supply chains less susceptible to severe disruptions (Godfray et al. 2010; Kummu et al. 2020; Marchand et al. 2016). However, trade policies should prioritize sustainability. Externalizing environmental costs to other countries (e.g., carbon leakage) should be prevented, and agricultural production should be globally allocated to locations associated with the lowest environmental costs. While factors like climate or soil quality that contribute to a region's comparative advantage in agricultural production are invariable, technology, capital, human capital, and knowledge, and infrastructure are subject to political influence (Godfray et al. 2010). Because of the many simultaneous and possibly counteracting mechanisms in the economics sector, changes in diets or trade are often simulated in equilibrium models to quantify their effects on prices, production, and environmental indicators (Rieger et al. 2023; Springmann et al. 2018b; Thom et al. 2024; von Lampe et al. 2014).

2.4 | Political Dimension

2.4.1 | Leibniz Consensus

Current institutional and political environments are insufficient to achieve SARAS. Rapid transformation by providing incentives to reduce negative externalities and overcome missing markets and institutions is needed. Integrated multi-component approaches are best suited. Changes in norms, regulatory instruments, and fiscal measures stimulate behavioral change. Examples can include reform of national dietary guidelines, health-and environmentally motivated taxes, and agricultural subsidies. New forms of cooperation across different actors and/or at different scales provide opportunities and could be facilitated by public support.

2.4.2 | Background

Due to the simultaneity of environmental and health-related problems, it is challenging to disentangle policy objectives and assess the appropriateness of policy instruments to stimulate behavioral change. The nature of environmental and human health-related externalities differs. It is well accepted that internalizing negative externalities like GHG and nitrogen emissions would increase society's welfare. Given that GHG emissions have global effects, instruments for global reductions represent the first-best options (Blandford 2021; IPCC 2019). Theoretically, instruments like emission trading systems or carbon taxes targeting emission sources directly should be the most effective. However, many agricultural emissions stem from non-point sources (e.g., fertilizer) and are highly variable, making them difficult to measure. Consequently, agriculture has been exempted from existing schemes directly targeting sources of emissions. Indirect instruments targeting consumers' food choices, like carbon consumption taxes and labels, would be easier to implement but require transparent communication on the magnitude of emissions (Blandford 2021).

Health targeting taxation cannot consider an individual's consumption level and may also tax recommended intake levels, inevitably resulting in some gross welfare losses and reduced efficiency of simple policy interventions (Härkänen et al. 2014; Lusk and Schroeter 2012). Additionally, most scholars agree that the simplistic neoclassical assumption of a rational, utility-maximizing consumer who only responds to prices and income does not fully explain observed behavior (Traill 2012). Nevertheless, fiscal instruments like taxes on fat and sugar-rich foods and drinks or tax reductions for fruits and vegetables enjoy high popularity in the public debate. The empirical evidence regarding their effectiveness is mixed. Most studies claiming positive effects of fiscal interventions are ex-ante assessments based on equilibrium models that consider the consumption feedbacks of levying taxes (e.g., Springmann et al. 2018b). Meta-analyses document evidence of reduced consumption of sugar-sweetened beverages following the introduction of a sugar tax (Afshin et al. 2017; Teng et al. 2019). The implementation of other food taxes (i.e., fat tax in Denmark) resulted in increased vegetable consumption but also unintended effects (e.g., increased salt consumption), leading to only minor improvements in public health (Smith et al. 2018). Sound impact analyses of health effects at an individual level are scarce (Jensen and Smed 2018). The observed changes in aggregate consumption and substitution patterns do not adequately represent the consumption by individuals with the highest health risks and long-term health effects. More fine-grained analyses are required here.

Non-fiscal measures focus on providing information such as child education, marketing campaigns, or national food-based dietary guidelines (Springmann 2020). National food-based dietary guidelines serve as the foundation for national food policies, including public procurement for schools and canteens. A comprehensive assessment of national dietary guidelines has shown that most guidelines do not align with health and environmental targets like the Paris Climate Agreement and the SDGs (Springmann 2020).

