

## **Agroecology and the Sustainable Intensification of Agriculture**

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Agricultural systems are amended ecosystems with a variety of properties. Modern agricultural systems have amended some of these properties to increase productivity. Sustainable agroecosystems, by contrast, seek to shift some of these properties towards natural systems without significantly trading off productivity. Modern agroecosystems have tended towards high through-flow systems, with energy supplied by fossil fuels directed out of the system (either deliberately for harvests or accidentally through side-effects). For a transition towards sustainability, renewable sources of energy need to be maximized, and some energy flows directed towards internal trophic interactions (e.g. to soil organic matter or to non-agricultural biodiversity for arable birds) so as to maintain other ecosystem functions. These properties suggest a role for agroecological design of systems so as to produce both food and environmental assets.

What makes agriculture unique as an economic sector is that it directly affects many of the very assets on which it relies for success. Agricultural systems at all levels rely on the value of services flowing from the total stock of assets that they influence and control, and five types of asset – natural, social, human, physical and financial capital – are recognized as being important.

As agroecosystems are considerably more simplified than natural ecosystems, some natural properties need to be designed back into systems to decrease losses and improve efficiency. For example, loss of biological diversity (to improve crop and livestock productivity) results in the loss of some ecosystem services, such as pest and disease control. For sustainability, biological diversity needs to be increased to recreate natural control and regulation functions, and to manage pests and diseases, rather than seek to eliminate them. Modern agricultural systems have come to rely on synthetic nutrient inputs obtained from natural sources but requiring high inputs of energy, usually from fossil fuels. These nutrients are often used inefficiently, and result in losses in water and air as nitrate, nitrous oxide or ammonia. To meet principles of sustainability, such nutrient losses need to be reduced to a minimum, recycling and feedback mechanisms introduced and strengthened, and nutrients diverted for capital accumulation. Mature ecosystems are now known to be not stable and unchanging, but in a state of dynamic equilibrium that buffers against large shocks and stresses. Modern agroecosystems have weak resilience, and transitions towards sustainability will need to focus on structures and functions that improve resilience while also meeting the primary goal of food production.

The desire for agriculture to produce more food without environmental harm, or even positive contributions to natural and social capital, has been reflected in calls for a wide range of different types of more sustainable agriculture: for a ‘doubly green revolution’, for ‘alternative agriculture’, for an ‘evergreen revolution’, for ‘agroecological intensification’, for ‘green food systems’, for ‘greener revolutions’ and for ‘evergreen agriculture’. All centre on the proposition that agricultural and uncultivated systems should no longer be conceived of as

separate. In light of the need for the sector to contribute directly to the resolution of global social-ecological challenges, there have also been calls for nutrition-sensitive, climate-smart and low-carbon agriculture.

Sustainable production systems should exhibit most or all of the following six attributes:

1. Utilizing crop varieties and livestock breeds with a high ratio of productivity to use of externally and internally derived inputs.
2. Avoiding the unnecessary use of external inputs.
3. Harnessing agroecological processes such as nutrient cycling, biological nitrogen fixation, allelopathy, predation and parasitism.
4. Minimizing use of technologies or practices that have adverse impacts on the environment and human health.
5. Making productive use of human capital in the form of knowledge and capacity to adapt and innovate and social capital to resolve common landscape-scale or system-wide problems (such as water, pest or soil management).
6. Quantifying and minimizing the impacts of system management on externalities such as greenhouse gas emissions, clean water, carbon sequestration, biodiversity, and dispersal of pests, pathogens and weeds.

Conventional thinking about agricultural sustainability has often assumed that it implies a net reduction in input use, thus making such systems essentially extensive (requiring more land to produce the same amount of food). Organic systems generally accept lower yields per area of land in order to reduce input use and increase the positive impact on natural capital. Recent evidence shows that successful agricultural sustainability initiatives and projects arise from shifts in the factors of agricultural production (e.g. from use of fertilizers to nitrogen-fixing legumes; from pesticides to emphasis on natural enemies; from ploughing to zero-tillage). A better concept than extensive is one that centres on intensification of resources, making better use of existing resources (e.g. land, water, biodiversity) and technologies.

The compatibility of the terms ‘sustainable’ and ‘intensification’ was hinted at in the 1980s, and they were first used in conjunction in a paper examining the status and potential of African agriculture. Until that point, ‘intensification’ had become synonymous with a type of agriculture that inevitably caused harm whilst producing food. Equally, ‘sustainable’ was seen as a term to be applied to all that could be good about agriculture. Combining the terms was an attempt to indicate that desirable ends (more food, better environment) could be achieved by a variety of means. The term ‘sustainable intensification’ was further popularized by its use in a number of key reports: *Reaping the Benefits* by the Royal Society; *The Future of Food and Farming* by UK Foresight; and *Save and Grow* by the FAO.

Sustainable intensification (SI) is defined as a process or system where yields are increased without adverse environmental impact and without the cultivation of more land. The concept is thus relatively open, in that it does not articulate or privilege any particular vision of agricultural production. It emphasizes ends rather than means, and does not predetermine

technologies, species mix, or particular design components. Sustainable intensification can be distinguished from former conceptions of ‘agricultural intensification’ as a result of its explicit emphasis on a wider set of drivers, priorities and goals than solely productivity enhancement.

Enabling policy environments are crucial for the adoption of agricultural systems that deliver both public goods (natural capital) alongside private (increased food and fibre) over time. Policy intervention in agricultural systems has clearly worked to increase output, such as during the Asian green revolutions, but has overwhelmingly involved trade-offs between provisioning ecosystem services (food production) and regulating and supporting services. The key question is: can it also address challenges such as improving natural capital, nutritional security and social-ecological resilience? Global-scale policy leaders are increasingly focused on these wider goals. Recently, the FAO made the case that agricultural policies need to emphasize nutrition, and can improve nutritional outcomes by emphasizing R&D that is inclusive of smallholders, focusing on important non-staple, but nutritionally dense foods, and integrated production systems. Similarly, there is an effort to spread awareness of climate-smart agriculture and ‘save and grow’ models that build natural capital while improving yields and nurturing resilience.

Despite great progress, and the emergence of the term ‘sustainable intensification’ and all its component parts, there is much to achieve to ensure agricultural systems worldwide increase productivity fast enough whilst ensuring impacts on natural and social capital are only positive.