

# Science and nutrition in the future

C. Gopalan

ALL exercises that seek to predict the future have their inherent limitations, even when they are seemingly based on careful analysis of past trends. The most objective analysis cannot fully allow for all the uncertainties and imponderables that could ultimately affect the future course of events.

Our chastening experience over the last few decades must sound a clear warning against rash ('old-testament') prophecies with respect to the global nutrition scenario of the future. Paul and William Paddock<sup>1</sup>, for example, had predicted in the 1960s, on the basis of projections based on then prevailing trends, that acute food shortage and widespread famine would overtake India in the year 1975. By a strange coincidence, 1975 proved to be the year when India achieved a bumper harvest and recorded its (till then) highest level of food grain production! The Paddocks had not anticipated the Green Revolution. Later predictions had set the date for India's 'disaster' at 1985. India survived! It is now clear that, contrary to earlier 'Malthusian' predictions, the major factor that underlies not just India's problems of undernutrition but global undernutrition as well is not overall shortage of food grains but low purchasing power and consequent limited access to food of vast sections of people.

In the early '70s, global food resources had dropped alarmingly to the point that only 20 'food days' were thought to be left on this planet to feed the growing population. The major concern at the World Food Conference of 1974, convened in the grim shadow of that food security crisis, was to achieve an increase in global agricultural production because most predictions had then indicated that there was not going to be enough food on this planet to feed its citizens. Almost within 10 years there has been a sea change. Today we have the situation when increased food production has been achieved, but the number of hungry people in the world is steadily growing. Because of increasing income inequalities, *between* countries and *within* countries, millions of poor around the world do not have adequate access to food; we are witness to the cruel paradox of global food surpluses reaching record levels on the one hand, and vast pockets of growing hunger

around the world on the other. The 'food crisis' of the early '70s has given way to the 'debt crisis', and many developing countries are being forced to 'manage' their economies in a manner that prevents them from effectively addressing the problems of poverty and hunger among deprived sections of their populations.

A report of the World Bank<sup>2</sup> in 1986 sums up the situation thus: 'The world has ample food. The growth of global food production has been faster than the unprecedented population growth of the past 40 years. Prices of cereals on world markets have been falling. Enough food is available so that countries that do not produce all the food they want can import it if they can afford to. Yet many poor countries and hundreds of millions of poor people do not share in this abundance. They suffer from a lack of food security, caused mainly by a lack of purchasing power.' This is a picture sharply at variance with the concerns of the early '70s.

Predictions as to the future of global nutrition have now become even more hazardous and call for even greater circumspection and caution than in the past. On the one hand, recent breathtaking advances in biotechnology (if wisely handled) offer the promise of a plentiful world; on the other hand, the increasing and hardening North-South divide threatens to accentuate prevailing disparities between the 'affluent few' and the 'deprived many'. Also, emerging evidence of increasing global environmental pollution holds out imponderable far-reaching possibilities with respect to the future of mankind itself—possibilities from which there may be no 'escape' even for the 'haves'.

## The past and the present

Before considering possible future trends, it may be useful to take a brief look into the past and the present.

According to a recent report of FAO<sup>3</sup>, 'the outstanding fact in food and agriculture is that the past 25 years have brought a better-fed (?) world despite an increase of 1.8 billion in the world population'. The FAO claim of a 'better-fed' world is apparently based on its finding that the 'average food availability' rose from 2320 calories per caput in 1961/63 to 2660 calories (2420 calories for direct human consumption) in 1980/85. However, as the same FAO report later concedes, the 'average' in a world of glaring (and growing) inequalities is a statistical illusion. A report of the UN World Food Council<sup>4</sup> in 1985, on the other hand, brings out the disturbing finding that, while

C. Gopalan is President, Nutrition Foundation of India, B-37 Gulmohar Park, New Delhi 110 049. This article is the text of a plenary lecture delivered at the XIV International Congress of Nutrition, Seoul, South Korea, 22 August 1989, and is printed with permission of the author.

between 1970 and 1980, 1.5 million more people were being added annually to the ranks of the 'hungry' of the world, this average annual 'hunger growth rate' showed a five-fold increase after 1980; and this could not be entirely explained by the African crisis. Thus between 1980 and 1985 alone, as many as 40 million more people of the world had to join the ranks of the hungry—i.e. eight million more annually. These figures would indicate that income disparities and consequent poverty, which were somewhat held in check in the '70s became worse in the early '80s. As a result, despite significant increase in global food production, the nutrition situation in the '80s had actually deteriorated. Indeed, it would appear that, as global food production increased, economic disparities between and within countries actually worsened.

