IFA AGRICULTURE CONFERENCE

Optimizing Resource Use Efficiency for Sustainable Intensification of Agriculture

Kunming, China
27 February – 2 March 2006

Sustainable Development from the Ground Up

K.E. SUKALAC
IFA, FRANCE

International Fertilizer Industry Association (IFA)
28, rue Marbeuf
75008 Paris
France
Tel: 33 1 53 93 05 33 Fax: 33 1 53 93 05 45/47 Email: ksukalc@fertilizer.org

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"Sustainable Development from the Ground Up"

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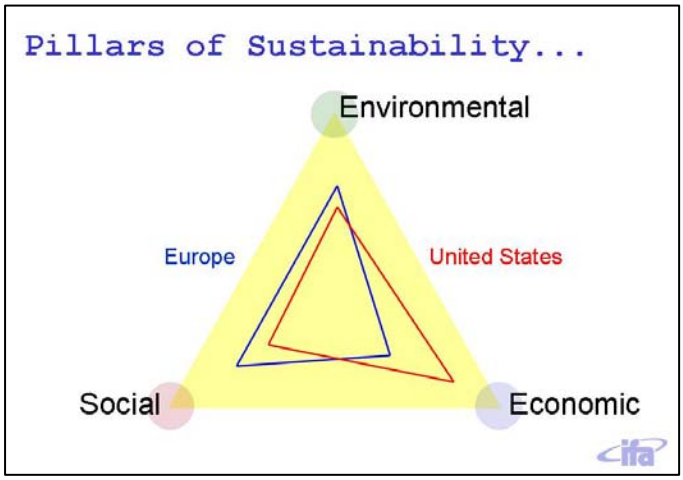
The term "sustainable development" entered the international policy arena in 1987 with the publication of the "Our Common Future" report from the World Commission on Environment and Development – also known as the Brundtland Commission in honour of its chairwoman.

This definition is largely aspirational, although the report did designate eight action areas: population and human resources, industry, food security, species and ecosystems, the urban challenge, "managing the commons" (public goods), energy and the link between conflict and environmental degradation.

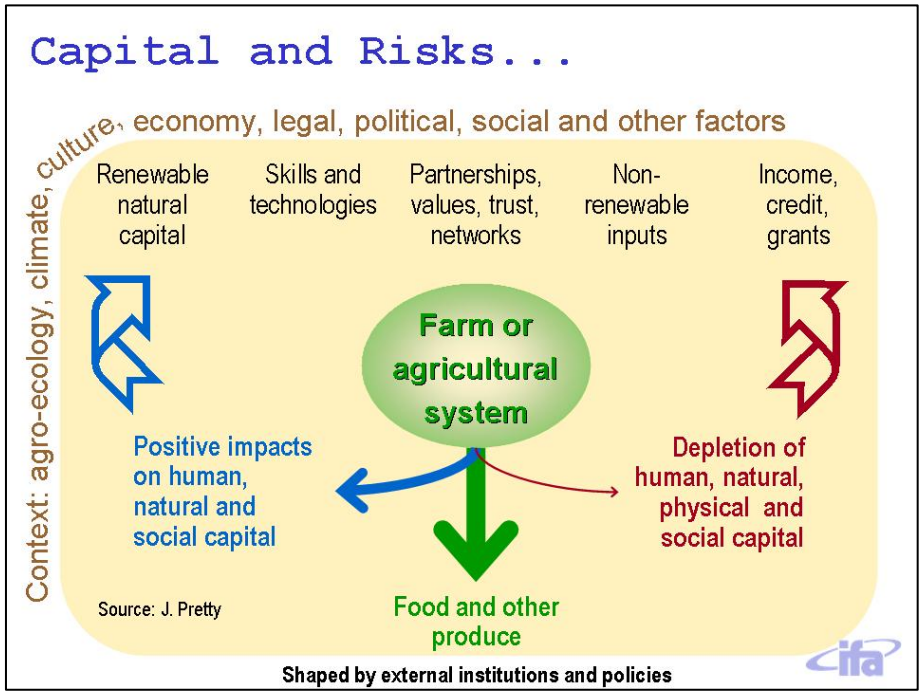
The Bruntland definition represented an important shift. Instead of focusing solely on ecological criteria, this concept of sustainability also takes into account the economic and social dimensions and implies the need to balance them.

