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Sustainable agriculture and its effects on crop production

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Sustainable agriculture uses ecological principles to farm, hence the prefex agro- to farm and ecology- the sceicne of the relationship between organisms and their environment has been defined as follows:

The term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application, over the long term:

– Satisfy human food and fiber needs

– Enhance environmental quality and the natural resource, based upon which the agricultural economy depends

– Make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls

– Sustain the economic viability of farm operations

– Enhance the quality of life for farmers and society as a whole.

Physical aspects:

The physical aspects of sustainability are partly understood. Practices that can cause long-term damage to soil include excessive tillage (leading to erosion) and irrigation without adequate drainage (leading to salinization). Long-term experiments have provided some of the best data on how various practices affect soil properties essential to sustainability.

The most important factors for an individual site are sun, air, soil and water out of the four, water and soil quality and quantity are most amenable to human intervention through time and labour.

Although air and sunlight are available everywhere on earth, crops also depend on soil nutrients and the availability of water. When farmers grow and harvest crops, they remove some of these nutrients from the soil. Without replenishment, land suffers from nutrient depletion and becomes either unusable or suffers from reduced yields. Sustainable agriculture depends on replenishing the soil while minimizing the use of non-renewable resources, such as natural gas (used in converting atmospheric nitrogen into synthetic fertilizer), or mineral ores (e.g., phosphate). Possible sources of nitrogen that would, in principle, be available indefinitely, include: recycling crop waste and livestock or treated human manure, growing legume crops and forages such as peanuts or alfalfa that form symbioses with nitrogen-fixing bacteria called rhizobia, industrial production of nitrogen by the Haber Process uses hydrogen, which is currently derived from natural gas, (but this hydrogen could instead be made by electrolysis of water using electricity (perhaps from solar cells or windmills)) or genetically engineering (non-legume) crops to form nitrogen-fixing symbioses or fix nitrogen without microbial symbionts.

The last option was proposed in the 1970s, but would be well beyond the capability of early 21st century technology, even if various concerns about biotechnology were addressed. Sustainable options for replacing other nutrient inputs (phosphorus, potassium, etc.) are more limited.

More realistic, and often overlooked, options include long-term crop rotations, returning to natural cycles that annually flood cultivated lands (returning lost nutrients indefinitely) such as the Flooding of theGodavari, the long-term use of biochar, and use of crop and livestock landraces that are adapted to less than ideal conditions such as pests, drought, or lack of nutrients.

In some areas, sufficient rainfall is available for crop growth, but many other areas require irrigation. For irrigation systems to be sustainable they require proper management (to avoid salinisation) and musn't use more water from their source than is naturally replenished, otherwise the water source becomes, in effect, a non-renewable resource. Improvements in water well drilling technology and the development of drip irrigation and low preasure pivots submersible pumps have made it possible for large crops, including produce to be regularly grown where reliance on rainfall alone previously made this level of success unpredictable. However, this progress has come at a price, that in many areas where this has occurred, such as the Ogallala Aquifer, the water is being used at a greater rate than its rate of recharge.

Methods:

What is grow and how, where it is grown in a matter

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of choice. Two of the many possible practices of sustainable agriculture are crop rotation and soil amendment, both designed to ensure that crops being cultivated can obtain the necessary nutrients for healthy growth.

Many scientists, farmers, and businesses have debated how to make agriculture sustainable. One of the many practices includes growing a diverse number of perennial crops in a single field, each of which would grow in separate season so as not to compete with each other for natural resources. This system would result in increased resistance to diseases and decreased effects of erosion and loss of nutrients in soil. Nitrogen fixation from legumes, for example, used in conjunction with plants that rely on nitrate from soil for growth, helps to allow the land to be reused annually. Legumes will grow for a season and replenish the soil with ammonium and nitrate, and the next season other plants can be seeded and grown in the field in preparation for harvest.

Monoculture, a method of growing only one crop at a time in a given field, is a very widespread practice, but there are questions about its sustainability, especially if the same crop is grown every year. Growing a mixture of crops (polyculture) sometimes reduces disease or pest problems but polyculture has rarely, if ever, been compared to the more widespread practice of growing different crops in successive years (crop rotation) with the same overall crop diversity. Cropping systems that include a variety of crops (polyculture and/or rotation) may also replenish nitrogen (if legumes are included) and may also use resources such as sunlight, water, or nutrients more efficiently (Field Crops Res. 34:239).