Estimates of actual numbers of hungry people in the world would naturally vary depending on the definition of 'hunger'. Using a 'stringent' definition of hunger as a level of energy intake less than 1.4 times the basal metabolic rate, an FAO report<sup>4</sup> had estimated the total number of people afflicted by chronic hunger in 87 developing countries to be 512 million in 1983/85, or 21.5 per cent of the population. The 'threshold' level of energy intake used by FAO for the above computation, which is below 80 per cent of the FAO/WHO recommended level of energy intake, has been considered as representing 'not enough calories to prevent stunted growth and serious health risks'. Using a more humane criterion—namely 'not enough calories for an active working life', which represents an energy intake less than 90 per cent of the FAO/WHO recommendation—the World Bank<sup>2</sup> had arrived at an estimate of 730 million, or 34 per cent of the population, afflicted by chronic hunger. A comparison of the trends in the '70s and in the early '80s would, however, show that in the '80s there has been a remarkable acceleration in the growth of hunger (Table 1).

One may perhaps argue about what constitutes 'hunger'—and there are always those who would postulate that people living on diets that provide much less than internationally recommended levels of energy intake are not 'hungry' but have become 'culturally adapted' to low intake! But there can be no such 'arguments' about death. Infant and child mortality rates in the developing countries had significantly declined during the '60s and '70s. According to a

UNICEF report<sup>4</sup>, during the early '80s this process has not only been slowed down but has actually been reversed in some cases. The decline in infant and child mortality rates is reported to be slowing down in sub-Saharan Africa. In a survey of 10 developing countries, UNICEF<sup>5</sup> reported that infant and/or child mortality rates had begun to rise in three, and in the rest the earlier rate of decline had slowed down; in eight countries the nutritional status of children had actually worsened since the early '80s.

Perhaps the only finding that could provide us some comfort is that the *percentage* of the hungry has declined in all developing countries except those of Africa. This only means that the hunger growth rate has fortunately not exceeded the population growth rate in these countries.

According to a World Bank Report<sup>2</sup>, nearly 64 per cent of the hungry live in South Asia, 23 per cent in Africa, seven per cent in Latin America and six per cent in the Near East (Table 2). Since, in the wake of the disastrous famine in Ethiopia and the unfortunate food situation in sub-Saharan Africa, global attention has largely shifted to Africa, it is important to draw attention to the following observations of UNICEF<sup>6</sup> which could help in restoring global perspective: 'In the last two years more children have died in India and Pakistan than in all 46 nations of Africa put together... In 1986 more children have died in Bangladesh than in Ethiopia, more in Mexico than in the Sudan, more in Indonesia than in all eight drought-stricken countries of the Sahel...'. This is not to argue against the well-deserved focus on Africa but to remind ourselves that the problem of global hunger is much larger and wider.

The major message that stands out of this brief survey is that the future challenge in the matter of combating global undernutrition will lie not only in devising new technologies and strategies for augmenting food production (important as they are), but also in overcoming and dismantling those systems and policies that contribute to the perpetuation and aggravation of glaring socioeconomic inequalities between the developed and developing countries on the one hand, and within developing countries themselves on the other. In short, the war against hunger is essentially a war against 'poverty'. This is not to say that we may now

Table 1. Estimates of global hunger in 87 developing countries

Year	FAO* estimates (millions)	World Bank† estimates (millions)
1970	460	676
1980	475	730
1985	512	—

Source: \*Ref. 4, †ref. 2.

Table 2. Distribution of hunger in 87 developing countries

Developing countries	Population (millions)
South Asia	470 (64%)
Africa	170 (23%)
Latin America	50 (7%)
Near East	40 (6%)
Total	730

Figures in brackets are percentages of respective populations with respect to total 'hungry population'.

Source: Ref. 2 (tables 2 and 3).



relax our efforts at augmenting food production. According to even conservative estimates the global population by the turn of the century would have risen from the present five billion to over six billion, 90 per cent of this increase being contributed by developing countries. Thus, even to maintain present levels of food consumption, the world has to achieve a minimal 25 per cent increase in overall food supplies within the next 15 years.

### Emerging trends in the nutrition scenario

As we approach the end of this century, indications of the changing profile of global undernutrition are becoming discernible; and these are likely to get into sharper focus in the early part of the twentyfirst century. Some of the major emerging trends may be briefly outlined.

#### *Elimination of acute large-scale famines*

It would seem reasonable to predict that the acute large-scale famines that used to decimate vast sections of populations of developing countries at distressingly frequent intervals during the last few centuries are unlikely to recur in future, except perhaps in some unfortunate parts of sub-Saharan Africa. There is today no global food shortage; administrations in developing countries and the international community have now acquired considerable expertise in 'crisis management' with respect to acute food shortage. Food which is available within an even outside the countries concerned can now be expeditiously rushed to threatened spots; early warning systems are now apparently far more efficient than in the past, and food distribution during emergencies better organised. It must also be said that developed countries, which have generally not shown much enthusiasm for changes in the present exploitative international economic order, have been more forthcoming and generous in the matter of responding to calls of distress. With better communications, news of acute famines afflicting large population groups, unlike in the past, now hit the headlines of the national and international press. Large-scale famines imply an indictment of present (national and international) economic order which, unlike that in the case of 'chronic silent hunger', is too loud and insistent to be ignored; political compulsions will demand that they are quickly aborted.