However, there is no single ideal mix of the three pillars of sustainability. There are sometimes conflicts among them, especially on the local level. For example, industrial mechanization may improve efficiency and thus reduce pollution while at the same time eliminating a large number of jobs. At the end of the day, society must decide how to weigh each pillar. Or rather societies must do so, as differences are apparent from one country or culture to another. For example, some of the differences between Europe and the United States in international negotiations such as those on climate change reflect different valuations of these three pillars (see illustration at right).



In reality the situation is even more complex. Differences of opinion on the relative weight of each pillar do not necessarily correspond to national boundaries. The fact that many activists disagree with official government positions regarding sustainability attests to these differing perspectives.

The concept of sustainability is therefore not static and is fraught with potential conflict. As a result, the concept is difficult to translate into operational terms. For this reason, I would like to present another, asset-based model of sustainability for your consideration. We are going to look at the example of a farm, but the same model could be applied to any productive activity.



In this model, sustainable development can be thought of in terms of protecting and building up different capital pools. Looking at the five sets of assets listed above the arrows in the diagram "Capital and Risks", they are (from left to right) natural capital, human capital, social capital, physical capital and financial or economic capital.

Briefly, sustainability depends on building up the capital base. Doing so is clearly easier in some cases (renewable resources) than others (non-renewable resources). Minimizing negative impacts on the capital base is also an important aspect of sustainable development. The system becomes unsustainable when output – in our example, agricultural production – wears down the capital base and makes it impossible to maintain the productive activity.

It should be noted that most systems can absorb some resource depletion before a crisis occurs, but beyond a certain point, damage may be irreversible. A good illustration would be what happens to an aquifer when irrigation pulls the water level down to such a point that salts or other contaminants make the well unsuitable for continued irrigation. The scale of the activity and the reversibility of any negative impacts play a large role in determining the overall impact on sustainability.

Priorities Have Evolved over Time

To continue our discussion about sustainability, we need to step back and look at the historical context. The Industrial Revolution allowed us to achieve unprecedented levels of population growth. The increased population density meant that former methods of carrying out many activities, including agriculture, became unsustainable. I would like to stress the concept of population density and not absolute population numbers. Africa today suffers not from too many people, but from a population level that stresses the currently available resource base, not least of all being poor soils. We will come back to this point later.

However, the Industrial Revolution also changed the way we look at the world. In many ways, it upset natural equilibria and created a need to think differently about how to meet our needs. Urbanization and increasing standards of living have both had a significant impact on

our attitudes, and these should not be underestimated when trying to understand today's debates about sustainable development.

Although such mindsets vary from one culture to another, international policymakers increasingly talk about an emerging global consumer class that behaves and thinks similarly everywhere in the world.

The first point is that technology has become so embedded in our daily lives that, in some ways, the general population has far too much faith in what it can achieve. Our insignificance before many natural phenomena is forgotten. The stunned reaction of the world in the face of the damage caused by last year's tsunami or Hurricane Katrina reflects this perfectly.

Human ingenuity and technology are certainly potent tools, but technology is not a cure-all. Nonetheless, our modern world makes it easy for us to forget this and to believe that anything can be accomplished immediately at the touch of a button.

Urbanization also means that modern society has become increasingly divorced from nature in other ways. Views about life and death, for example, have become clinical in many places. Many urban dwellers are hypocritical carnivores, happy to eat meat as long as it bears no resemblance to the animal from which it came. The result is that urban consumers have romantic visions of agriculture, with ideals that are far-removed from reality.