Policies across domains should exhibit greater coherence. Support for agricultural activities that cause GHG emissions counteracts climate efforts and should be abolished. Redirecting support towards agricultural practices that enhance carbon sequestration will alter relative prices and the availability of foods, consequently affecting nutrition (Springmann and Freund 2022).

Further analysis of policy instruments, including their design, implementation, and intended and unintended effects, is necessary. When evaluating any policy instrument targeting sustainable agriculture, a comprehensive assessment should consider socially differentiated impacts and other aspects of lifestyles beyond nutrition. In addition to prices and income, factors like consumers' time constraints, decision-making within households, loss aversion, asymmetric information, and time-inconsistent behavior must be accounted for. Their respective impacts on consumer decisions should be quantified to identify starting points for effective policies and to perform ex-ante impact analyses of political instruments. Achieving sustainable and resilient agriculture, healthy and affordable food, and long-term health requires close coordination between approaches from economics, political science, and social sciences.

2.5 | Social Dimension

2.5.1 | Leibniz Consensus

The influence of culture and social interactions on food production and consumption, as well as the broader values of food beyond its nutritional content, need to be acknowledged when transitioning to SARAS. Food serves as a collective synchronizer and a catalyst for comprehensive socio-economic change. The successful transition to SARAS relies on leveraging these recognitions through integrated measures that shift the perception of food from mere "fuel" to a reflection of "culture" This involves actively utilizing changes in consumption patterns to drive agricultural transformation, creating new markets for sustainable and resilient products (such as protein crops and legumes), and production practices (such as agroecology). Since food and eating behaviors are deeply rooted in social norms and individual preferences, they can play a pivotal role in accelerating sustainable and resilient agrifood systems, including institutional and governance structures. It is crucial to support individuals and communities in making nutrition-related decisions by fostering fair food environments that align with human perception, decision-making, and behavior, providing more and easier choices for more sustainable diets. In such food culture systems, bottom-up consumer-driven innovations and government regulations on firms and markets work together to enable sustainable agricultural livelihoods and food choices. Alongside globalized systems, greater attention should be paid to integrated regional agrifood systems, which facilitate social innovations through cooperative and collaborative models.

2.5.2 | Background

In recent decades, the globalized agrifood system has resulted in a growing disconnect between food production and consumption and has weakened the understanding of its social impacts while increasing its contribution to climate change. The predominant focus on treating food as a mere commodity has led to an underestimation of its value as a central and essential social good. Consequently, the agrifood system has become less resilient and more fragile (Béné and Devereux 2023). This situation is further complicated by the various stakeholders involved in the agrifood system, including the system itself (sector, markets), actors such as farmers and traders, and individuals who are consumers, leading to a diffusion of responsibility. Each stakeholder assumes that others should take the initiative, resulting in a lack of action (Conti et al. 2021). Therefore, we argue that a comprehensive perspective considering individual agency and systemic factors is critical for achieving SARAS. In fact, we notice grassroots alliances for sustainable transformation that encompass direct interactions between producers and consumers. These alliances foster new hybrid cooperation and pooling solutions to achieve scale effects and act in shorter supply chain organization especially in the urban–rural nexus (Martens et al. 2022; Opitz et al. 2019). Participants in such food sub-sectors not only benefit economically and create ecological benefits but also profit from social learning including improved household management skills (e.g., reduced food waste), recognition of the value of food, and greater appreciation for the farming profession (Opitz et al. 2017; Zoll et al. 2018). Moreover, establishing fair food environments is critical for transforming food consumption (Spiller et al. 2020). For instance, introducing sustainable practices in public catering at schools and workplaces, and providing consumers with reliable and easily accessible information, can empower individuals to make informed choices (Dimbleby 2021; Spiller et al. 2020). Numerous city food strategies have been launched to co-develop inclusive, healthy, and sustainable food sectors that strive for resilience (Säumel et al. 2022). Leveraging public procurement to support regional, organic, and fair-trade products in communal catering holds substantial potential as a tool for an integrated, multi-level policy approach for the entire food system (Doernberg et al. 2019). The need for more resilient agrifood systems is increasingly recognized at the macroeconomic level, as reflected in strategies like the European Green Deal and the Farm to Fork strategy (Jackson et al. 2021; Nisbett et al. 2022). We believe only simultaneous bottom-up and top-down changes can induce production and behavioral changes facilitating SARAS. However, these strategies do not yet encompass a comprehensive global perspective on the inequities and shortcomings of the global agrifood system which continues to fall short of achieving zero hunger for all (SDG 2) despite massive increases in global income (Byerlee and Fanzo 2019). Severe forms of food insecurity result from systemic failures of global and local power regulation, with hunger being a weapon of war (Brück and d'Errico 2019). Achieving SARAS, thus, demands not only an integrated view from the individual to systemic levels but also a global understanding of disparities and inequities between and within countries and agrifood systems of the Global South and the Global North.