#### *Decline in the incidence of florid forms of undernutrition*

In most developing countries, unlike in the case of developed countries of Europe and North America, the 'health revolution' (thanks to modern health technology) appears to have preceded socioeconomic development. Health services in developing countries, both with

respect to outreach and quality, are improving much faster than income levels. Countries currently unable to overcome poverty are at least able to institute 'death-control' and 'child-survival' strategies like the oral hydration programme and universal immunization. As a result, infectious diseases, which generally play the major role in the aggravation of undernutrition and its progression to a fatal termination, are being controlled, even in the continuing presence of poverty and dietary inadequacy. 'Conditioned' undernutrition (conditioned by the superimposition of infections) may be expected to decline, even if primary undernutrition (due to primary dietary inadequacy) continues.

Even before the end of the first half of the present century, beri-beri (cardiac and 'dry'), which used to be an important public health problem among rice-eating populations in parts of Asia, had markedly declined. Classical pellagra is now limited to small pockets and is not a serious health problem either. There is now evidence that florid forms of PEM (protein-energy malnutrition) like classical kwashiorkor are on the wane. With better control of measles and diarrhoeal diseases, the incidence of keratomalacia may also be expected to diminish. Iodine deficiency diseases (despite the inept manner in which goitre control programmes are being implemented in some countries) are bound to eventually decline since the technology for goitre control is well within the reach and competence of all developing countries. The decline of these diseases will be more rapid in some countries than in others.

All this would imply that increasing numbers of undernourished children will survive and reach adulthood. If developing countries are content with this result and stop short with death-control strategies, their populations will only be progressively burdened with an increasing pool of substandard survivors—a situation that could only lead to further erosion of the quality of their human resources. This is not an argument against measures to ensure child survival; it is a warning against stopping short with such measures. Strategies that may be adequate to ensure 'survival' will not be adequate to ensure good health and nutrition; the latter will need far greater inputs. The 'distance' in the developmental journey that has to be covered between the point of achievement of better 'child survival' on the one hand, and the point of optimal health and nutrition on the other, constitutes the crucial twilight phase—the transitional stage—of development, the important last stretch that will make the real difference between an underdeveloped and a developed society. This phase has to be traversed expeditiously. This will be the major challenge that will confront several developing countries in the next three decades.

#### *The demographic transition*

Several developing countries are currently implementing



fertility control programmes as an important part of their plans. Though the impact of these programmes has been varied and, as yet, not spectacular in many developing countries, there is no doubt that the demographic transition is gathering momentum. Apart from fertility control measures, because of improvement of health services, life expectancy is also increasing. These developments will be inevitably reflected in progressive ageing of populations of developing countries, at an even faster rate than what may be expected in developed countries. Thus, according to a UN report<sup>7</sup>, children below 15 years in the 'less developed' countries of the world in the year 2025 will constitute only 25.8 per cent of the total population of those countries as against 39.4 per cent in the year 1980; and 'old' subjects above 60 years of age will be 12.4 per cent of the population as against 6.3 per cent in the year 1980—a doubling of the proportion of the aged (Table 3). In 1980, the aged (over 60 years of age) constituted 13 per cent of all dependents in developing countries, the other 87 per cent being accounted for by children under 15 years of age; by the year 2025, however, the aged will constitute a third of the population of dependents in the less-developed countries, with young subjects under 15 years of age accounting for only two-thirds. Indeed, in some developing countries of Asia, the ageing trend promises to be even more rapid. Thus it has been projected that the percentage of population aged 60 years and over, which stood at around five per cent in 1980 in Indonesia, the Philippines and Thailand, will show a three-fold rise to 13 to 17 per cent by 2030. Since, at least in the older age groups even in developing countries, women outnumber men (see, for example, Table 4 and Figure 1), it may be expected that a major proportion of 'old' dependents will be women.

The problems of an ageing society which also happens to be poor will be qualitatively different from those of an affluent ageing society. In the case of the former, the

**Table 3.** Projected change in the profile of 'dependency ratio' in the world

Age group (years)	Distribution of dependent population	
	1980	2025
Less-developed regions		
0-14	87% (39.4)	68% (25.8)
> 60	13% (6.3)	32% (12.4)
More-developed regions		
0-14	60% (23)	46% (19.7)
> 60	40% (15.2)	54% (23.6)

Figures in brackets indicate age group population as a percentage of the total population.

