Health in the bioeconomy

There is growing interest in the potential of the bioeconomy to support human progress within planetary boundaries. The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms, and derived biomass, including organic waste), and their functions and principles,[1] including the production of food; animal feed; and bio-based products, energy, and services. The bioeconomy's so-called value-pyramid has pharmaceuticals and other low-volume chemicals at the top, then food and feed, bioplastics and polymers, bulk chemicals, and lastly energy, heat, and fuels in descending order.[2] The European Commission's vision of the bioeconomy embodies principles of sustainability and circularity, aiming to minimise waste and move towards a closed loop economy. Building an economy that relinquishes dependence on fossil fuels and on harmful policies and practices, which undermine the chance for sustainable development, is an alluring prospect. The transformation of the use of land, including for agriculture, forestry, wetlands, and bioenergy could, for example, potentially contribute approximately 30% of the greenhouse gas mitigation required by 2050, amounting to approximately 15 billion tonnes of carbon dioxide equivalent annually, to meet the demanding target of only a 1·5°C increase in the global average temperature higher than that of the pre-industrial era.[3] However, to achieve the potential benefits and address potential harms, it will be essential to underpin this bold vision with a commitment to equity and to assessing the potential health effects, both positive and negative.

There are many pathways by which the bioeconomy could influence health. Pharmaceuticals derived from natural products are important in health care, notably in anti-infective agents and cancer therapeutics. Between 1940 and 2014, 49% of all small molecules for cancer approved by the US Food and Drug Administration or similar agencies were either natural products or derived directly from them.[4]

However, reconciling the demands for bioenergy to replace fossil energy with the increasing requirement for sufficient food to satisfy the growing world population might be challenging. A review of 75 studies assessing the competition between food, feed, and fuel suggests the need to prioritise strategies to increase food production over those for animal feed or biofuels to address food insecurity.[5] A range of potential trade-offs and synergies were identified, with trade-offs being more common. Competition between these three uses of bioenergy might be direct (ie, each having a different use for a specific type of biomass) or via competition for land use. Options to alleviate competition include reducing food loss and waste, planting bioenergy crops on marginal lands unsuitable for food crops, and dietary shifts to reduce the consumption of animal-source food in countries with high rates of consumption. Reducing sugar consumption is good for public health and could also offer the potential to increase bioethanol production without competition with food production.[6] Strategies for carbon dioxide removal could make important contributions to the achievement of climate targets. These plans include enhancing carbon sinks through soil carbon sequestration and afforestation. Bioenergy with carbon capture and storage is also advocated as a potential solution, although the feasibility and sustainability of large-scale deployment is a matter for debate; for example, because of concerns about the land and water use required.

Indigenous communities often act as environmental defenders and custodians of land rich in biodiversity. If land occupied by Indigenous communities is appropriated by powerful interests to grow food, feed, or fuel, biodiversity loss will be accelerated and inequities increased. In many parts of the world, Indigenous communities face high amounts of criminalisation and violence, including assassination.[7] Respect for the knowledge of Indigenous people and customary land rights should be guiding principles in proposals for the development of the bioeconomy.

Innovation will be necessary to advance the bio-economy. One example of such innovation is future foods, which include mycoproteins, insects, cultured meat, spirulina, sugar kelp, and chlorella. Emerging evidence suggests that future foods can provide a full spectrum of essential macronutrients and micro-nutrients, making them better alternatives for food sourced from animals than from plants,[8] but more needs to be known about the bioavailability of nutrients. All the future foods assessed, except sugar kelp, show a similar or higher dry-matter protein content than plant-source

and animal-source food, and are able to provide essential amino acids. Protein-rich biomass can also be produced via the direct air capture of CO_2 with the use of bacteria that oxidise hydrogen and renewable electricity in a closed system, independent of local climate. The protein yield per unit land area that can be achieved by this technology is several times greater than that from soybean production, with approximately one-tenth of the water use.[9]

Bioplastics offer a fossil fuel-free alternative to conventional plastics, but their socioeconomic and health implications are currently unclear. A study evaluating the toxicity of 43 commonly used bio-based or biodegradable compounds, or both, together with their precursors, found that 67% of the samples induced baseline toxicity, 42% induced oxidative stress, 23% induced anti-androgenicity, and one sample induced oestrogenicity.[10] There were no clear toxicological benefits of these compounds compared with conventional plastics, and the raw materials for bioplastics were generally less likely to show toxicity than the final products.

The combustion of solid fuels, including wood, crop residues, and dung, is a major source of the household air pollution that causes 1·8 million or more deaths a year. In India, a considerable programme is underway to replace solid fuels with liquified petroleum gas. Biomethane offers a renewable alternative that, according to emerging evidence from a study in rural India, when compared with traditional stoves, reduces firewood use, household air pollution, and hospital visits for respiratory illnesses.[11]

Nature-based solutions are increasingly advocated to address climate change adaptation and mitigation, with the potential to contribute to other environmental goals, such as the protection of biodiversity. There are potential mental and physical health benefits from an increased amount of green space in cities; mangrove and wetland restoration can contribute to flood protection; and, for example in the Brazilian Amazon, forest protection can reduce exposure to air pollution from fires, malaria, and diarrhoeal disease incidence.[12]

There is an extensive research agenda to advance understanding of the synergies and trade-offs for health and development of different bioeconomy products, technologies, and strategies, particularly in low-income settings. It is clear, though, that the bioeconomy framework should not focus exclusively on innovative products, but additionally encompass the commitment to respect human rights, reduce inequities, and to protect and improve both the health of humanity and the state of natural systems.

I declare no competing interests.

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