From Green Revolution to Agroecology

by Maarten Stapper

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The core of life on Earth is the daily requirement of food for people and all living organisms in webs of life, or ecosystems. These natural, self-organising ecosystems, which have provided food for millennia, are increasingly being taken apart—by ecological destruction and changing climates caused by ever increasing world population; industrialisation, including food production using cheap oil; deforestation; and urbanisation—all driven by economic growth and consumerism, and all affecting the health and wellbeing of people and earth. This increasingly puts pressure on food availability and price. Hence food security has become a major global issue and will remain so, especially given ongoing degradation of soils, depleting water resources, peak oil, global warming and a population of nine billion people by 2050.

The critical renewable resources of soil and water are being used up, with costs being borne by farmers. The soils of one-quarter of the world's arable land are in a highly degraded state, while agricultural land is being lost through urbanisation and further land degradation. What are we doing with this precious resource? The average arable land per person in the world is 2100 m^2, with an annual loss of 1 per cent. It is therefore important to regenerate degrading soils, making them productive again through sound management practices, while also protecting agricultural land in peri-urban areas to improve local food production systems, shorten food miles and secure freshness for health.

Issues about food need involvement from urban consumers. Consumers need to know where, when and how their food is produced and processed. Changes in urban food provisioning are needed for equitable food security and health, and consumers generally need to reduce food waste and regain respect for food generally. Most food is now produced with synthetic fertilisers and chemicals and over-processed with artificial additives, leading to nutrition-related chronic diseases. The health and wellbeing of urbanised people requires regeneration of sustainable, decentralised, community-based food systems—from production to distribution, processing, marketing, shopping, preparing and eating—while ecological principles have to be incorporated in management practices to restore the cycles of life on agricultural land as functioning agroecosystems.

Industrial Agriculture, Food and Health

World-wide, modern agriculture is degrading soils to ever lower fertility, leading to dependency on fossil fuel-related synthetic fertilisers and chemicals to obtain the highest yields. The Green Revolution is stalling, yields have plateaued. To offset degrading soils, more and more inputs are being applied to maintain yields, creating a self-perpetuating system of dependence on artificial inputs. In turn, production practices have gradually led to food with low nutrient density and chemical residue contamination, affecting human health and increasing chronic disease.

Food at the farm gate now takes far more energy to produce than is generated in edible calories. Globally, agriculture accounts for more than 20 per cent of greenhouse gas (GHG) emissions, and producers are pressured to reduce these. At the same time, the global marketplace for inputs and outputs of industrial farming is under pressure given decreasing oil supplies.

Current recommended practices use harsh synthetics and ignore the delicate balance of microbes, humus, trace minerals and nutrients in soil. Such practices expose roots to harsh conditions, making them more sensitive to saline or acid conditions, and the whole plant more susceptible to environmental conditions such as drought, heat and frost. Synthetic, water-soluble fertilisers make plants more susceptible to diseases and insects, with plants growing out of balance in rapid growth response to the few easy available nutrients provided. Management practices like these have led to marked losses in soil organic carbon and decimated the diversity and abundance of organisms in the soil foodweb. In turn the biodiversity of landscapes has been greatly reduced and many species are threatened.

Disruption of the soil’s biological and chemical processes by pesticides and fertilisers usually leads to physical problems like increased compaction, reduced water infiltration, water and wind erosion, and loss of nutrients to surface- and groundwater. Increased demand for price-competitive animal products has led to factory farming, where large numbers of animals are fed grain in confined areas, affecting animal welfare, food quality and waste disposal. Science and industry have also embraced genetic modification (GM) technology as a solution to food problems.

In GM, foreign species’ genes with desired traits are injected into selected food and fibre crops. This approach, however, does not treat the cause of problems, as crops on degrading soils remain dependent on synthetic inputs. Farmers also lose their ability to save seed, as GM seed has to be purchased every season. The genetic diversity of seed stocks decreases markedly, increasing vulnerability to biotic, or living, and abiotic, or non-living, factors, for example, disease or drought. Despite the promises that GM will improve yield, drought tolerance, food quality, fertiliser efficiency and so forth, only the management tools of herbicide tolerance (for example, glyphosate) and insect resistance are commercialised GM traits. GM yields have not increased and pesticide use has risen to combat problems of resistance, with one group of insecticides or herbicides replacing another. Herbicide use has increased and glyphosate hazards to crops, soils, animals and people are becoming apparent, while weed resistances keep developing, requiring more herbicide applications. New diseases and pests keep appearing that need chemical control.