Source: Ref. 7.

**Table 4.** Sex ratio (no. of females per 1000 males) by age above 60 years for the more-developed and the less-developed regions, 1985

Age (years)	More-developed regions	Less-developed regions
60-64	1311	1013
65-69	1399	1064
70-74	1563	1122
75-79	1721	1245
> 80	2237	1451

Source: Ref. 7 (table 6).

disabilities incidental to old age will be greatly aggravated by superadded disabilities arising from primary dietary inadequacy and undernutrition. Under-nutrition among the aged will be a far more important problem in the developing than in the developed countries. The proportion of the poor and under-nourished among the aged in the developing countries will be higher than their proportion in the population of these countries as a whole, for the obvious reason that in the situation that generally obtains in a poor society, wherein workers' wages are related to productivity and physical stamina, the aged poor will find it hard to earn their livelihood. Under the impact of 'modernization', still-prevailing cultural traditions and value systems, which now ensure that the elderly are looked after by their offspring, may get progressively eroded.

Developing countries will be increasingly compelled to address the nutrition problems of the aged within the next few decades. Allocations for the welfare of the aged and arrangements for this purpose will become increasingly necessary. Unlike in affluent countries where old age pensions and substantial allocations for the welfare of the aged are possible, poor developing countries will be hard put to decide whether their meagre resources should be deployed for the protection and promotion of the nutritional status of the young or for looking after the aged. The powerful 'economic' arguments in favour of 'investments' on the young, who are the harbingers of the future, will not apply to the aged; the case for the latter must rest on 'humanitarian' grounds.

It is, however, to be hoped that, at least in this area, the East will not have to blindly copy the West. 'Old age homes' where the elderly are lonely and isolated, however comfortable and well-appointed they may be, are a repudiation of the culture and civilization of the East. The challenge to leaders in developing countries is to ensure that in the quest for modernism and material affluence, the East does not discard the values and traditions that have been the hallmark of its culture and which, over the centuries, had provided it with the fortitude to tide over poverty and privation. There must be many imaginative ways by which the elderly can be enlisted for productive welfare programmes. In the

