

Socio-technical innovation bundles for agri-food systems transformation: report of the International Expert Panel on Innovations to Build Sustainable, Equitable, Inclusive Food Value Chains

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In 2019, the Cornell Atkinson Centre for Sustainability and the journal Nature Sustainability, together with its sister journal Nature Food, jointly convened a year-long international panel of 23 experts on ‘innovations to build sustainable, equitable, inclusive food value chains’. The goal of the panel was “to identify the innovations that would turn agri-food systems into healthy, equitable, resilient and sustainable systems, and shed light on the enabling conditions for such innovations to diffuse and scale up”. During 2020, the panel synthesised the best current scientific evidence to describe the present state and external drivers of the world’s agri-food systems (AFSs), to assess emerging innovations, to develop a vision for AFSs in 25–50 years, and to consider how to encourage agri- food value chain (AVC) actors to move together from the present state to that future vision through bundling of distinct innovations.

Technological and institutional innovations in AFSs over the past century have enabled dramatic, global advances in human wellbeing, but these gains have had massive, adverse and unsustainable spill-over effects on climate, the natural environment, public health and nutrition, and social justice. We must innovate to transition to AFSs that are healthier for all people and for the planet, and that can sustain current and future generations. The costs that farmers and downstream value- chain actors incur, and the prices consumers pay, understate food’s true costs to society once adverse environmental, health and social spill-over effects are included.

The panel identified and described five types of AFS: (i) rural and traditional; (ii) informal and expanding; (iii) emerging and diversifying; (iv) modernising and formalising; and (v) industrialised and consolidated. Four key features apply to all AFSs.

1. Human agency: the many actors in AFSs make decisions independently in pursuit of their own objectives, many of which end up in conflict with each other.
2. Heterogeneity: one-size-fits-all solutions do not exist.
3. Spillovers: there will always be unintended spill-over effects.
4. Science: we must look to science-based solutions.

Looking 25–50 years into the future, the panel considered three major drivers of change with serious implications for AFSs and AVCs. The first is shifting human population patterns. By 2050, more than two thirds of humanity will reside in urban locations; and the global population should peak in the 2060s at about 10 billion, with the majority of that growth occurring in sub-Saharan Africa. The second major driver will be income growth, especially in today's low and middle income countries, meaning that at least half of growth in global food demand to 2100 will occur in Africa. Income growth will also fuel added consumer demand for nutrients, and non-nutritive attributes of food such as appearance, taste, convenience, safety, social status, storability, perceived environmental or social attributes. This will concentrate value addition and employment growth in the post-farm-gate portions of AVCs. The third major driver is climate change, which is already resulting in habitat destruction and biodiversity loss. This will necessitate a reorientation of food production away from heavy dependence on land and oceans so as to increase carbon sequestration in trees and soils, conservation of natural ecosystems, and production of renewable geothermal, solar and wind energy. This will steadily reduce the land and water footprint of food production, with capital increasingly substituting for land and water inputs. Taken together, these drivers imply a need “to focus on Africa, on post-farmgate activities within AVCs, and on turning AFSs from a source of climate and biodiversity stressors to a locus of solutions”.

Having assessed the current state of AFSs and external drivers of future AFSs, the panel developed a vision for AFSs 25–50 years in the future (2045–2070). This vision is based on four core AFS design objectives: healthy and nutritious diets, equitable and inclusive value chains, resilience to shocks and stressors, and climate and environmental sustainability, summarised as ‘HERS’ (healthy, equitable, resilient, sustainable). Both trade-offs and synergies exist among these design objectives. AFS adaptations cannot attend only to unidimensional concerns, whether about climate, employment, environment, equity, health, productivity or resilience. Therefore, ‘socio-technical bundles’ are required “to address looming challenges and to deliver on the considerable promise of a rich pipeline of emergent technologies – a portfolio to bring about multiple objectives that no one innovation can simultaneously satisfy”.

Unfortunately, no one-size-fits- all innovations exist to take us from the present, perilous state of AFSs to a HERS future. Many candidate socio-technical bundles are available, but those that can work in one system may be ill- suited for others; and appropriate paths from today to tomorrow necessarily differ by context. It is therefore necessary to pay close attention to five key balancing acts simultaneously.

- Spatial extent of supply chains and food environments: weighing the benefits, costs and risks of localised and global AVCs.