2.6 | Balancing Local and Global Solutions for SARAS

2.6.1 | Leibniz Consensus

A successful transformation toward SARAS requires knowledge of possible global and regional pathways and well-designed policy packages that mitigate trade-offs between health, environment, and social objectives aligned with global goals. International, multilateral agreements and coordination serve as solid guard rails. Policy frameworks like the EU Farm to Fork Strategy translate international targets into regional or national action plans. Including agriculture and nutrition in the National Determined Contributions (NDCs) as consented in the Paris Agreement would emphasize the interdependence between global food systems and climate change and would request governments to address both challenges simultaneously.

2.6.2 | Background

National food and nutrition strategies must align with global targets and multilateral agreements, like the SDGs, the Paris Agreement, and the Sendai Framework for Disaster Risk Reduction to achieve SARAS. Explicitly disclosing agrifood system emissions in the NDCs is a crucial step towards global transformation in line with the Paris Agreement (Amjath-Babu et al. 2019; Schulte et al. 2020). This alignment would facilitate the harmonization of efforts and collective contributions towards global sustainability.

Acknowledging that reaching the targets of the Paris Agreement and the SDGs will require significant changes and pose challenges to societies, modeling exercises have shown that achieving these targets is possible (Soergel et al. 2021). By utilizing models and combining methods from social and natural science, we can identify global and national transformation pathways and make informed decisions based on comprehensive assessments and shared visions (Bai et al. 2016; Hainzelin et al. 2023). These models integrate diverse factors, including environmental impacts, economic considerations, and social dynamics, all of which are relevant to ensure SARAS. Modeling frameworks that link several models allow for consistent analyses of changes in energy, economy, land use, and climate (Soergel et al. 2021). National pathways can provide tailored, context-specific solutions (González-Abraham et al. 2023; Rasche et al. 2023; Zerriffi et al. 2023). While national solutions may need to be scaled up for cost efficiency and broader impact, global solutions may need to be tailored to local contexts to ensure effectiveness. Careful consideration of the appropriate scale for implementation maximizes positive outcomes. Addressing the challenges of down- and upscaling is vital for SARAS.

Any single agrifood system can only be considered sustainable and resilient if it does not function at the expense of other systems. A SARAS should prioritize equitability and fairness and promote social justice and inclusivity (Pharo et al. 2019; von Braun et al. 2023). High-income countries must consider the impact of their decisions on low-income countries and vulnerable groups, fostering cooperation and support to address global challenges.