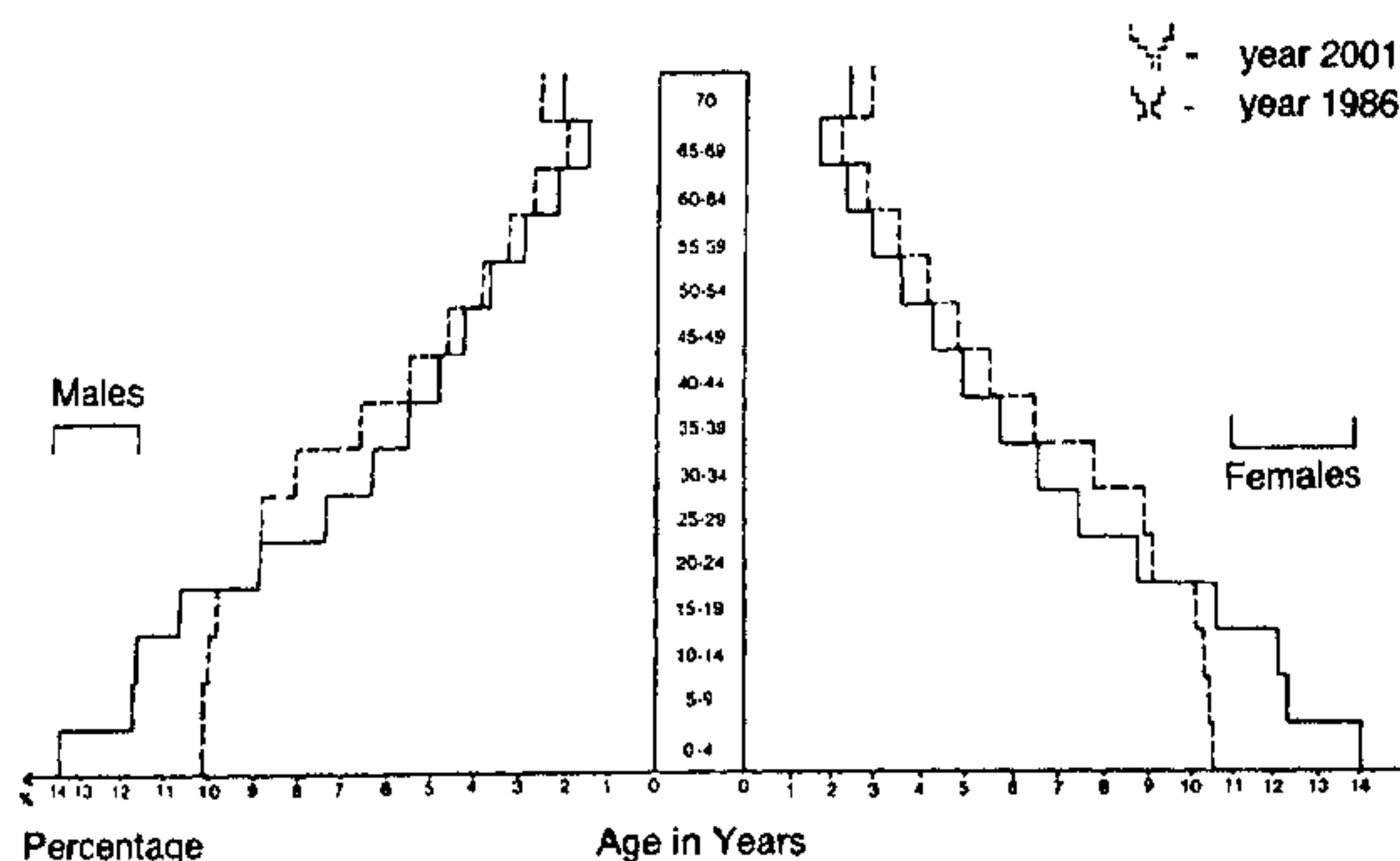


Figure 1. India's population pyramid.

Tamil Nadu Nutrition Programme (*not* the World Bank-assisted one), for instance, elderly 'destitute' women of the village had been entrusted the job of overseeing feeding operations; this is one way and there must be several others. What the elderly seek is not comfort in solitary splendour but an opportunity to be part of their society in useful ways which will lend them dignity and emotional satisfaction.

#### *Growing importance of urban undernutrition*

Industrial development, practically in all developing countries, has inevitably led to migration of rural labour to urban areas in search of employment. This process will gather further momentum in the decades ahead. The poor who migrate to urban areas have no access to the urban land market, and housing facilities for labour are poor in most cities. As a result urban slums are growing at a distressingly rapid rate in most developing countries. The bigger the city the greater is the proportion of its slum-dwellers. Thus, in 1981 in India, while the slum population constituted 20 per cent of the population of medium-sized cities (with populations below one million), it accounted for more than one-third of the population of cities with populations exceeding one million<sup>8</sup>. Almost 40 per cent of the population of the metropolitan cities of Bombay and Calcutta in India were living in urban slums in 1981, and quite a good proportion of them on pavements. It would appear that in African and Latin American metropolitan cities the situation is even worse, possibly because of the even faster pace of urbanization (especially metropolitanization).

While it is generally the case that the nutritional status of the urban poor is somewhat better than that of their rural counter-parts, studies of the National Nutrition Monitoring Bureau in India covering 16 major Indian cities have actually shown that the

nutritional status of urban slum-dwellers in India is no better than that of poor rural labour<sup>9,10</sup> (Table 5).

The urban population of all developing countries will rise rapidly in the next three decades, and even with the most efficient management of the urban influx, it may be expected that at least one-third of this urban population will be living in slums. It is estimated, for example, that the urban population of India, which is currently 24 per cent of India's population, will increase to 35 per cent in 2011 AD. The total urban population in 2000 AD will clearly exceed 300 million, and more than 100 million of these will be in urban slums<sup>8</sup>. The nutritional problems in urban slums in developing countries will have to receive for greater attention in future than they did in the past.

The features of urban undernutrition will sharply differ from those of rural undernutrition in many important respects, including seasonality. The advantage of easier access to health centres in urban areas will be negated by the disadvantages of crowding, insanitation and industrial pollution. Food expenditure could constitute a lower proportion of total expenditure in urban areas and diets could be expected to be actually poorer. The studies of NNMB in India referred to earlier had shown that the diets of urban slum-dwellers are poor. Since urban undernutrition is more

Table 5. Percentage distribution of 1-5-year-old children according to Gomez' classification

Category	Weight as % of standard			
	>90	75-90	60-75	>60
<b>Boys</b>				
Urban slum*	9.0	39.0	42.5	9.4
Rural†	9.9	40.8	39.2	10.1
<b>Girls</b>				
Urban slum	16.8	43.0	34.6	5.6
Rural	19.1	45.6	29.6	5.7

Source: \*Ref. 10, †ref. 9.



'visible', the expanding slums could be a source of increasing political unrest; political considerations could compel disproportionately higher allocations of developmental budget for the urban sector to the neglect of the still large rural sector, even as the organized industrial urban labour have managed to extract a bigger slice of the cake than the unorganized rural labour. Thus the next three decades will bring to increasing focus, in the developing countries, the problems involved in the agonizing choices with respect to apportioning of meagre resources as between the 'young' and the old, and as between the rural poor and the urban poor.

