

# Regenerative Agriculture, Agroecology and Sustainable Intensification

**Jules Pretty, University of Essex, UK**

Agricultural systems are amended ecosystems with a variety of properties. Modern agricultural systems have amended some of these properties to increase productivity. Regenerative and 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 maximised, and some energy flows directed towards internal trophic interactions (e.g. to soil organic matter or to agricultural biodiversity) so as to maintain other ecosystem functions. These properties suggest a role for redesign of systems to produce both food and environmental assets and services.

What makes agriculture unique as an economic sector is that it directly affects many of the very assets upon 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 recognised 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 re-create natural control and regulation functions, and to manage pests and diseases rather than seeking 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 to water and air as nitrate, nitrous oxide or ammonia. 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 shift the focus to structures and functions that improve resilience as well as meeting the primary goal of food production.

The desire for agriculture to produce more food without environmental harm, and then especially positive contributions to natural and social capital, has been reflected in calls for a wide range of different types of more regenerative and 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 a variety of forms of 'natural farming'. 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 also 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.

Regenerative and sustainable production systems should exhibit most or all of the following six attributes:

1. Utilising crop varieties and livestock breeds with a high ratio of productivity to use of externally- and internally-derived inputs;
2. Eliminating the external inputs where possible, and minimising use of technologies or practices that have adverse impacts on the environment and human health;
3. Building the health of the soil through increase organic matter, which in turn increase carbon capture;
4. Harnessing agroecological processes such as nutrient cycling, biological nitrogen fixation, allelopathy, predation and parasitism;
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 minimising 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, decrease costs 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 fertilisers to nitrogen-fixing legumes; from pesticides to emphasis on natural enemies; from ploughing to zero-tillage). A better concept is one that centres on intensification of resources, making better use of existing resources (e.g. land, water, biodiversity) and technologies.

Compatibility of the terms “sustainable” and “intensification” was hinted at in the 1980s, and then first used in conjunction in a paper examining the status and potential of African agriculture. Until this point, ‘intensification’ had become synonymous for 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. The combination of the terms was an attempt to indicate that desirable ends (more food, better environment) could be achieved by a variety of means. The term was further popularised 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 emphasises 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' because of the explicit emphasis on a wider set of drivers, priorities and goals than solely productivity enhancement.

Regenerative systems go even further – seeking to build and improve the natural capital in and around agricultural systems. Soil health is a key - where microbial communities are improved through high soil organic matter, plants are healthier, soils are able to absorb water better, carbon is captured, and costs to farmers are reduced through reduced need for and use of agrochemical inputs.

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. The UN FAO made the case that agricultural policies need to emphasise nutrition, and can improve nutritional outcomes by emphasising R&D which 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, there is much to achieve to ensure agricultural systems worldwide increase productivity fast enough whilst ensuring that impacts on natural and social capital are only positive.