Meeting future food needs within planetary boundaries will require concerted action throughout the food system, including improvements in farming systems, shifts in diets and waste, and system-wide transformations (Foley et al 2011, West et al 2014, Garnett 2014, Steffen et al 2015). Clark and Tilman (2017) ground-truth the relative potential of a handful of these strategies using currently available life cycle assessments. Looking across multiple environmental impacts, they compare the burdens of different food types, methods of food production, and levels of agricultural input-use efficiency.

What is novel about their meta-analysis is its breadth and depth—to our knowledge, a life cycle environmental impact data set of this size has not yet been compiled and compared. Their analysis provides information for current decision-makers in many roles throughout the food system, from individual consumers to national governments. Additionally, the database generated and shared can be used to inform further analyses and expanded as new research becomes available.

The relative environmental impacts of broad food categories were generally consistent across five impact categories: greenhouse gases, land use, energy use, acidification potential, and eutrophication potential. Overall, plants have lower environmental impacts (2–25 times lower) than all meat and animal products. Within the meat category, beef stands apart as having the largest environmental impacts across almost all indicators.

Results comparing different agricultural production systems within a food category are less definitive. For organic systems, they found mixed results: organic uses less energy, emits comparable greenhouse gas and acidifying emissions, and has higher land use and eutrophication impacts compared to conventional. Similarly, grass-fed beef systems require more land, but show no significant difference in other impacts analyzed. For fisheries, Clark and Tilman’s (2017) results combined with previous literature suggest that non-trawling methods should be preferred from an environmental perspective. The relative burdens of aquaculture compared to fisheries and of field-grown versus greenhouse produce are less clear due to limited impact scope and high heterogeneity of production systems.

There may be other reasons to choose food from alternative production systems that are not captured by this analysis, such as reducing pesticide use to protect bee populations and supporting regional farmers and economies. While further research is needed, Clark and Tilman (2017) add to the literature challenging popular perceptions that a single alternative production system could be a ‘silver bullet’ (Tuomisto et al 2012, de Vries et al 2015, Seufert et al 2012). They provide a more nuanced view: designing systems that leverage the relative strengths of conventional and alternatives should be prioritized.

The third analysis assessed the correlation between agricultural input efficiency and environmental impacts. The trends of their comparisons were consistent: with a higher nitrogen or feed use efficiency, they found lower environmental impacts. The largest differences, however, appear to be driven by the different inherent efficiencies of food products, underscoring the importance of food choice in reducing environmental impacts. Still, increasing input efficiency has a role to play. Adopting strategies to increase input use efficiency in the least efficient crop and livestock systems could have the greatest benefit. However, we should learn from past attempts to increase efficiency. For example, intensification has produced unintended consequences in both cropping systems (e.g. increasing synthetic fertilizer use has contributed to the global pool of reactive nitrogen) and livestock systems (e.g. shifting to high-energy diets of human edible grains and oilseeds, relying on growth promoting pharmaceuticals).

The limitations of this meta-analysis mostly stem from the limitations of life cycle assessments (LCA) of agri-food systems to date (circa 2015). Further study and methodological development of LCA is needed to more fully understand the environmental sustainability of food. The field of LCA is rapidly advancing...
methods to capture biodiversity, soil quality, and pesticide toxicity impacts (Eady et al 2016, Chaudhary et al 2015, Rosenbaum et al 2015). For land use, a method was recently developed that can be used in conjunction with LCA to assess the opportunity cost of using arable land to produce livestock feed instead of food (van Zanten et al 2016, Tichenor et al 2017a). At the same time, challenges undoubtedly remain. A prime example is comparing intensive versus extensive animal production systems where the majority of pollutants in an impact category are produced and experienced locally or regionally (e.g. eutrophication potential). In these cases, there may be non-linear relationships between emissions loading per unit area and ecosystem response (e.g. soil phosphorus saturation thresholds) that are not captured by current impact assessment methods and food-based functional units (Tichenor et al 2017b).

Although more research is needed to fully understand the sustainability of different food systems, we know enough now to take action. Choosing plant-based foods, regardless of production system, will almost always have a lower environmental impact than animal-based foods. Clark and Tilman’s (2017) findings add to the growing consensus that healthy and sustainable diets can align closely (Nelson et al 2016). To ensure this alignment and promote long-term food security, the environmental impacts of food should be taken into account in countries’ dietary guidelines and other relevant policies. We should also raise consumer awareness about foods’ environmental profiles using strategies like food labeling (Leach et al 2016).

Scientists and practitioners must continue to develop and integrate methods that assess systems’ sustainability more holistically, including temporal and spatial dynamics as well as economic and social dimensions. Comprehensive analyses across food categories and environmental impacts—like this one—are one of the tools that we need to move towards a more sustainable food future.

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