These influences on powerful urban consumers have created contradictory demands. A vocal minority insists on organic agriculture, but will not accept that one-third of the world's population would have to be eliminated to achieve this goal, not to mention the likely devastating effects on the world's forests. These fundamental inconsistencies are based on emotion and ideology; reason and science will only have limited success in addressing them.

Food security is just one element of sustainability, but I would like to discuss it in some detail. In this diagram, you can see several definitions of food security, from the most fundamental definition to a more nuanced and complete vision; alternatively, we could say that the top definitions focus on needs and the latter ones on desires. These definitions also reflect how societies give different weights to the three pillars of sustainability. Furthermore, there is some correlation between this spectrum and the level of development of a country.

Food security is the traditional sustainability challenge linked to soil fertility, but many others should also be taken into account by policymakers, farmers and agribusiness. Agriculture is intimately related to environmental stewardship, economic development and culture. Indeed, soil fertility is relevant for the three major multilateral environmental agreements to emerge from the Rio Earth Summit: the United Nations (UN) Framework Convention on Climate Change, the UN Convention to Combat Desertification and the UN Convention on Biological Diversity.

The following sections will give an overview of why soil fertility is important for balanced nutrition and other aspects of human well-being, climate change mitigation, water management, the fight against desertification and biodiversity.

Back to Basics

The participants at this conference do not need to be told that all forms of life need energy, nutrients and water, and that plants are no exception. Without water, oxygen, carbon dioxide and numerous mineral elements, they would die, and so would we.

With the exception of water, oxygen and carbon, the substances needed for plant growth – including nitrogen, phosphorus, potassium, sulphur, calcium, magnesium, boron, chlorine, copper, iron, manganese, mobyldenum, zinc and sometimes cobalt – are obtained from the soil, or from what is added to the soil by animals and humans. If the soil cannot deliver enough of any nutrient, the growth of the plant is limited. A deficiency of any single nutrient, even one required in very small quantities, is enough to limit growth.

Where nature is still relatively untouched – in the rainforests of central Africa and the Amazon basin, for example – a closed nutrient cycle exists. In such cases, plant growth is limited by the nutrients, sunlight, heat and water inherent in the cycle. Agriculture breaks this cycle in several ways. The soil is exposed to the dangers of leaching and erosion. Nutrients are "exported" in harvests carried off the farm or "imported" in animal feed. Good agricultural management is vital if irreversible damage is to be avoided.

Nutrient losses are partly offset by the decomposition of organic matter in the soil and the gradual weathering of soil minerals, but these natural processes are far too slow to meet the demands of a growing population.

Until the mid-19th century, the human population was effectively limited by the nourishment that could be produced by the inherent fertility of agricultural soils, enhanced by the addition of animal, crop and human wastes. Mineral fertilizers introduced extra nutrients into the agricultural milieu, making it possible to feed growing urban populations. The growth of cities during the industrial revolution led to an increasing loss of nutrients from the natural cycle, a displacement of nutrients from agricultural lands that continues today and has accelerated with urbanization. The problem is compounded by the fact that cities usually flourish in areas with the most fertile soils, thus encroaching on the richest farmland.

Beyond Food Security: The Nutrition Challenge

The Green Revolution, which brought high-yielding varieties, mineral fertilizers and crop protection products to farmers across the globe, significantly raised yields, thus saving millions of people from potential starvation. However, it may inadvertently have contributed to human nutrient deficiencies or "hidden hunger" in several ways. Today, more than three billion people are estimated to suffer from at least one micronutrient deficiency.

Steady yield growth means that more micronutrients are removed from the soil. Unless they are replaced, these nutrients will also be missing from the food products made from the crops in question.

Furthermore, the main Green Revolution crops – wheat and rice – are fairly poor in micronutrients. Diversifying diets should help fight hidden hunger.

