Agricultural alternatives to soil

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In the mid-20th century, food production from agriculture sharply increased worldwide; however, this was achieved through heavy use of agrochemicals. Extensive collateral damage from excessive use of pesticides, herbicides, and fertilizers has occurred to the wider environment. This has led to biodiversity loss, pesticide resistance and the emergence of new pests, pollution and decline of freshwater supplies, and soil degradation and erosion, as well as direct harm to health. In a Review, Pretty examines the alternative approaches that can achieve sustainable intensification of farming systems by integrating pest management with agroecological systems to minimize costs, maximize yields, restore ecosystem services, and ensure environmental enhancement.

livestock breeds—combined with increased use of inorganic fertilizers, manufactured pesticides, and machinery—led to sharp increases in food production from agriculture worldwide. Yet this period of agricultural intensification was accompanied by considerable harm to the environment. This imposed costs on economies and made agricultural systems less efficient by degrading ecosystem goods and services. The desire for agriculture to produce more food without environmental harm, and even to make positive contributions to natural and social capital, has been reflected in many calls for more sustainable agriculture. Sustainable intensification (SI) comprises agricultural processes or systems in which production is maintained or increased while progressing toward substantial enhancement of environmental outcomes. It incorporates these principles without the cultivation of more land and loss of unfarmed habitats and with increases in system performance that incur no net environmental cost.

SI seeks to develop synergies between agricultural and landscape-wide system components and is now a priority for the Sustainable Development Goals of the United Nations. The concept is open; emphasizes outcomes rather than means; can be applied to any size of enterprise; and does not predetermine technologies, production type, or design components. SI can thus be distinguished from earlier manifestations of intensification because of the explicit emphasis on a wider set of environmental as well as socially progressive outcomes. Central to SI is an acceptance that there will be no perfect end point. No designed system is expected to succeed forever, and no single package of practices is able to fit the dynamics of every ecosystem.

ADVANCES

Three nonlinear stages in transition toward sustainability have been proposed to occur: efficiency, substitution, and redesign. Although both efficiency and substitution are important, they are not sufficient for maximizing coproduction of favorable agricultural and beneficial environmental outcomes without redesign. Whereas efficiency and substitution tend to be additive and incremental within current production systems, redesign should be the most transformative. Redesign presents social and institutional as well as agricultural challenges.

It is now clear that SI is spreading to increasing numbers of farmers and is being practiced on a growing area of farmland. By 2018, it was estimated from these initiatives that across some 100 countries, 163 million farms had crossed an important substitution-redesign threshold by using SI methods in at least one farm enterprise, and over an area approaching 453 million ha of agricultural land. This is equivalent to 29% of all farms worldwide and 9% of agricultural land.

OUTLOOK

Pest management exemplifies the need for continuing active intervention for SI; the job is never done. Ecological and economic conditions will change, and agroecosystems will have to be adaptable in order to deliver a range of ecosystem services, including food production but also water and soil conservation, soil carbon storage, nutrient recycling, and pest control. Cooperation—or at least individual actions that collectively result in additive or synergistic benefits—is needed for SI to have a transformative impact across landscapes. Farmers will have to be given the confidence to innovate in a flexible way as conditions change. Every example of successful redesign for SI at scale has involved the prior building of social capital. Widespread adoption of IPM needs new knowledge economies for agriculture. Technologies and practices are growing, but new knowledge needs to be collectively created and deployed and needs to give equal emphasis to ecological and technological innovations. The concept and practice embodied in the SI model of agriculture will be a process of adaptation, driven by a wide range of actors cooperating in new agricultural knowledge economies.