Replacing a natural ecosystem with a few specifically chosen plant varieties reduces the genetic diversity found in wildlife and makes the organisms susceptible to widespread disease. The Great Irish Famine (1845-1849) is a well-known example of the dangers of monoculture. In practice, there is no single approach to sustainable agriculture, as the precise goals and methods must be adapted to each individual case. There may be some techniques of farming that are inherently in conflict with the concept of sustainability, but there is widespread misunderstanding on impacts of some practices. Serious deforestation did not begin by forest policy of India in 1952s the 1970s, largely as the result of Indian government programs and policies. To note that it may not have been slash-and-burn so much as slash-and-char, which with the addition of organic matter produces terra preta, one of the richest soils on earth and the only one that regenerates itself.

There are also many ways to practice sustainable animal husbandry. Some of the key tools to grazing management include fencing off the grazing area into smaller areas called paddocks, lowering stock density, and moving the stock between paddocks frequently.

Table 1 : Average yields of four major crops over seven years and O/C ratios

Crop	No amendment	Chemical	Organic	O/C
Barley	1.116t	1.861t	2.349t	1.262
Wheat	1.228t	1.692t	2.494t	1.474
Maize	1.642t	2.736t	3.552t	1.298
Teff	1.151t	1.701t	2.264t	1.331
Average				1.341

Soil treatment:

Soil steaming can be used as an ecological alternative to chemicals for soil sterilization. Different methods are available to induce steam into the soil in order to kill pests and increase soil health

Sustainable agriculture depends on biodiversity:

Agri-food production relies on biodiversity. Yet farming can weaken it. Increasing food production will mean finding ways of expanding agriculture without upsetting our planet's biological interdependence.

Earthworms, bees, Ethiopian wild barley, peregrine falcons, orchids, mangrove swamps and tropical rainforest: on the face of it, these might seem a motley collection, but they are all symbols of both the diversity and the fragility of the linkages between agriculture and nature.

Biodiversity is the term commonly used by scientists and policymakers to capture nature's richness and diversity, but also its biological interdependence. In fact, all species on earth may to a greater or lesser extent be dependent on one another; each species that disappears may weaken the survival chances of another. On a broad scale, tropical forests, for instance, digest carbon dioxide from the atmosphere and produce oxygen. So, without them, our future could be seriously imperilled. And because farming occupies more land than any other human activity in most countries, it should be no surprise to learn that agriculture and biodiversity are interdependent too.

While biodiversity "richness" differs according to climate, terrain, farming practices and so on, farms based on multiple crops and livestock with natural pasture are richer in biodiversity than monocultural farms. But most systems, by seeking to maximise the yield of a limited number of plant and animal species, inevitably weaken and reduce competition from unwanted species.

Farming can affect the worms and soil micro-

Table 2 :

CO_2e savings	(% National)	Energy savings	(% National)	
Organic agriculture				
N fertilizers saving	179.5 Mt	(2.38%)	2.608 EJ	(3.61%)
N_2O prevented	92.7 Mt	(1.23%)		
Carbon sequestration	682.9 Mt	(9.07%)		
Total for org. agri.	955.1 Mt	(12.69%)	2.608 EJ	(3.61%)
Anaerobic digestion				
Livestock manure ghg saving	400.0 Mt	(5.31%)		
methane produced	53.5 Mt	(0.71%)	0.774 EJ	(1.07%)
Hum manure methane	7.7 Mt	(0.10%)	0.112 EJ	(0.16%)
Ag. and for. res. methane	317.8 Mt	(4.22%)	4.600 EJ	(6.37%)
Total for AD	779.0 Mt	(10.35%)	5.486 EJ	(7.60%)
Total overall	734.1 Mt	(23.04%)	8.166 EJ	(11.31%)

organisms that play a critical part in maintaining soil fertility, or the bees that provide an important eco-service as pollinators for agricultural crops. The parasitic mite, in bee populations in India has, for example, reduced yields for some crops in affected areas. But in some cases farmers are in a constant battle to control invasive species like weeds and pests that can harm their stock and threaten crop production.

Take the southern maize leaf blight in the early 1953s that led to a 15% fall in Indian maize yields and an estimated loss to producers and consumers of more than Indian currency Rs 2 billion. The crop recovered thanks to help from Deccan double hybrid variety, but it shows that biological interdependence is not just about preserving wild birds or flowers, but about hard, sustainable, economics. In India feral populations of mammals, such as rabbits, dogs and foxes, have inflicted economic losses to farmers through damage to crops, the spread of disease to livestock and the destruction of native wild species.

