SCIENCE, DEVELOPMENT AND FOOD SECURITY
THIRD WORLD ACADEMY OF SCIENCE LECTURE, CAIRO 1992

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Material versus intellectual development

Interpretations of "Development" are as many and diverse as the organisations that describe themselves as development agencies. To describe N America as "developed" and Egypt as "less-developed" displays a dismally deficient sense of history. Egypt was home to an advanced civilised technological society before Americans discovered the bow and arrow. Egyptians were literate and numerate more that 5000 years ago, having devised a decimal numerical system and the means to communicate in writing. It is not surprising that the mathematics of dynastic Egypt were largely related to agriculture. Calculations of area, multiplying length by breadth, were used to determine the size of farmers' fields and were expressed in measures of grain. Before the 4th Millenium Egyptians had calculated Pi, the ratio of circumference to diameter as the square of 16⁄9 equal to 3.158, not greatly different from the now accepted value of 3.143. The value of Pi was calculated in order to determine the capacity of cylindrical grain bins. Egyptian mathematicians of the period also discovered the formula to calculate the volume of a truncated pyramid. The word for "volume" related to the amount of earth to be excavated to create a reservoir, irrigation dyke or canal.

Most remarkable was the Egyptian calendar. During a period of more than fifty years, the Pharaohs' officers recorded the height of the Nile flood on which their agricultural production depended. They found that the average interval between floods to be about 365 days. On this they based the official calendar by which to guide the sequence of agricultural operations. Subsequently by observation of the heliacal rising of Sirius in the Cairo latitude, they compensated for the error of six hours per year or one day every four years.

Egyptian farmers used animal drawn ploughs over 5000 years ago; and before the Theban Pharaohs caused the vast Lake Moires reservoir to be constructed, Egyptian engineers had permeated the land with dykes and canals for irrigation. The Egyptian incised saddle stone and rotary quern provided the essential principles for modern grain mills. A hand operated saddle stone in which the grain was fed through a hopper and the flour emerged in a steady stream was the first recorded continuous processing technology.

I wish, therefore, to disassociate myself from the arrogant assumption that development is measured by a present state of material affluence. Any nation which believes itself to be in all respects developed is clearly unaware of Plato's philosophy that the more we have and know the more we realise how much we have to learn; and the more we learn, the more we are yet able to learn. The brash relatively new western world has yet much to learn from Egypt's long history of scholarship.

Development Conferences and Commissions

The larger international development agencies seem to act on the principle that when all else fails convene a conference or employ a high level commission. Over the years United Nations agencies have held conferences and engaged commissions that have generated innumerable recommendations, most of which seem to have been ignored or neglected.

The 1972 Conference on the Environment in Stockholm gave birth to the UN Environment Programme based in Nairobi. Following the World Food Congress in 1975, the World Food Council and the International Fund for Agricultural Development were established in Rome. The International Conference on Desertification was held in 1977, and in 1978 the UN Conference on Science and Technology for Development took place in Vienna. 1981 was the year of the UN Conference on Energy Resources.

In June 1992, the UN Conference on Environment and Development, now being called the Earth Summit, will take place in Brazil. One can only hope that its proceedings and recommendations will receive more active and sustained response than have those of its predecessors.

In addition to these various international gatherings, the World Bank and its related agencies have sponsored a series of Commissions to study and recommend upon courses of action for technical, economic and social development. In 1967, a Commission was led by Lester B Pearson, a former Prime Minister of Canada. A second similar Commission in 1977 was chaired by Willy Brandt, former Chancellor of the Federal Republic of Germany. Ten years later the UN Commission on Environment and Development was led by the Prime Minister of Norway, Mrs Gro Harlem Brundtland. In 1990 and 1991, Dr Mobub Ul Haq, formerly Pakistan's Minister of Economic Planning, carried out two further studies on development with particular emphasis on such human and social issues as public health care, education, literacy and human rights. The Ul Haq reports are interesting in that several nations which rank high on the list when judged by Gross Domestic Product, appear much further down when their social conditions are taken into account.

