Environment and development

M. S. Swaminathan

The key to a better common future for mankind lies in coupling the right use of modern space and information technologies and biotechnology with ecological obligations.

The World Commission on Environment and Development (1987) called for the achievement of necessary growth rates in economic development without harm to the life-support systems of the planet, terming this *sustainable development*. This will be the theme for the UN Conference on Environment and Development scheduled to take place in Brazil in June 1992. Sustainable development involves paying concurrent attention to problems of intra- and inter-generational equity. The large volume of literature currently becoming available on this topic suggests that the problem facing us now is not so much one of discovering *what* must be done to ensure sustainability, but more importantly, learning *how* to achieve it.

In population-rich but land-hungry countries like India, China and Bangladesh, enduring food security will depend greatly on strategies to enhance crop yields. At the same time, the onward march of the green revolution will have to be on the basis of 'green' or environmentally friendly technologies. If productivity-enhancing technologies do not spread to more areas and farming systems, the poverty of small-farm families will persist, since they will have very little marketable surplus and thus will not be able to profit from the remunerative output-pricing policies of governments. Nor will it be possible to prevent the further expansion of cultivated area at the expense of forests and soils vulnerable to erosion or other forms of damage to their innate biological potential.

Both the Food and Agriculture Organization of the UN (FAO) and the United Nations Environment Programme (UNEP) estimate that an important cause of deforestation in the world is the spread of agriculture into forest lands. At the same time, population increase and growth in purchasing power make a more rapid advance in agricultural production necessary. Thus a continuous quest for technologies that can help enhance the productivity of economic plants and farm animals per unit of time, land, water and energy is essential. For example, in India, cereal production will have to increase by at least seven million metric tons per year during the present decade to meet demand, as against the average annual increase of 3.5 million tons of food grains achieved during the last two decades. In Sub-Saharan Africa where population is growing at 3.5% a year, food production will have to be more than tripled in the next 25 years to meet the needs of the growing population. Similar progress will be needed in respect of other agricultural commodities. Can such advances in agricultural production and productivity be achieved without over-exploiting land and groundwater resources and increasing the problems created by biotic and abiotic stresses?

The solution lies in ecological agriculture. A major aim of the strategy described as low-input sustainable agriculture (LISA) by the US Department of Agriculture is to ensure the long-term sustainability of *current production levels in the USA*. However, while defending the *status quo* in yield as the priority task in industralized nations, raising average yields is the urgent need in developing countries. For example, the average yield of paddy in California is about 8.5 tons per hectare, while the current average paddy yield in India is about 2.5 tons per hectare. India already has over 47% of its land area under agriculture. Every fourth farmer in the world is an Indian farmer. Less than 4% of the arable land of the country is under pastures and grazing lands, although India has over 20% of the world's farm-animal population. Unless rice yields are doubled within the next 20 years, it will be difficult to manage the national food security system without food imports. The same situation prevails in respect of wheat, sorghum, pulses, oilseeds and other food crops. So the pathways for sustainable agriculture in India will have to be based on substantial advances in productivity and not just on the maintenance of current yields and production levels, as in the US.

We thus face a paradox. On the one hand, several of the components associated with traditional green-revolution or land-saving technologies, particularly those involving the use of high doses of mineral fertilizers, chemical pesticides and heavy farm machinery, have negative ecological repercussions. While on the other hand, a continuous growth in terrestrial and aquatic productivity is a must in countries where

M. S. Swaminathan is Chairman, M. S. Swaminathan Research Foundation, 14 II Main Road, Kottur Gardens, Madras 600 085.

This article is the text of the acceptance speech delivered by the author at Los Angeles, USA, on 5 April 1991, on the occasion of the award of the Tyler prize for environmental achievement.

agriculture holds the key not only to food security but to the livelihood security of rural families. Only new research strategies designed to combine the strengths of traditional and frontier technologies can help us face this situation.