Another key issue hardly raised is the decreased mineral density of foods at the farm gate; mineral density has more than halved over the past sixty years. This follows decades of breeding for high yields with synthetic fertilisers and selection for look, taste, shape, use in processing, shelf-life and transportability, but rarely quality. Mineral density can be 20 to 80 per cent lower when using glyphosate herbicide on tolerant GM crops as glyphosate immobilises nutrients, thus lowering uptake. The quality of animal products produced in factory farms with grain, hormones, antibiotics and steroids is also questionable. Current modes of urban food provisioning affect food quality through transport, refrigeration and long storage. Packaging keeps produce looking attractive and fresh, but green vegetables lose nutrition for every day stored. For ease of use, taste, look and shelf-life, foods are being highly processed. Refining, heating and extrusion are detrimental processes, removing or locking up minerals.

Synthetic chemicals poison or confuse most life forms. The direct impacts of chemicals as poisons are studied pending release of products by regulators who set safety levels to their intended use. However, frequent use over time and cocktail effects with other chemicals are not measured. A chemical may only be taken off the market when problems become obvious. DDT was the first example, as described by Rachel Carson in *Silent Spring* (1962). Connections between synthetic chemicals in food are increasingly being found to be associated with chronic diseases, yet medical research concentrates on cure rather than prevention.

In similar vein, GM produce has not been proven safe by the GM industry. The scientists involved claim GM crops have undergone more tests before release than any non-GM crop, but this is hardly an argument. Neither multi-generation animal feeding nor agroecological plant–soil–animal–human links have been studied, nor is there surveillance of GM-food consumption. Independent research is not permitted but those who have done long-term animal feeding studies have found health problems with liver, blood, immunity, allergens and fertility. Recently

Professor Giles-Eric Seralini found GM corn both toxic and carcinogenic for rats in a two-year study. His study outcomes received unmitigated criticism about the inappropriateness of the methodologies used. I have been asking CSIRO for such a study all along. We have to ask why GM scientists are not doing such studies themselves.

Food Production Enhancing Biodiversity

Recent UN studies of world food production report the need to shift to agroecological approaches. Agroecology is the science behind productive, low-risk farming in harmony with nature, farming that overcomes the need for synthetic fertilisers and chemicals.

Studies include those by the Food and Agricultural Organisation (2006), the International Assessment of Agricultural Knowledge, Science and Technology for Development (2008), UN Special Rapporteur De Schutter (2010), and the UN Environment Programme (2011). For a global perspective, most use the large 2006 overview study by Professor Jules Pretty which covers projects in fifty-seven developing countries, where average crop yields increased by 79 per cent. These UN agencies have concluded that agroecological training of farmers in developing countries, representing more than 1 billion people, will greatly improve people's livelihoods in local communities and reduce migration to cities.

It will be more difficult to re-train farmers (and scientists) who have grown up with industrial farming. Industrial farmers find themselves on a treadmill they cannot easily step off. Worldwide, however, some practitioners, professionals and scientists have broken away from the mainstream after becoming aware of the negative impacts on the environment and on human health. In India whole villages are changing from high-input, high-risk, unprofitable Green Revolution farming to agroecological farming using improved indigenous knowledge. This move away from industrial farming is happening world-wide and has led to so-called alternative farming practices that follow agroecological principles, for example, 'organic', 'biodynamic', 'low external input' and 'biological'. They use biological inputs as stimulants (for example, seaweed), inoculants (for example, vermiculture), mineral fertilisers (for example, rock phosphate) or fertilisers (for example, composted manure). Compost and compost tea (water extract from compost) are universal inputs serving all four categories.

Comparisons between such agroecological systems and industrial agriculture have been made and show the former's great potential, but adoption of these practices is poor because of a lack of advisory services and our low capacity for biosensitivity. Successful producers, the innovators and early adopters, seem to have a capacity for biosensitivity—a 'gut feeling', 'green thumb', ‘third eye’ or ‘sixth sense’. This allows them to feel and sense intuitively what is good for the soil, plants and animals. Organic agriculture has become the most widely recognised agroecological movement. Those who actively manage soil health with biosensitivity achieve yields similar to their industrial farming neighbours without using synthetics. Those who do not have that capacity usually have low yields as ecology is not reactivated. It is these examples that provide the so-called proof in agricultural science for the view that ‘organics only achieves half the yields’ and that ‘we can’t feed the world with organic farming’.