Fifty per cent of world cereal soils are deficient in zinc and 30 per cent of cultivated lands across the globe lack iron. Yet micronutrients positively influence yields, crop quality, seed vigour and symbiotic nitrogen fixation. In keeping with the principle of balanced nutrition, appropriate levels of each nutrient help improve the efficiency with which plants absorb and use each element and water, thus reducing losses to the environment.

Furthermore, fertilization can directly increase the content of micronutrients that are beneficial for humans. As well as contributing to health and the environment, micronutrient applications can significantly improve farmers' economic returns.

However, while the fertilizer industry can supply the necessary micronutrient fertilizers, the nutrition challenge requires a concerted effort from farmers, policy makers and other sectors in the agri-food chain. Providing micronutrient fertilizers is not always enough to achieve dietary balance, especially since there is a complex interaction among micronutrients, macronutrients and anti-nutritional factors.

How Soil Fertility Relates to Sustainability Concerns	
Food production / economic development	• Greater soil fertility is needed to support higher yields, which feed a growing population and increase farmers' return per unit of cultivated land. • Soils must be rich in all necessary nutrients in order for the food products coming from that land to contain the optimal nutritional balance needed for human well-being.
Climate change	• Carefully managing the nitrogen applied to crops can reduce losses of this vital nutrient to the atmosphere, where it may take the form of nitrous oxide, a potent greenhouse gas. • Because plants remove carbon dioxide from the atmosphere during their growth, increasing crop yields and the resulting crop residues can augment the carbon-containing organic matter in soils, generally resulting in richer soils. • The ability of plants to capture solar energy is a necessary precondition for the cultivation of bioenergy crops. Higher soil fertility supports higher yields of these renewable energy sources.
Water	• Proper plant nutrition favours high levels of water use efficiency. • Fertile soils containing all necessary elements support vibrant plant growth, which reduces the amount of nutrients that may run off to ground and surface water, thus limiting the overenrichment of waters. • Soils that are fertile and contain adequate organic matter retain more water. This is an important aspect of the water cycle.
Desertification	• Rich soils favour a vigorous crop cover, which helps impede erosion. • The increased water retention of rich soils also helps resist desertification.
Genetic heritage	• The microorganisms found in soil represent a huge reservoir of biological diversity, much of which is not fully understood and has not yet been harnessed for agricultural management practices or other uses.
Culture / leisure	• Healthy, fertile soil is a powerful symbol in many cultures and represents the bounty of nature. • Increasing the fertility of agricultural lands can prevent marginal lands and valuable habitat areas from being cultivated. This also frees land for leisure purposes, such as parks.

Addressing Climate Change at the Roots

Agriculture and climate change affect one another, but scientists are still studying the complex interactions involved. Nitrogen in the soil may be absorbed by plants, or it may be lost to the environment through a number of pathways. Some of these raise atmospheric N_2O levels.

According to experts of the Intergovernmental Panel on Climate Change (IPCC), N_2O, mostly from fossil fuel combustion, is responsible for 7.5 per cent of the total calculated greenhouse effect of human activities. The N_2O concentration in the atmosphere is increasing at a rate of about 0.2 per cent per year.

Whether in organic or inorganic form, excess nitrogen can eventually lead to enhanced N_2O emissions. Globally, biological nitrogen fixation adds as much nitrogen to the soil as does commercial fertilizer and contributes proportionately to nitrogen emissions.