Commitments to Development

Each of the International Commissions had difficulty in defining "development". Pearson stated development cannot be measured simply by economic indicators: Gross National Product takes no account of more important human values. Brandt stated outright that his Commission would not try to define development but insisted that it should not be confused with continuous material growth; it should focus more upon people than on machines; and that there are no simple or instant means to development. Brundtland described development as the process by which we improve the quality of our lives. It means providing for the needs of present populations without depletion of resources required by future generations. Mobub Ul Haq's reports illustrate how most of the recommendations made by Pearson, Brandt and Brundtland have been ignored by most development and donor agencies who seem more disposed to flit from one fashionable slogan to another.

In 1967, Pearson urged donor agencies to increase their aid flows to reach 0.7 percent of their GNP by 1975 and one percent by 1980. Since little response was evident, Brandt in 1977 repeated Pearson aid goals but gave donors until 1985 and 2000 AD to reach the 0.7 percent and one percent targets respectively. Brundtland and Ul Haq pointed out that rather than aid flows having increased, overall assistance had declined as a proportion of donor GNP.

	1965	1975	1985
Total donor aid % GNP	0.48	0.35	0.35

The most generous were Saudi Arabia and Kuwait whose aid between 1975 and 1985 averaged over 3 percent of GNP. Following the ravages of the Gulf War it is unlikely these levels will be maintained.

Poverty perpetuated

The opening sentence of the Pearson report reads: "The widening gap between developed and developing nations is the central issue of our time". This melancholy situation has not greatly improved. In 1967 the poorest nations comprised 66 percent of world population and recorded 12 percent of global GNP. In 1990, the poorest nations representing 61 percent of world population had only 6 percent of global GNP. The High Income nations who make up 23 percent of population enjoy over 85 percent of global income. Pearson, Brandt and Brundtland recommended more favorable conditions of trade. Yet between 1968 and 1988 the poorer nations' proportion of international trade fell from 15 to less than 12 percent.

In 1990 the net asset flow from low income to high income nations was roughly $60 billion. Over 30 percent of the exports of Japan, USA and the European Community are to low income countries. Applying the Economist's formula that relates export income to employment in the exporting country, exports to the poorer nations support 8 million jobs in the EC and 2.5 million in both Japan and the USA. Various forms of protectionism cost low income countries more than $50 billion in commodity trade.

Less than 8 percent of bilateral assistance supports education, health or other social services. Most technical assistance is tied to the provision of capital equipment and expatriate advisers. Very few donor agencies provide sustained support for research to be carried out by African, Asian and Middle Eastern scientists on projects which they recognise as priorities.

Scientific and technological development

Four hundred years ago Francis Bacon made his often quoted dictum: "Nam et ipsa scientia potestas est": Knowledge is in itself power. Technological development depends upon sound scientific knowledge and intellectual development which require that all citizens have access to education, to essential sources of information and to freedom of expression. Without intellectual development there can be little progress in science, technology, agriculture, industry or the prudent utilization of natural and derived resources. The catastrophic consequences of uncontrolled pursuit of wealth were made evident by Boesky, Levine, Millken and other junk bond manipulators, and by such disreputable entrepreneurs as Robert Maxwell. Governments who encourage such delinquencies can hardly be described as morally and ethically developed.

Egypt has an enviable history of scholarship and technological innovation. Despite many adversities, given adequate resources, Egyptian scientists can lay the foundations for the nation's, indeed for much of the region's future food security. As an eminent historian wrote about Egypt: "Nowhere has man's ingenuity fought so persistently with the forces of nature."