### *The double burden*

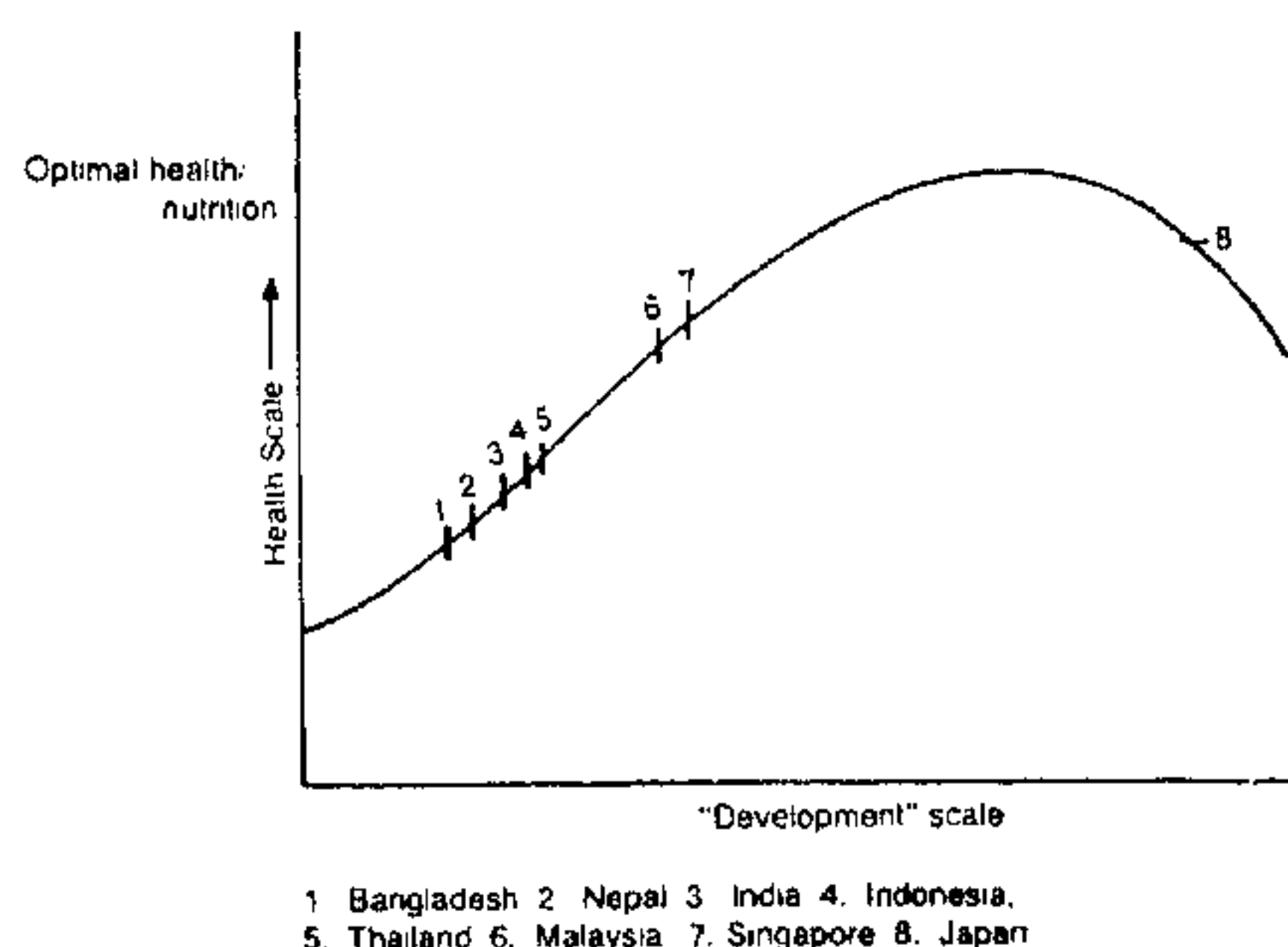
As the poor countries of today move up the developmental scale and achieve increasing economic prosperity, their current problems associated with poverty and undernutrition could gradually give way to a new set of health/nutrition problems attributable to affluence and overnutrition. Degenerative and neoplastic diseases in these countries could rapidly escalate in the next three or four decades. The challenge that many developing countries will face in the early part of the next century will be to ensure that the momentum of the developmental process does not carry them over to the other side of the hill, as indeed it has done in the case of most developed countries of today (Figure 2). This scenario in effect suggests that the relationship between rising affluence on the one hand and optimal health/nutrition on the other is not linear; that there comes a point when unbridled affluence could begin to prove deleterious and may need to be vigorously checked. As much care with respect to avoidance of dietary excesses could become necessary in future as is now needed to overcome dietary deficiencies.