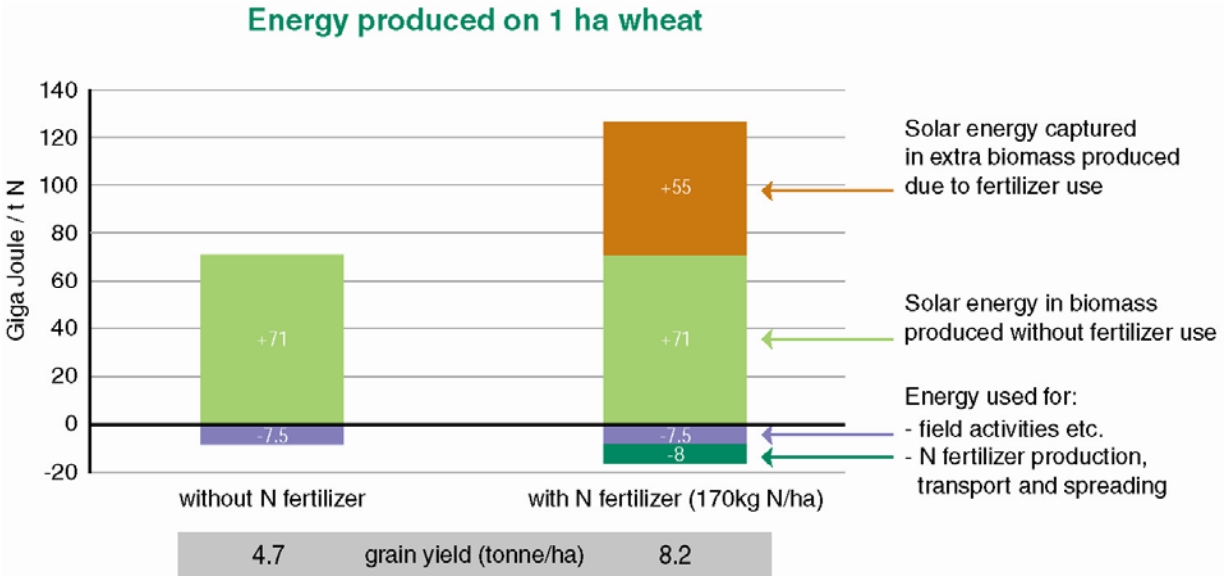
Best management practices, which match nitrogen supplies to crop requirements and integrate animal manure and crop residue management into crop production, result in a net reduction of N_2O emissions. The proper balance of nutrients favours the efficient use of applied and residual soil nitrogen. Other agricultural practices that minimize nitrogen losses include the adoption of reduced tillage practices, the prevention of water-logging through improved drainage and the treatment of sodic soils. Moreover, enhanced-efficiency nitrogen fertilizers coupled with site-specific fertilization practices can also help reduce N_2O emissions.

Although nitrogen fertilizers can be a direct or indirect source, they account for only 0.8 per cent of current N_2O emissions.

The most familiar references to agriculture and climate change are in relation to carbon sequestration: the ability of plants to convert atmospheric carbon dioxide into carbon stored in the plant's biomass or in soil organic matter. Fertile soils favour this capture. This can create a virtuous circle because a high level of soil organic matter is one characteristic of fertile soil.

Finally, fertile soils contribute to higher yields of bioenergy crops and therefore greater amounts of a renewal source of energy.

When it is necessary to use mineral fertilizers to supply the necessary crop nutrients, some people question whether the energy used to produce fertilizers leads to a net negative environmental impact. In fact, as shown in the diagram below, a life-cycle study of nitrogen fertilizer use shows that much more energy and carbon dioxide equivalents are captured as a result of fertilizer use than are consumed or emitted during the production, distribution and application of fertilizers. Some 95 per cent of energy required for fertilizer production is consumed by the nitrogen fertilizer sector.



Source: European Fertilizer Manufacturers Association, citing data from Küsters and Lammel. "Investigations of the energy efficiency of the production of winter wheat and sugar beet in Europe" in *European Journal of Agronomy*: 1999 11 (1), pp. 35-43

When Water Quality Has Nothing to Do with Water

Proper nutrition predisposes plants to absorb and use water efficiently. And adequate moisture allows plants to take up optimal levels of nutrients. Furthermore, fertile soils retain more water, which is good for crops over time and is an important part of the natural water cycle.