Science and food security

Food security requires that all people have access to an adequate diet. It depends equally upon sustainable production and efficient, equitable distribution. The world's annual gross primary production is estimated at about 3 billion tonnes of grain equivalent, of which crop land provides 80 percent, range land and fisheries each 10 percent. Among affluent nations, per caput consumption averages one tonne, among the poorest one-sixth of a tonne grain equivalent/year. Estimates of potential production vary significantly but conservative forecasts suggest a sustainable level of between 7 and 10 Btge, sufficient, if equitably distributed, to maintain a world population of ca 8 billion.

Anthropologists tell us that the first hominids appeared on earth about 25 million years ago. It is no more than 10 thousand years since plants were first cultivated and animals domesticated. If we were to compress the entire period of human existence into the equivalent of one year, farming has been practised for less than one day, agricultural research for less than one minute. Yet during that minute, remarkable progress has been made, particularly in raising the yield potential of many food crops. The higher yielding cereal varieties resulted from the systematic repartitioning of plant metabolites; by moving more of the synthesised biomass from the stalk into the grain. Plant breeding and selection has also reduced the time from planting to harvest, thus permitting farmers in favorable climates to plant and harvest two or three successive crops in the same year.

Novel methods of transgenesis now permit the hybridization of crop species that are sexually incompatible. In seeking means of reducing dependence on chemical pesticides there is particular interest in transferring genetically controlled resistance to particular pests and parasites from wild into cultivated species. There are only two species of the rice genus Oryza that are cultivated. There are about twenty wild Oryza species several of which display resistance to pests to which the cultivated types are susceptible. The International Rice Research Institute is coordinating an international program of wide hybridization to transfer various pest resistant genes from wild to cultivated rice species. In effect the genes will alter the plant's biochemistry by enabling it to synthesise one or more substances that are toxic or repellent to particular pests. There is need for cautious monitoring of these transgenic hybrids to ensure that the substances toxic or repellent to pests do not cause harm to human consumers.

Several years ago potato breeders in the USA and Britain crossed wild species from Peru with cultivated genotypes to increase their resistance to particular pests. In so doing they introduced a potent neurotoxin that was fortuitously discovered just before the resistant hybrids were to be released to farmers. Consequently, in the future, plant breeders will need to work closely with nutritionists and toxicologists to ensure that new desirable agronomic characters are not accompanied by hazards to consumers' health.

Sustainable food security

Few economic sectors can benefit more than crop and livestock producers and food processors from an equitable distribution of wealth. There is a limit to how much food the wealthiest of people can consume. As poor people acquire income they will first spend to improve the quality of their diets. Consequently, from purely economic considerations the most favorable state for farmers and food companies is for purchasing power to be so evenly distributed that all people can afford an adequate diet and thereby stimulate greater production. The worst is for wealth to be concentrated in few hands.

These were among the considerations the Brundtland Advisory Panel had in mind when we wrote about sustainable food security. Since then, the literature on sustainable agriculture has become confused and in some respects contradictory. Contradictions arise from trying to devise global solutions for immensely variable and diverse conditions; from equating "sustainable" with particular production systems variously described as organic, biodynamic, regenerative or low input. Some come from observers, mostly in affluent countries, who are disturbed by the excessive use of agro-chemicals and the misuse of water in heavily subsidised irrigation systems. Though European and other high income countries could benefit their economies by reducing their consumption of chemical fertilizers, pesticides and fossil fuel energy, farmers in Africa, Asia and the Middle East need to increase crop production by at least 3 percent per year simply to feed the 80 million new mouths that appear every year. Crop increases of this magnitude cannot be realised from closed subsistence farming systems. An eminent Asian scientist put the matter succinctly: "Low input technologies are what poor farmers have had for many generations. What they now need are more productive not less productive technologies."

Across Asia there is barely 0.2 ha of arable land per person and though fertilizer use over the past two decades has increased from 36 to 80 kg/ha this includes Japan whose farmers average 435 kg/ha, and falls far short of European Community farms which range from 300 to almost 800 kg/ha/year. Wherever practical, animal and green manure from legume crops are alternatives to chemicals. But animal manure can soon lose more than half its nitrogen through volatilization and leaching.