Sustainable agriculture has several dimensions—social, cultural and economic, besides ecological. For example, when in the mid-eighties the European Community subsidized sugarbeet sugar heavily, a thriving sugarcane industry on Negros Island in the Philippines collapsed, leading to great human misery in the rural areas. In respect of commodities of international trade, the agricultural policies of industrialized nations tend to determine the economic sustainability of the cultivation of those crops in developing countries. At the same time, national economic policies have a profound impact on the sustainability of land- and water-use patterns. High price incentives could lead to cultivation of water-loving plants in low-rainfall areas, resulting in an unsustainable exploitation of the aquifer and in the abandoning of scientific crop rotations. High export subsidies, often necessitated by heavy debt-servicing burdens, lead to the cutting down of forests and to soil and water mining. Thus technology and trade both need attention if the principle of ecological sustainability is to be integrated with that of economic efficiency.

There are now probably about two million farmers in the US and ten million farmers in the countries constituting the European Community. In contrast, in India, the number of operational farm holdings is presently about 100 million. Ecologically sound technologies like integrated pest management, integrated nutrient supply, and sustainable management of groundwater resources can be adopted under conditions of small holdings only if all the farming families in a village or watershed cooperate. This task is made complex in large countries like India and China not only by the numbers involved, but by the pressures of competing needs. Unless there is equity in sharing the benefits, cooperation will not be easily forthcoming. For example, in semi-arid rainfed areas, cooperation in water saving is seen only in places where there is equity in sharing the harvested water. Today, 'water lords' who have access to groundwater resources often exploit them with only a short-term profit motive. Development that is not equitable cannot, in the long run, become sustainable. This is true both within and among nations. We therefore need a new paradigm of agricultural research and development for enduring global and national food security, consisting of three interacting components—ecological sustainability, equity-based economic efficiency, and convergence and synergy among the efforts of governmental, non-govermental and corporate sectors.

The new technologies that can help make such a paradigm an operational reality are in the areas of biotechnology, space and information technologies, new materials, and management technology. Space and information technologies enable the integration of meteorological and marketing data with land- and water-use plans. A computer-aided extension system can help spread such integrated information in rural areas with speed and accuracy. Current and emerging biological technologies offer opportunities of pyramiding genes conferring tolerance to a wide spectrum of biotic and abiotic stresses. Management technologies can help optimize benefits from the available land, water, energy and credit resources, and promote the conjunctive use of surface and groundwater resources in an effective manner.

Successful genetic engineering requires access to a wide range of genetic resources of crops and animals. About 1.5 million species have been described by taxonomists so far. Some experts estimate that over 50 million species may exist on our planet, if we take into account the prevailing genetic variability in invertebrates and microorganisms (see, for example, the data relating to fungi, bacteria and viruses in the Table). Unfortunately, interest in the science of biosystematics is waning among young scholars and we may not even know what we are losing. Meanwhile, a number of 'protected areas' of the world have been described by the International Union for the Conservation of Nature (IUCN) as being threatened. Yet, even now, hardly 3% of the terrestrial ecosystems and 1% of marine ecosystems have been designated as 'protected areas'. But already 91 such sites in 57 countries, comprising both developing and industrialized countries, including the USA, are threatened, owing to both anthropogenic pressures and unsustainable development, and this list is growing. In developing countries, the threat to national parks, biosphere reserves and reserve forests often comes from human communities that perceive the protection as being in conflict with their economic survival. This is a sad reflection on the quality of our management of biological wealth. The loss of ecosystems, species and genes is occurring at a time when new gene combinations may be essential for adaptation to potential changes in climate and sea levels and to a higher incidence of ultraviolet-B radiation, and when

Numbers of known and estimated total species of selected groups of organisms.

Group	Known species	Total species	Percentage known
Vascular plants	220,000	270,000	81
Bryophytes	17,000	25,000	68
Algae	40,000	60,000	67
Fungi	69,000	1500,000	5
Bacteria	3 000	30,000	10
Viruses	5,000	130,000	4

Source Hawksworth, D. L., *Mycol. Res*, 1991, **95**, (in press).

genetic engineering has opened up the possibility of moving genes across sexual barriers.