Indeed, with respect to many developing countries, it seems likely that over a great part of the first half of the

next century, they may have to carry the double burden of 'old' problems of undernutrition and poverty which they have eradicated only partially and 'new' health/nutrition problems arising from affluence and nutrition (Table 6). These two sets of problems—the two ends of the health/nutrition spectrum—may exist side by side in the poor and affluent sections, respectively, of their populations. Given the current income disparities in many countries, this is by no means an unlikely scenario. Thus it has been reported that the prevalence of coronary heart disease in urban Delhi is over six times (7.3 per cent) that in its rural environs<sup>11</sup>.

We had already pointed out that developing countries will in future have to simultaneously fight problems of undernutrition among children and the rural poor on the one hand and new problems of undernutrition among the aged and the urban slum-dwellers on the other. All this would imply that the health systems and the administrations of these countries must achieve a greater degree of versatility and resourcefulness in order to combat an even broader spectrum of problems of malnutrition. This would call for a wider range of expertise and inputs in future than in the present and the past.

Because of these developments, we may predict that, as we move to the twentyfirst century, the science of nutrition will become even more relevant and important to mankind than what it is today. Nutrition scientists may have to devote more attention to the effects of so-called marginal and moderate undernutrition on human function and behaviour, an area that would call for a great deal of sophisticated interdisciplinary effort; to problems of undernutrition in the aged; to the role of nutritional factors in the pathogenesis and progression of degenerative diseases; to changes in micronutrient composition (especially trace-element composition) of foods following on changes in soil chemistry induced by intensive agricultural technology, and the impact of such changes on health and nutritional status of populations; and to the possible health/nutrition impact



**Figure 2.** Impact of development on the profile of public health (a diagrammatic illustration).

**Table 6.** Death rates due to various causes in some SEAMIC countries and the USA

Cause of death	Deaths per 100,000 population				
	Japan	Malaysia	Thailand	Indonesia	USA*
Cancer	164.2	11.41	29.9	0.03	194.7
Coronary heart disease	39.5	13.7	1.4	0.3	216.0
Hypertensive disease	8.8	1.2	3.2	0.2	12.9
Cerebrovascular disease	101.7	11.1	9.2	1.2	62.1
Diabetes	7.5	1.6	3.4	0.25	15.4
Chronic liver disease	13.7	1.1	8.0	0.6	10.9
Accidents	45.8	13.1	24.8	0.3	39.5

Source: SEAMIC Health Statistics (1988), \*World Health Statistics, WHO (1988).

of the powerful newly emerging biotechnologies with their possible unimponderable side-effects.

### **The challenge of the future**

The demands of global nutrition in the coming decades, and indeed in the next century, will pose formidable challenges to science. On the one hand, scientists have to ensure that the present momentum of agricultural production is maintained and augmented in order that there is enough food to feed the world's growing population; also, the tempo of industrial development has to be maintained and widening job opportunities must become available to ever-increasing numbers of people around the world, so that people freed of poverty could find access to food. On the other hand, in pursuing the above objectives, great care has to be taken that the mounting environmental hazards already unleashed by the developmental process are not only not further aggravated, but are effectively contained and combated. This implies that alternative strategies in the field of energy, agriculture and industry will have to be identified. It is also to be ensured that the emerging powerful tools of biotechnology are used in a manner that will not aggravate current inequalities but for the benefit of mankind as a whole. Environmental hazards, which are growing in their dimensions, are of concern not just to developing countries but to developed countries and to the world as a whole. Some of these concerns are briefly highlighted below.

#### *Deforestation*

The denudation of the world's forest cover has proceeded during the last several years at an estimated rate of about 11.5 million hectares per year. As a result of such deforestation, plains and valleys are being subjected to recurrent excessive flooding. In India, for example, more than 20 million hectares of land are currently being affected annually by flooding due to deforestation with disastrous consequences such as silting of dams and salination and alkalination of soils. In the Gangetic plains of India alone, the loss due to flood damage has been estimated to exceed one billion dollars annually.

#### *Desertification*

Population increase, overgrazing and uncontrolled expansion of agricultural crops have led to the expansion and advance of deserts. North Africa is losing 100,000 hectares of range lands and crop lands annually due to desertification. The rate of desertification in Sahelo-Sudanian Africa, Iran and north-east Brazil is also accelerating.

#### *Fertilizer and biocide use-related hazards*

While developing countries encounter major hazards

due to deforestation and desertification, developed countries face hazards due to intensive modern agricultural technology. Leaching of nitrates into ground-water supply and problems created by surplus manure are posing serious threats in some countries such as the Netherlands. These developments acquire significance in view of epidemiological studies that suggest possible links between environmental nitrates and gastric cancer. The emergence of new pests and resistant varieties of pests due to intensive use of biocides also threatens to create new problems.