For legumes to fix any of the 75000 tonnes of nitrogen that float above every hectare of the earth's surface significant energy is required: equivalent to 14 moles of ATP for every mole of nitrogen fixed by symbiotic soil bacteria. Because of the high energy demand in converting atmospheric nitrogen to an assimilable form, legumes in general produce lower yields than cereal grains.

When used prudently and conservatively, chemical fertilizers pose no greater hazard to human health or the environment than organic sources of nitrogen and other nutrients. It would be ecologically beneficial if the wealthy nations reduced their consumption of agro-chemicals and provided the quantities saved to farmers in the poorer regions whose need to increase crop production is so desperately urgent. Those from affluent societies who express concern for our environment must come to recognise that the needs, resources and constraints in Africa, Asia and the Middle East are vastly different from those of N America, Japan and Europe whose governments, collectively, subsidise agriculture to the tune of $270 billion per year thereby creating huge surpluses that depress commodity prices and crop production in poorer parts of the world.

Soil and Water

A recent UNEP report makes the alarming statement that during the past 50 years 12 billion sq km of once fertile land have suffered serious degradation. This an area larger than Canada. The causes of soil degradation are many. Most devastating in many countries is conversion to non-agricultural use by urban and industrial spread. Our Egyptian colleagues have shown how deserts can be recovered for crop and livestock production. But once land is covered with asphalt, bricks and cement it is lost forever.

Other degradations result from over-cultivation, overgrazing, removal of trees and ground cover, excessive tillage, continuous monoculture of shallow-rooted crops, chemical contamination, wind and water erosion.

Soil is a living bank, and like a commercial bank, if more capital is withdrawn than is deposited bankruptcy results. Of all the world's soil, one-third suffers from too much and one-tenth from too little water.

Almost 2500 years ago Herodotus the Greek historian wrote "Egypt is the gift of the Nile". No nation understands the importance of water better than Egyptians one of whose Pharaoh's is believed to have said: "Let not a single drop of water that falls on the land go into the sea without first serving the people". The ancient ruler would be deeply distressed at how little of the 40 trillion cubic meters that flow out from the world's rivers every year is productively used.

Between 1950 and 1970 more than 30000 dams were built around the world, more than half being for irrigation and flood control. Many were neither wisely designed nor prudently managed with the result that the total capacity is being reduced by more than one percent/year through silting. There is little need to remind Egyptians of the salinity and other damage that can be inflicted upon soil by mismanaged irrigation. Egyptians were the world's pioneers in irrigated agriculture. Today, more than 70 percent of world water use is for crop irrigation and FAO estimates that one-third of the world's food crops come from irrigated land. In the USA agriculture absorbs 85 percent of all water used but, being heavily subsidised, irrigation water is sadly misused. Californian farmers pay less than 10% of the water cost. In the Central Valley even cattle pastures are irrigated. Aquifers below California are seriously overdrawn, several to less than 25 percent of capacity. Some are so low that pumps draw silt and saline water, and land is heavily subsiding. Governments must realise that water is a precious resource. It is not of unlimited abundance and will likely be wasted if freely provided.

Reclaiming the Desert

It is 15 years since UNEP convened its international conference on desertification. In the intervening period at least 30 million hectares of land have been turned into desert, evidence of how little attention was paid to the conference recommendations. The government of Egypt, and our friends in the American University of Cairo are among the few who have taken imaginative productive action. The Desert Development Program is a model from which other governments and development agencies could learn valuable lessons. It demonstrates a fine example of comprehensively integrated farming systems research and management. It illustrates the benefits of carefully conceived agro-forestry in combining elements of protective tree planting with soil and water management, crop and livestock production, ecologically sound pest management and the prudent use of agro-chemicals. It has demonstrated that cropping systems designed to give highest yields may well be unsustainable. Its managers have been sensitive to social and economic considerations and to the need to demonstrate in cooperation with farmers what research has discovered to be practical and useful.