Nonetheless, the most commonly discussed link between water and soil fertility relates to the presence of agricultural nutrients, whether from croplands or livestock production, in ground and surface waters. The fertilizer industry rarely talks about water protection per se; we focus instead on the root cause of potential negative impacts of nutrients on water quality. IFA therefore advocates improving nutrient use efficiency. Good nutrient management favours optimal uptake by plants. As well as preventing nutrient losses to the environment, this is good for plant health, crop quality and yields. It also raises the returns on farmers' investments.

Stemming the Tide of Desertification

Desertification is the degradation of land in arid, semi-arid and dry sub-humid areas, primarily caused by human activities and climatic variations. Local conditions often mean that only a very low population density can be supported without damaging soil fertility in these areas. Although other regions, mostly in Asia and Latin America, are also concerned, the most dramatic examples of desertification are found in Africa, where declining soil fertility is linked to decreasing agricultural productivity.

With an estimated value of four billion US dollars, the nutrients lost every year from Africa's soils are a key element of that continent's poverty trap. This is why one key recommendation of the recently released UN report “Investing in Development: A Practical Plan to Reach the Millennium Development Goals” is to support the "massive replenishment of soil nutrients for smallholder farmers on lands with nutrient-depleted soils, through free or subsidized distribution of chemical fertilizers and agroforestry" in order to meet food demands in Africa, as well as in some regions of Asia and Latin America.

Soil fertility is linked to land degradation or preservation in several ways. As mentioned above, high levels of soil organic matter improve water retention. Furthermore, fertile soils can support a more vigorous crop cover, which can help prevent the erosion that contributes to desertification.

Since 1998, IFA has been involved in a multistakeholder partnership to address this issue through improved soil health in seven West African countries.

The emphasis has been on improving land productivity by enhancing farmers' access to improved technology and inputs, especially credit and mineral fertilizers. Farmers learn to combine locally available organic resources and mineral fertilizers to build up soil fertility and to improve fertilizer use efficiency, an approach known as integrated soil fertility management (ISFM). In this case, mineral fertilizers are seen as a way of increasing the supply of available organic matter.

These soil fertility technologies are part of a holistic method that also teaches farmers business skills and how to conduct agronomic experiments on their own. The project also addresses the need for an enabling market system, with access to credit, timely delivery of appropriate inputs and opportunities to sell produce. The results have been striking–more than 60,000 farmers have participated to date and increased their incomes as a result of increased soil fertility.

The Dust Bowl era in 1930s North America highlighted the importance of protecting soil fertility to prevent environmental, economic and social disaster. Little or no replenishment of the nutrients mined from the soil by intensively cultivated crops was a key factor in this disaster.

Teeming with Life

Soil fertility is also linked to the goals laid out in the United Nations Convention on Biological Diversity. Although of mineral origin, healthy soil is also a rich ecosystem containing a multitude of life forms, most of which are invisible to the naked eye. These organisms play an important role in maintaining soil quality and regulating nutrient cycles. They also constitute a rich source of genetic resources.

Given this vibrant world beneath our feet, it is not surprising that the soil has such a strong symbolic value in many cultures. Representing Mother Earth or the very source of life, the soil is often attributed a spiritual value.

Soil fertility is also linked to the well-being humans receive from leisure activities. In developed countries, agricultural intensification made possible by good soil fertility management has preserved many wilderness areas and important habitats. Furthermore, it has also permitted the conversion of suboptimal cultivated lands to leisure purposes, such as parks.

We Must Work Together from the Ground Up

The ground beneath our feet is at the heart of many of the sustainability issues facing policymakers today. Because of the many interactions of the soil with food production, the environment and economic development, an integrated approach to soil management is required. Farmers are pivotal as the stewards who care for the land, but they must be supported by agribusinesses that provide appropriate inputs in a timely manner. This in turn depends upon governments putting place the right regulatory framework and key infrastructures, including transport, information, credit and markets.

However, policy frameworks that have generally focused exclusively on increasing yields may now need to be adapted to incorporate other objectives. Clearly, the sustainable intensification of agriculture can only be achieved through greater cooperation and innovation.