Degrading soils, rising input costs and difficulties in making the shift to organics led to the development of biological agriculture, which allows minimum use of synthetic fertilisers and chemicals. Emerging in the United States as a practice distinct from organics, biological agriculture is an easily adopted agroecological practice. It takes the best practices and materials from industrial and organic agriculture to enable farmers to make a profitable, gradual transition towards organics. Healthy soils are created step by step using biological inputs, thus minimising synthetic inputs that work against biology and balance. Fungicides and insecticides, which also kill beneficial microbes, are avoided and are not needed in any case as plants become resistant to pests. Pests become indicators of unbalanced plants; weeds become indicators of unbalanced soils. Further agroecosystem improvements to develop fields within a sustainable landscape may be achieved by managing natural energies and water through permaculture, Yeomans’ Keyline Design or Natural Sequence Farming principles.

Healthy Soils with Carbon for Healthy Food

A healthy soil in an agroecosystem is a soil in harmony—with the physics, chemistry and biology in balance. These factors are interactive and have strong links with soil organic carbon, the foundation for a living soil and life on earth. Soil biology seems to be the driver, using the diversity and abundance of microbes (algae, bacteria, fungi) and larger organisms (mites, beetles, earthworms) in the soil foodweb. Genes switch on and off in order to adapt to local conditions, and plants in healthy soils become more productive by activation of gene expression for self-protection. Microbial activity forms soil aggregates—crumbs—for stable soil structure. This feature greatly benefits soil aeration, which is important for water infiltration, and allowing deep and dense root systems. Soil structure and soil carbon are also aided by earthworms (present only when there is an abundance of microbes), which make humus.

The organisms in a soil foodweb work together by creating a home to sustain life. Beneficial organisms make soil nutrients plant-available and protect plants against insects and diseases. Abundant and diverse soil biology ensures that under all circumstances there are beneficial species active to undertake any task. Symbiosis is this balanced, mutual interdependence of different species. It is a protective mechanism in nature that develops in response to compatible needs. Such systems run on carbon, water and nitrogen free from the sky. A healthy soil is a self-organising system that endeavours to optimise the environment for optimum plant growth. Soil microbes feed nutrients to plants on demand and in return they are fed carbon exudates from the roots, which ultimately become soil organic carbon.

Soil health requires biodiversity not only in soils but also in the surrounding landscape, for example, in predator–prey species and pollinators. Windbreaks and shelterbelts improve the soil surface microclimate and provide a 'home' for the aerial component of the soil foodweb. Ecology is about balance. Too little is deficient and too much is toxic; it has to be just right for each factor, the balance being achieved through self-regulation. In agroecological farming, except organics, synthetic fertilisers and chemicals can be applied in small amounts, below toxic levels that would breach critical thresholds. A functional agroecosystem is resilient as it can recover from such a small application. It is the larger, combined and repeated applications that cause system collapse.

Soil organic carbon with a large humus proportion acts as a sponge for water, air and nutrient retention, and a home for soil biology. Soil carbon is of critical importance for soil fertility but has generally been more than halved (up to 80 per cent) with industrial agriculture and thus has significantly contributed to the increase of carbon dioxide in the atmosphere. In Australia, soil carbon content is now less than 1 per cent for most fields.

Soil carbon above 2 per cent makes plant growth markedly less susceptible to environmental conditions, because minerals and water are more available to plants, and there is less variation in diurnal soil temperature. Soil organic carbon is maximised through capture by green plants, ground cover being important in this respect. In Australia, with agroecological management, topsoil organic carbon can increase more than ten times faster than the 1 per cent over forty years science says is possible under industrial agriculture best management practice. Sequestration of carbon at depth is also higher because of greater root activity with microbes that make humus: three to eight tonnes of carbon per hectare per year is achievable.