Having watched with interest and admiration how the program has developed since its inception in 1979, I offer sincere congratulations to Drs Bishay, El Lakany and their colleagues. The many who seek to discover the mysteries of research for sustainable agriculture would be wise to study what these outstanding Egyptian scientists have planned and achieved.

Aquaculture

The ancient Pharaoh emphasised the need to use every drop of water for human benefit. Fish farming, the culture of aquatic species, has been practised for as long as there is historical record. Only recently has science begun to replace empiricism. In addition to natural inland and coastal waters, throughout developing regions there are 600000 sq km of man-made lakes constructed for irrigation, flood control and power generation. The Keban reservoir in Eastern Turkey covers 70 thousand hectares and supports over twenty fishing cooperatives. After flooding the valley by damming the Firat River, a limnological study of water composition and seasonal temperature gradients helped scientists to decide optimum stocking densities and aquaculture management systems.

The International Development Research Centre was among the first to encourage aquaculture research, first in Asia, later in this region. Since 1972, the journal "Aquaculture" has expanded from less than 500 to over 3000 pages per year. The literature indicates that more than 40 species of carp, tilapia and other fresh water species are cultured commercially. In Scotland, the output from salmon farms increased from 1000 tonnes in 1979 to 30000 tonnes in 1989.

Considerable progress has been made in biological improvement based on greater understanding of reproductive physiology and patterns of growth. Some important species will not lay eggs or spermiate when in captivity. Gravid females can be induced to release their eggs by injections of gonadotropin release hormones. The earliest experiments used extracts of pituitary hormones from Pacific Cohoe salmon. More advanced methods use release hormone analogues, anti-oestrogens that stimulate gonadotropin release, and progesterone derivatives that act upon the ovaries.

In some species, females are more profitable than males, either for their roe, or because they have a higher flesh to bone ratio. Control of sex differentiation can be by hormone administration or chromosomal regulation of genetic information from gamete to zygote. Sex inversion of Chinook salmon is realised by androgen treatment of newly hatched alevins. Growth rates are accelerated by treatment with avian or bovine growth hormones synthesised by genetically modified bacteria.

Sustainable Agriculture

CASAFA, the ICSU Committee of which Prof El Lakany and I are members, was invited by the Secretary-General, Maurice Strong, to prepare for the UNCED to be held in Brazil, a report on Sustainable Agriculture and Food Security. The report reviews several hundred related publications and makes a series of observations and recommendations on agricultural policies, biological and physical resources, the management of soil and water, protection of genetic diversity, control of pests and pathogens, crop utilization, food safety, waste disposal, and related socio-economic issues. ICSU headquarters in Paris will provide a copy to anyone who is seriously interested.

The report points to the many contradictions among definitions of and prescriptions for sustainable agriculture. It emphasises that it is unhelpful to equate sustainable with any particular production system or philosophy. Scientists and development agencies should not try to impose on farmers in developing countries, measures designed to correct wasteful practices in more affluent agricultural economies. Most of the papers which propose low-input, labour-intensive systems are written by people from the more prosperous societies. None that we could find was written by a poor farmer from a developing country.

It is comfortable for those whose lives will not be affected to propose how poorer people should change their habits. In agriculture, significant change bears with it significant risk, risk most often to be borne by farmers. To minimise risk, any major change to established farming systems should be based on sound research and thorough on-farm evaluation. Changes to familiar farming systems should be introduced prudently with due regard for relevant economic, social and human concerns. The sustainable agriculture literature gives more attention to technologies than to policy, social and economic constraints.

Protocols for systematic monitoring and cost evaluation of land degradation, surface water pollution and ground water depletion barely exist in most jurisdictions. Also hard to find are practical formulae by which to weigh the present against the future costs and benefits of alternative systems of production, of soil, water and pest management; to assess probable risks and by whom the risks will likely be borne.