Quantitative and qualitative descriptions of pathways for future global agrifood systems show transformation opportunities (FAO 2018b; Pharo et al. 2019; Searchinger et al. 2019), but policy considerations must be accompanied by ex-ante analyses (Béné et al. 2019; Hainzelin et al. 2023; Huber et al. 2024). For example, Huber et al. (2024) emphasize the role of social factors in ex-ante policy assessments to evaluate the uptake of sustainable farming practices, while Coderoni et al. (2021) investigate the role of environmental policies in assessing European agricultural policies. Additionally, Parra-López et al. (2009) utilize ex-ante methods to analyze policies aimed at achieving sustainable agricultural landscapes, and Möhring et al. (2023) apply both ex-ante and ex-post analyses to study pesticide-free wheat production in Switzerland. Challenges, trends, and solutions are closely intertwined, and trade-offs and synergies must be considered from both a modeling and policy perspective to ensure successful transformation (Calicioglu et al. 2019). One frequently claimed approach to address these trade-offs and synergies is the implementation of policy bundles (e.g., Barrett et al. 2022; Fesenfeld et al. 2020; IFPRI 2022; OECD 2021; Parsons and Barling 2022). Policy bundles consider various government domains and stakeholders at different levels. They must be carefully designed and consider political economy aspects, like compensating losers, to successfully transform agrifood systems.

To shift production and consumption towards SARAS, it is crucial to reallocate sufficient financial resources. Repurposing subsidies can incentivize shifts in the agrifood system using public funds (Gautam et al. 2022). By setting the political frame and incentives for producers to act sustainably, financial resources from the private sector can be reallocated to contribute to SARAS (Díaz-Bonilla et al. 2021; Diaz-Bonilla and Echeverria 2022). High-income countries should support low-income countries by providing financial assistance and technical expertise. For example, investment in research and development focusing on underutilized crops or coping mechanisms of vulnerable regions can improve the resilience of the agrifood system and food security (Hendriks et al. 2023; Manners and van Etten 2018). Diversification of production and nutrition patterns can cushion shocks caused by climate change, conflict, or economic disruptions (Fan et al. 2022; Harris et al. 2022; Mustafa et al. 2021; Parsons et al. 2019).

Multilateralism and international cooperation are crucial for enhancing the transformation towards SARAS, as stated in SDG 16 and SDG 17 (Soergel et al. 2021). Strong institutions and multi-stakeholder, participatory governance approaches, increasing the diversity of decision-makers, support this effort (Balié 2020; Hebinck et al. 2021; van Bers et al. 2019).

3 | Discussion

The multitude of recent crises and the increasingly accurate projections of future crises, like climate change and the depletion of natural resources, emphasize the importance of the SARAS concept. While previous concepts and nutrition recommendations have primarily focused on the environmental and health aspects of sustainability, the COVID-19 pandemic and the Russian aggression against Ukraine have highlighted the relevance of resilience in agrifood systems. The measures and recommendations to achieve SARAS presented in this paper are summarized in Table 1.

International cooperation is essential to drive change, minimize spill-over effects, and create synergies. SARAS cannot be achieved by individual countries alone, as many environmental and social problems cross borders and impact multiple nations. Collaboration is necessary to establish a global agrifood system that is sustainable and resilient for everyone. High-income countries must take the lead in transforming their agrifood systems, acknowledge their responsibility as major contributors to climate change and environmental degradation, and support lower middle-income countries also financially in transforming theirs.

High-tech solutions like vertical indoor farming with alternative food sources can enhance healthy nutritional resources, especially in large urban areas. Preserving extensive systems can attain satisfactory levels of agricultural production while simultaneously supporting ESS, like grazing cattle and preserving biodiversity. In other situations, intensively farming specific areas and reserving the rest exclusively for ESS may prove more efficient.

Diversification regarding production (origin, technologies), consumption (food sources, composition), trade, and political measures (dietary norms, regulatory instruments) is key to SARAS. Diversification of production systems can promote crop diversity and reduce reliance on a limited number of staple crops that may be vulnerable to pests and diseases. Diversification of trade partners can mitigate the risk of food shortages following political instability or environmental shocks in a specific region, particularly when domestic production is susceptible to weather-related shocks. Other countries can help improve global resilience by increasing domestic production or shifting consumption to increase their degree of self-sufficiency. Expanding the diversity of decision-makers to include civil society, grassroots alliances, and representatives from the private and education sectors can significantly enhance the absorptive, adaptive, and transformative capacities of agrifood systems, fostering a sustainable and prosperous future for all.