- Scale of production: considering the gains from economies of scale and scope against the costs and risks of concentration.
- Product diversity: balancing the benefits of diversification with the costs of complexity.
- Functional diversity: weighing the added costs and prospective waste associated with redundancy against the resulting insurance against risk and concentrated market power.
- Internalisation of negative externalities: balancing reduction of the adverse environmental and public health effects of some AFS activities against the equity, health and nutrition damages that can arise from raising the cost of foods.

The panel examined “a profuse pipeline of promising options”, spanning the full range of AVCs, and drawing on a diverse array of sciences. It concluded that opportunities for ‘creative disruption’ abound. Innovations were grouped under eight headings.

1. Digital technologies are transforming AFSs along the entire AVC, revolutionising how crops are planted, monitored, harvested, marketed and consumed.
2. Innovative financing. Achieving the United Nations Sustainable Development Goals (SDGs) and the HERS objectives will require massive financial investments, particularly from private funding. Investor incentives to address environmental, health and social justice externalities include landscape bonds, conservation finance, social bonds, advance market commitments, prizes for key innovations, and benevolent patent extensions.
3. Innovative social protection instruments. Transformation inevitably brings dislocation, so effective social protection instruments are necessary to protect those who stand to lose out from creative disruption. For example, to overcome long-standing, systemic discriminatory access to social protection, to better deliver healthy diets, and to mitigate the privacy and human dignity risks posed by digitisation.
4. Innovations in civic engagement and policy. Technical innovations tend to be ‘pushed’ from the supply side rather than ‘pulled’ by citizens seeking improved living standards. Shifting from product-oriented solutions towards human-centred innovation requires both technological and institutional innovations that counter concentrated commercial and political power, and advance greater civic engagement.
5. Sustainable animal and plant production systems. Animal and plant production systems must be placed on a more sustainable footing, shifting from dependence on non-renewable inputs to systems that complement improved genetic material, irrigation and safe agrochemical use with agroecological principles such as diversity and the circular economy (reduce, reuse and recycle wastes).
6. Alternative, land-saving nutrient production systems. The land and oceans footprint of healthy diets needs to be reduced. Most of the land reduction will come from reducing the use of large livestock. There are four key strategies to achieve these transitions: (i) tap microbes and fungi to produce novel foods through ‘precision fermentation’ processes; (ii) use microalgae and insects as substitutes for land-intensive oilseeds-based proteins and fishmeal; (iii) employ tissue-engineering methods to grow animal tissue outside the body (‘clean’ or ‘cellular’ meats); (iv) deploy aero-, aqua- or hydro-ponic methods in controlled environment agriculture.
7. Supply chain innovations. These include pre-competitive engagement of large-scale supply chain actors with transnational governance bodies, civil society and supplier networks on

measures and certifications in support of the SDGs; food processing advances that improve sustainability, food safety and nutrition while decreasing food loss and waste; and packaging that provides preservation performance while being 100 percent recyclable, biodegradable or compostable.

8. Health and nutrition innovations. These include new foods such as genetically modified and biofortified staple crops, alternative proteins based on microbial or cellular alternatives, reformulated foods, and 3D-printed foods. Innovations along the supply chain include taxes on unhealthy foods, subsidies for healthy foods, and front- of-the-pack labels to increase transparency of the content, source and environmental footprint. Tracing technologies can provide information on the origins and safety of foods. Tracking individual diets and nutrition status can provide highly personalised and targeted dietary guidance.

Few, if any, of these innovations “can adapt and scale effectively without essential dialogue, consumer trust, and supporting policies and institutions to navigate a complex maze of biophysical, political economy, and sociocultural obstacles”. None can effectively target all four HERS objectives simultaneously, and most will generate both positive and negative spillovers across HERS objectives. Few can address even a single objective on their own. Stakeholders must, therefore, work together to build socio-technical innovation bundles of complementary innovations “to deflect opposition and obstruction, mitigate stark trade-offs, and facilitate adaptation and up-scaling in order to deliver impact at scale across objectives”. Pathways to impact must be identified in advance to ensure that spillovers and perverse incentives are minimised.

The panel sums up with seven essential actions to guide AFS transformations:

1. develop socio-technical innovation bundles;
2. reduce the land and water footprint of food;
3. commit to co-creation with shared and verifiable responsibility;
4. deconcentrate power;
5. mainstream systemic risk management;
6. develop novel financing mechanisms; and
7. reconfigure public support for AFSs.

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