Communications between macro-economists in planning ministries and micro-economists working with farmers tend not to be orderly or systematic with the result that agricultural policies, and development agencies choice of policies may be based more on political expediency than an understanding of all that is implied in satisfying the needs of both present and future generations.

Conventional economic theory and accounting practices are not wholly sensitive to the needs of future generations for an adequate share of essential resources. By what rational criteria can present demand and consumption value be related to future loss through biological species and natural resources being exploited to near extinction? In Europe and N America, economic progress is measured by increase in production of processed goods and saleable services. Environmental economics must be sensitive to the value of resource conservation.

Under stressed conditions, urgent demands for food may conflict with ecological ideals. Poor people in urgent need of food and fuel will not give first priority to soil and forest conservation. That there must be compromise between urgent demand and ecological ideals is not always recognised by idealists whose lives and welfare are not at risk.

It is essential that governments and development agencies give high priority to food and agricultural research and development. Some seem to have been lulled into euphoria by mountains of grain and butter in Europe and tales of green revolutions in Asia. Global food security demands greater investments in research than are today apparent.

FUTURE PROSPECTS FOR FOOD SECURITY

The World population is expected to increase by 25 percent over the next decade and by a further 35 percent during the first quarter of the next century. By the turn of the century the population will rise by about 90 million per year equivalent to the combined populations of Egypt, Syria, Lebanon, Jordan, S Arabia and Kuwait. The 15 million hectares of the Earth's arable land seriously degraded each year could, wisely cultivated, grow sufficient grain to feed almost 90 million people.

More than 25 percent of the world's cereals are produced by five nations who export 40 percent of their production. If this proportion is to be maintained, present annual grain exports of 170 MT will need to rise to 225 MT by the end of the century. Past history does not inspire confidence that these surplus producers will be compassionate reliable providers. Nor is there evidence that the much proclaimed New World Order is immediately destined to accept a more equitable balance of world trade or to devote any significant peace dividend to the eradication of poverty and malnutrition.

Delivery from farm to consumer

Among the many hundreds of publications on sustainable agriculture remarkably few make any mention of post-harvest systems: the logistics, technologies and economics of preservation, processing, distribution and utilization of crops and livestock between farms and consumers. In all regions of the world urban populations are increasing rapidly. By the next century almost half the earth's population will live in cities. Already, 8 of the 10 cities with more than 10 million inhabitants are in developing countries.

Dense urban populations cannot be fed from small subsistence farms. Safe and efficient food processing and distributing systems are needed to ensure food security in every country. Food industries reduce waste by preserving perishable crops and livestock, they convert by-products to animal feed and other useful purposes, and they provide employment for skilled and semi-skilled people. Though less than four percent of Canada's population work on farms, over twenty percent are employed in food processing and distributing industries.

Human resources

Scientists seem generally more at ease when writing about techniques and properties of materials than about people. But it is through a vast assortment of human skills and experience that science and technology progress. To achieve food security and sustainable systems of farm production and post-harvest distribution requires the integration of many specialised disciplines. Equally necessary are people trained and experienced in the planning and management of integrated production and post-production systems, systems that take balanced account of the needs and resources of farmers, food processing and distributing industries and consumers. It is a challenge to the world's universities to provide training for such essential people. This Cairo university has demonstrated an exceptional standard of integrated agricultural systems management in the Egyptian Desert Development Program. It is an example other universities should be encouraged to follow.

Science has provided us with a remarkable arrray of techniques and tools by which to acquire, analyse and disseminate knowledge. Science and derived technologies provide the affluent nations with adequate, varied and affordable diets; with immense comforts and conveniences. Science can provide food security for all people, but for this to come about requires a marked change of heart and will among the 23 percent who enjoy 85 percent of the world's income. It requires pragmatic acceptance of B R Sen's dictum that: "One man's hunger is every man's hunger; one man's need is every man's need".