We point out clearly that scientific research of SARAS requires a multidisciplinary perspective and that political action to implement SARAS requires stakeholder cooperation across the economic and political, as well as the local and global level.

Our assessment demonstrates that there are both synergies and trade-offs on the transformative path to SARAS. These trade-offs arise within and between economic, social, political, and ecological dimensions, as well as between short- and long-term perspectives and sustainability and resilience objectives. Gains and losses vary depending on the context, stage of the agrifood system, local conditions, and goals. Therefore, we advocate for targeted measures that consider all stages and actors in the agrifood system of any specific region.

No single measure is a panacea, and a global approach is necessary to achieve sustainability and resilience without shifting the burden to other actors or nations. A system approach is essential, considering the interconnectedness of production, distribution, consumption, waste management, and others. This way, we can identify and address the root causes of environmental and social problems, rather than merely treating their symptoms. Only by transforming the entire agrifood system towards SARAS can environmental damage be reversed, inequalities reduced, safe and healthy food provided, and mitigation and adaptation efforts on climate change be effective.

4 | Conclusion and Future Research

The agrifood system has gained significant attention on the policy agenda, particularly after the UN Food System Summit in 2021 and the COP27 in 2022. This heightened focus is attributed to its crucial role in addressing numerous global challenges, including malnutrition, climate change, environmental degradation, poverty, conflicts, and economic crises. To attain systemic resilience in the global agrifood system, a comprehensive approach is required. In this paper, we develop the SARAS concept, a novel perspective that combines health, sustainability, and resilience. We provide an overview of the relevant dimensions (ecological, economic, political, social) that must be considered and discuss potential measures that can be implemented.

Numerous solutions for different stages of the agrifood system already exist, ranging from production to consumption. While international agreements provide the overarching framework and some solutions are applicable on a global scale, others are highly specific and tailored to particular regions or crops. The implementation of these solutions may encounter challenges related to up- and downscaling, particularly in regional or local contexts. Therefore, it is imperative to apply existing solutions, while ensuring their alignment with regional or national conditions. To accomplish this, multidisciplinary strategies are necessary, incorporating insights from ecological, economic, social, and political research (as presented here), collaboration and knowledge-sharing, and involving all stakeholders contributing to the transformation (e.g., farmers, food producers, consumers, politicians, educators, etc.). This process should be founded upon political will and courage, adequate resource availability or provision, and societal endorsement.

We present evidence that for achieving SARAS, careful consideration of intricate system interconnections and the involvement of various stakeholders and dimensions are needed. Trade-offs and synergies must be identified and quantified to analyze net impacts. Consequently, further research should embrace an interdisciplinary approach that encompasses the entire agrifood system. Despite significant progress, several aspects of this transformation remain unclear and require further investigation. While the ultimate objective appears well-defined, there are multiple pathways that can lead us there. Incorporating global objectives into national or regional requirements, while accommodating diverse political realities, presents a formidable challenge. Although the benefits of SARAS for health, environment, and climate are widely recognized, effecting changes in individuals' dietary patterns poses considerable difficulties. Furthermore, while a multitude of policy instruments exists to address various challenges, the assessment and cost–benefit analyses of these instruments are heavily reliant on the specific context and the prevailing political economy, rendering their application in other settings challenging. Employing multi-stakeholder and cross-domain strategies, along with the comprehensive implementation of various measures, can provide valuable assistance in overcoming these challenges.

In summary, achieving SARAS requires a holistic approach that considers the complexity of the system, encompassing ecological, economic, social, and political aspects, as well as multiple objectives like planetary and human health, fairness, and welfare. It requires careful deliberation of regional contexts, up- and downscaling challenges, and solutions for different stages of the system. While international agreements provide the overarching framework, the actual transformation occurs at the regional or local levels, emphasizing the need for collaboration and knowledge sharing of multiple stakeholders and between regions.

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