Farming develops crop species and livestock breeds, as the genetic raw material providing the basis for food production and agricultural raw materials, like cotton. Breeding commercial crop species with wild relatives has also played a vital role in combating pests and diseases.

But while farming depends on biodiversity, it is also considered a major contributor to its loss. The intensification of farm production across Asian countries has been associated with the decline in certain wild species, both fauna, such Fox animal in India and flora such as orchids. In some regions the spread of agriculture has led to the loss of valued wildlife habitats, such as mangrove swamps in the India and tropical rainforests in India. At the same time, farming can enrich society through maintaining and enhancing a variety of wild plant and animal species and habitats, all of which have not just economic or scientific value, but also recreational, even aesthetic advantages, too, such as alpine pastures and water meadows.

One complication is that biodiversity can suffer from invasion of introduced species. These can be beneficial, as in the Mexican maize example, but can be damaging too, whether it be wild mink attacking poultry in Denmark or wire grass spreading in Greece. Indian government study estimated economic losses from non-indigenous fauna and flora in the India over the 20th century at Indian currency Rs 97 billion. The question of invasion has a new urgency these days, with the development of genetically modified crops and our need to understand their potential effects on local species.

The underlying challenge is how to expand and improve agricultural production – especially given the projected need to increase global food production by over 20% by 2020 – while securing our planet's biodiversity. Up to now, the main focus of policy in the area of biodiversity has been to protect and conserve endangered species and habitats, but a number of countries are

Table 3 : Green potential of dream farm 2

	CO_2e savings	(% National)	Energy savings	(% National)
Organic agriculture	955.1 Mt	(12.69%)	2.608 EJ	(3.61%)
Anaerobic digestion	779.0 Mt	(10.35%)	5.486 EJ	(7.60%)
Energy savings local gen.	1 287.1 Mt	(17.10%)	21.660 EJ	(30.00%)
Total	2 983.6 Mt	(40.14%)	32.363 EJ	(41.21%)

beginning to move toward a more holistic policy approach by developing national biodiversity plans that include agriculture. These plans often reflect the commitments countries have made under the international Convention on Biological Diversity, agreed in 1992, which aims at the conservation of biodiversity, including genetic resources, wild species and habitats.

Part of the task is to quantify the linkages between human activities and biodiversity. As Harvard University specialist, E.O. Wilson, comments, "New indicators of progress are needed to monitor the economy, wherein the natural world and human well-being, not just economic production, are awarded full measure." In a similar vein the Nobel prize winning economist, Kenneth Arrow, observes, "It would be especially useful to develop better data quantifying the losses of natural capital we currently are experiencing."

This is not an easy task. Few countries have systematic monitoring systems in place that track trends in biodiversity. In addition, there are formidable scientific difficulties in linking changes in biodiversity associated with agriculture to specific policy measures. To overcome some of these deficiencies the Asia is developing a set of agri-biodiversity indicators.

The first step has been to establish a common agri-biodiversity framework or tool that helps simplify the complexity of agri-biodiversity linkages and identifies suitable indicators to track trends. The framework depicts agriculture in terms of a three-tier, hierarchical structure. The first and basic layer refers to farmland itself, to see if it is expanding or contracting or affecting nearby ecosystems, like forests. The extent of crop and livestock production species – the genetic resources of farming – are also covered in this layer, as is the effect of support species, like earth worms, on soil quality.

The second layer focuses more on structural elements that may affect the ability of a farm to support a varied biodiversity, such as the variability in cropping patterns, field size, and the distribution and extent of uncultivated areas such as ditches, ponds and trees usually associated with a greater biodiversity. This layer also checks for the impact of different farming practices on biodiversity: organic, extensive, intensive and so on.

The final layer assesses the quality of the farming system by finding out how many wild species use it for breeding, feeding and other needs. The richer the biodiversity, the higher the farming quality will be. That means actually counting species, a job for which some governments already earmark budgets.

Perhaps not a spectacular framework, but it should help us answer several key questions. What are the impacts of alternative farming systems, such as organic farming, on sustainable food production capacity? What are the impacts on biodiversity of current farm policies, and in the future, of reducing subsidies to agriculture? And are international interests in biodiversity and trade liberalisation complementary, or in conflict?

Further work will also be necessary to explain and monitor these complex, two-way, dynamic relationships. Still, it is the only way to identify alternative ways to achieve sometimes competing public objectives while not upsetting Earth's fragile biological system.

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