Coastal and mountain ecosystems richly endowed with biological diversity are often among the most seriously threatened. Coastal mangroves, sea grasses, coral reefs and associated flora and fauna rich in genes of value in the breeding of new strains of plants for adaptation to potential changes in sea levels are being destroyed indiscriminately. Recently, my colleagues and I at the Centre for Research on Sustainable Agricultural and Rural Development in Madras have established near Chidambaram in the state of Tamil Nadu, in collaboration with the state forest Department, a Genetic Resources Centre for Adaptation to Sea-Level Rise. We have also developed a programme, jointly with the International Tropical Timber Organization, for establishing a global grid of genetic-resources centres for mangrove species. Mangrove forests are being destroyed at a rapid rate for a variety of reasons—tourism, pollution, industrial requirements, the spread of coastal aquaculture, and the extension of human settlements right up to the coast. Both ecological security of coastal regions and livelihood security of coastal communities will be adversely affected if coastal flora and fauna are lost. We also need methodologies for an ocean-capability classification on the model of land-capability studies. As much carbon is fixed in the ocean as on land, and techniques for deriving greater food yield from such aquatic carbon fixation are required.

The task of achieving sustainable advances in biological productivity is thus a formidable one. The progress made so far through changes bred in plant architecture and physiological responses is largely due to a higher allocation of the total biomass to the part that has economic value. Further progress will depend on our ability to improve total biomass production per unit of land and water. This is where the tools of molecular biology have added to our research capability. The biological technologies essential to derive the necessary gene combinations through recombinant-DNA experiments are largely being perfected in the private sector in industrialized nations and will thus be covered by patent protection. Mechanisms for the speedy dissemination of environmentally friendly technologies are essential if the needs for planet protection and patent protection are not to become antagonistic.

I would like to close by drawing attention to two basic requirements for harmonizing conservation and development. Fulfilling these requirements is beyond science but within the capacity of society.

First, the adoption of sustainable life-styles by the economically affluent sections of humankind is a must for halting the growing depletion of environmental capital stocks. If we measure in financial terms the total economic value of human production from the dawn of human civilization up to 1900 AD, the figure would be about US$600 billion. But today, the world economy is growing by more than this amount every two years. Today's 15-trillion-dollar economy could multiply five-fold in another 50 years; but this world production is still very unequally divided. In 1880, the ratio of real per capita income between Europe on the one hand and India and China on the other was 2:1. By 1965, this ratio became 40:1. It has been widening ever since and is now nearly 70:1. This has repercussions in every area—energy consumption, release of greenhouse gases, trade imbalances, and the spread of poverty. Economic entitlements for the poor are essential for their household, nutritional and livelihood security. But ecological obligations of the rich are equally essential for protecting the planet's environmental endowments. Economic entitlements and ecological obligations, when coupled, can lead to lasting human happiness. This is an area where the rich and well-to-do have to set the example. Unless affluent nations and affluent people everywhere take the lead in promoting the growth of a conservation society based on the integration of the best in modern agricultural, industrial and information technologies with the best in traditional practices and life-styles, it will be difficult to halt either the ever-widening rich–poor divide or continuous environmental deterioration.

Second, living in harmony with nature requires curbing of the growing violence in the human heart—violence that is reflected at different levels: individual, community and country. Last year at this time, the prospects for lasting peace and goodwill on earth appeared bright. Unfortunately, events since last August have again fostered the culture of violence towards both nature and fellow human beings. About 50 years ago, Mahatma Gandhi asked, 'How can we be non-violent to nature unless the spirit of non-violence becomes central to the ethos of human culture?' Two months ago, while watching television pictures of cormorants, flamingos and grebes, not to mention children, struggling for life in the region affected by the Gulf War, I was reminded of the basic truth underlying Gandhi's conviction.

So it seems that a 'greening' of the human mind must precede the greening of our Earth. A 'green' mind is one that cares, saves and shares. If only this attitude pervaded our psychic environment, we would not have over 600 million children, women and men going to bed hungry tonight, including over three million children in the USA, according to a recent report of the Food Research and Action Center.

A better common present is essential for a better common future. Unless the poor and the panda receive concurrent attention, the divorce between environment and development will persist.