Thus soil carbon not only improves soil fertility, it also helps to slow global warming through lowering carbon dioxide in the atmosphere. It further restores the water cycle by maintaining moist topsoils, with dew formation and evapotranspiration keeping the soil surface cooler, thereby attracting rainfall. Once confirmed by science, and with the relevant policy changes, soil management via agroecological practices could become an option for carbon credit payments to farmers.

Observations in Practice

The shift away from industrial farming is important but difficult as agroecology is seen through a different lens from industrial farming and felt with biosensitivity. The understanding of such complex systems grows with personal experience. Farmers and gardeners have to monitor and measure, and know what to look for in learning a new production system Learning to interpret what is happening is key. Holistic Management is an approach that provides support for such change where complex farming systems are seen within a landscape and farmers address the 'whole' to bring about effective management. This requires learning how to simplify operations, decrease reliance on inputs and restore the land, which in turn enable increased farm profitability, family harmony and improved ecological footprint. To work with nature's complexity we must focus on the important processes that operate in any ecosystem, which are also the four foundation blocks of agroecosystems: the water cycle, the mineral cycle, the flow of energy, and community dynamics.

Agroecological farming systems are also greatly supported using permaculture principles. As David Holmgren has noted, perma(nent agri)culture is about consciously designed landscapes that mimic the patterns and relationships found in nature, allowing an abundance of food, fibre and energy for local needs. The movement has a worldwide following and great results in urban farming. In subsistence farming the first steps are the use of polycultures, composting, controlled grazing and capturing rainfall. Budgets can remain the same when starting from high-input farming but with a gradual change to biological inputs. Generally, in the first year returns per dollar invested are at least equal, but with visible soil improvement as a bonus. After two or three years, fertiliser use may be halved and chemical use lowered by 80 per cent. Production is usually similar to one's industrial farming neighbours in normal years and higher in years affected by drought or frost. Financial outcomes have lower highs but higher lows. Operating with lower risk and avoiding chemicals greatly improves the health and well-being of farming communities.

Science

Science is critically lagging behind the new directions of producers and consumers, and is generally not providing scientific support. Indeed its first response seems always to be the shrill question: 'Where is the proof?' The working agroecological farming systems of experienced producers cannot be replicated by science and are therefore rejected, such successes being viewed as merely 'anecdotal'.

R&D in multifunctional agriculture is fragmented and lacks a unified direction for studying the sustainability of systems. Complex, self-adjusting, cyclical biological systems are in fact difficult to quantify, but that is at least in part because current specialisation and multi-factorial research methodology is inadequate. Specialised disciplines are connected in nature but separated by artificial lines in science. Further, science and governments are influenced by multinational corporations and stick to the current path of industrial agriculture. Personal values, habits, experiences and intended outcomes influence scientists to remain with the current paradigm as they formulate their hypotheses, develop experimental designs, pose experimental questions and complete data collection and analysis. The current powers that fund research thus keep getting the answers they expect (and want). The resulting food production systems and associated business models, however, are unlikely to ever stop land degradation, provide equitable food security or deliver required food quality. GM technology rollout, for example, is controlled by GM company contracts that prevent the publishing of negative findings. After ten to fifteen years unintended outcomes for environment, animals and people are gradually becoming visible and are being published.

Agricultural science needs a paradigm shift to a holistic, transdisciplinary approach to describe how cycles keep operating rather than why they work; tackling the ‘whole’ not through ‘mechanism’ (a linear model) but through ‘organism’ (a cyclical model).

Scaling Up for Change

We need functioning agroecosystems across landscapes, regions and countries. Only then, with supportive urban-rural interaction, can local food security, biodiverse landscapes and slowing of global warming be achieved. Cuba is the only country developing such systems nationwide. On a smaller, regional scale, successes have been achieved in Brazil, Malawi, Niger and China. Scaling up requires appropriate public policy to create enabling environments for such productive and earth-enhancing modes of production. UN agencies have to connect with non-governmental organisations and networks of farmers practising such farming, and consumers wanting real, local food and a clean, biodiverse environment.

Successful transition requires governments at all levels to create an enabling environment for production, trading and consumption of local food by communities and small business, which is food sovereignty. Education of students, consumers and producers in preventative health of self and community, plants, animals and earth is critical. Science must develop a unified methodology to study agroecosystems holistically, with governments, producers and consumers connecting with scientists to solve problems encountered in local practice. What we need is local solutions for global healing.

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