#### *Greenhouse effect*

There is mounting concern about climatic changes that could be caused by increasing concentration of carbon dioxide and other gases in the earth's atmosphere. It is feared that this could cause a 'greenhouse' effect, resulting in the warming of the earth's atmosphere (global warming) and a rise of the sea level. If some of the gloomy predictions in this regard turn out to be true, large tracts of land could disappear under the sea in the course of the next century. Sea-level rises of the order of 5 to 24 cm per decade have been predicted, implying that coastal areas presently less than one to three metres above sea level and fertile areas around river deltas will be seriously threatened by the middle of the next century. It is this scenario that had prompted the Chief Delegate from the Maldives at a UN meeting to express the fear that by the middle of the next century, his country could be swallowed by the sea!

#### *Depletion of the ozone layer*

The depletion of ozone in the stratosphere due to increased levels of nitrous oxide (NO) and chlorofluorocarbons (CFCs) is also causing concern. The impact of these developments on global crop production is now being debated. While these hazards should cause concern, their impact on the global nutrition scene within the next few decades does not appear imminent.

The hazards listed above should highlight the scientific challenges that lie ahead in sustaining agricultural and industrial development in the next century.

### **The biotechnology revolution**

Modern advances in biotechnology offer immense possibilities of improving global nutrition. Through the application of the new tools of biotechnology, far-reaching developments in the fields of agricultural production, health and medicine have now become possible. Biotechnology promises an increasing agricultural productivity through enhancement of the efficiency of photosynthesis; new tissue-culture techniques indicate possibilities of phenomenal gains in food yield; bio-



Table 7. The promise of biotechnology\*

1. Agricultural productivity through
  - a. enhanced efficiency of photosynthesis
  - b. accelerated pace of plant breeding through tissue culture techniques, e.g. in case of oil palm, coconut, bananas and tubers
  - c. use of techniques such as embryo rescue, protoplast fusion, DNA vectors to overcome barriers of sexual incompatibility.
2. Reclamation of poor soils; e.g.
  - a. in SE Asia alone 86.5 million hectares of currently unproductive land can be made productive through cultivation of rice varieties tolerant to salinity and alkalinity
  - b. adaptation of cereal crops to drought-prone areas of sub-Saharan Africa.
3. Accelerated development of 'low-input' agriculture system, e.g.
  - a. use of varieties needing lower inputs of fertilizers, and disease and pest-resistant varieties with ability to fix nitrogen
  - b. identification of biological pesticides effective against important pests.
4. Development of integrated systems for recycling of agricultural wastes into energy—as are now being attempted in Brazil, China and India.

\*Swaminathan, M. S., *Science*, vol. 218, 1982.

technology can help in the reclamation of poor soils now rendered unproductive because of salinity and alkalinity (Table 7). Biotechnological tools may become useful in the prevention and control of communicable diseases.

However, all these would become possible only if these technologies are harnessed and promoted for the good of mankind as a whole. Unfortunately, the increasing trend towards commercialization and privatization of biotechnology research, which is now being shrouded in secrecy, the emergence of powerful transnational corporations in the industrialized countries supported by university-industry complexes that are aiming at consolidation of their monopolistic hold over the emerging new technologies, the increasing proprietary hold over biotechnology research through patent protection—all these trends indicate that commercial prospects rather than mankind's basic needs could determine the future course of biotechnological research and its application. There is the growing fear on the part of developing countries that, given the present trends, these new biotechnological tools may be used to develop substitutes for commodities presently being imported by developed countries from the developing countries. Over the past two centuries developing countries like Mexico, Brazil, China, Chile, Ethiopia and India provided rich plant-genetic resources for the whole world. These resources were freely collected without any compensation by the

industrialized countries. Now, powerful private seed industries located in industrialized countries are seeking patent protection for the plant-genetic varieties that they are developing out of the plant-genetic resources they had originally appropriated, free of cost and compensation, from what was called 'common heritage'. These disturbing trends indicate that modern advances in biotechnology that hold out great promise of a happier world could instead become powerful instruments for the domination of the many by the few.

It is often said that science is neutral and that it is the manner in which science is used and applied that makes it ultimately beneficial or harmful to mankind. Unfortunately man's acquisition of knowledge is often not matched by enhancement of his wisdom and compassion.

As we move to the twentyfirst century, it is becoming increasingly clear that the world has the resources and the technology to ensure good nutrition for all its people. The future of global nutrition will, however, depend on the answer to the question: 'Will man's wisdom and concern for his fellow men triumph over his greed?'

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