UNEP/GC 13/4

The State of the Environment 1985

Environmental aspects of emerging agricultural technologies

Population and the environment

United Nations Environment Programme

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CONTENTS

SUMMARY

In compliance with Governing Council decision 12/3 C of 28 May 1984, two closely interrelated topics are considered in the present report: environmental aspects of emerging agricultural technologies and population and the environment. The report reviews the present state of affairs in each of the two areas and studies possible future developments. It also outlines some recommendations designed to make it possible to achieve sustainable agricultural development to feed a growing world population, and to control rapid population growth to reduce increasing pressures on the world's limited natural resources.

I. ENVIRONMENTAL ASPECTS OF EMERGING AGRICULTURAL TECHNOLOGIES

Despite world-wide increases in food production during the past few decades, famine and malnutrition remain widespread. This situation has been created and aggravated by a combination of social, economic, environmental and political factors, ranging from inequitable access to resources and products to the often primitive conditions of production and processing of agricultural output in many areas.

The availability of abundant and cheap sources of fossil-fuel energy during the last three to five decades has enabled farmers to enjoy extraordinary growth in output in developed countries and in some sectors of the third world. Unfortunately, this technical revolution has not had wholly beneficial effects: pushed to its extreme it is detrimental to the environment. Moreover, it is by no means always suited to the needs of the hundreds of millions of poor farmers and landless labourers in the third world, and the wisdom of pursuing this agricultural technology in the future will surely be called into question in view of the present world energy situation.

There is much evidence that in many parts of the world the environmental costs of present agricultural technologies are high, but there is no commonly accepted measure of environmental costs. These costs are real, but typically they are not priced, in part because of difficulties involved in identifying and quantifying all the impacts of the use of or damage to land, water, ecosystems and so on.

Long-term solutions that would lead to environmentally sound agricultural development include the devising of technologies that generate significantly lower environmental costs than those currently used. Such technologies must be suited to local conditions and must be acceptable to farmers. They include integrated pest management, minimum tillage and the development of new types of seeds that are tolerant of salt or disease, or capable of enhancing biological nitrogen fixation or increasing the efficiency of photosynthesis.

II. POPULATION AND THE ENVIRONMENT

There is no simple correlation between population and environment. In order to meet needs and improve the quality of life, people develop and use resources of the environment. Just as some patterns of development have improved environmental conditions, others have tended to degrade them, sometimes irreversibly. Stable populations are being reached in many developed countries, with low birth and death rates. In contrast, the capacity of a number of developing countries to manage their environment so as to secure the well-being of their people is coming under severe stress in the face of pressures created by rapid population growth, its uneven distribution, and inadequate socio-economic development.

Interactions among mass poverty, population growth, environmental degradation and slow development are making it difficult for many developing countries to secure a sustained improvement in their social, economic and environmental situation. Population policies can have only limited success when poverty remains widespread, environmental conditions deteriorate, and natural resource availability and productivity remain low. On the other hand, environmental programmes for reforestation, desertification control, provision of drinking-water supply and sanitation and the like do not have the intended impact when population continues to grow rapidly, its distribution remains uneven, and development gains remain meagre and not broadly based.

The world has the natural resources, technology, expertise and other resources to provide for a decent quality of life for the projected high levels of global population. However, there is no automatic mechanism linking the needs of a country or region to its capacity to meet them. Growing evidence of environmental stress in many areas, and notably in Africa, with its attendant drought, famine, starvation, suffering and forced migrations, underline the fact that co-ordinated action on the fronts of population, resources, environment and development is urgently needed.

Population and environmental policies have increasingly come to respond to the needs of social and economic development. In this process, the interface between the two has become clearer, and programmes based on recognition of this interface should improve the effectiveness of both population and environment

policies. Basic education, improvement in the status of women, employment-generating public works to improve infrastructure and natural resource availability, land reform to ensure equitable access, provision of drinking-water supply and sanitation and spatially balanced industrial, agricultural and settlements development are some areas deserving urgent attention.

Countries which are experiencing or are likely to experience environmental stress along with high population densities need to devise and implement well-focused and well-co-ordinated measures to pursue their population, environment and development goals. Their efforts, however, need to be facilitated by greater international economic co-operation, as well as development assistance targeted to areas of potential environmental stress and embodying an integrated approach to issues of population, environment and development.

SUGGESTED ACTION BY THE GOVERNING COUNCIL

The Governing Council may wish to:

Take note of the report of the Executive Director and endorse some or all of the recommendations for action contained in part one, chapter VII and part two, chapter V of the report;

Request the Executive Director to:

(a) Distribute the report to all Governments, relevant United Nations organizations and other intergovernmental and non-governmental organizations;

(b) Bring to the attention of all Governments and relevant intergovernmental and non-governmental organizations the recommendations for action endorsed by the Council;

(c) Continue to accord high priority, within the environment programme, to activities related to environmentally sound agricultural policies and practices;

(d) Provide assistance, on an experimental basis in the next three years, in co-operation with the relevant United Nations bodies and other organizations, to six countries, two from Africa, two from Asia and two from Latin America, in the formulation and implementation of environmentally sound agricultural policies

and practices selected from among those enumerated in part one, paragraph 53 of the present report;

Invite the Conference of the Food and Agriculture Organization of the United Nations, the Committee on Food Aid Policies and Programmes of the World Food Programme, the World Food Council and the Governing Council of the International Fund for Agricultural Development, as well as the United Nations regional commissions, to consider the recommendations for action listed in part one, chapter VII of the present report with a view to supporting their implementation;

Invite the Governing Council of the United Nations Development Programme, acting in its capacity as governing body of the United Nations Fund for Population Activities, and the United Nations Population Commission, to consider the recommendations contained in part two, chapter V of the present report with a view to supporting their implementation;

Further invite the United Nations Fund for Population Activities, appropriate non-governmental organizations such as the International Planned Parenthood Federation and the International Union for Conservation of Nature and Natural Resources, and multilateral and bilateral development assistance organizations, to co-operate with the United Nations Environment Programme in the design and implementation of pilot activities exemplifying an integrated approach to solving population and environment problems;

Request the executive heads of the Food and Agriculture Organization of the United Nations, the World Food Programme, the World Food Council, the International Fund for Agricultural Development, the United Nations Fund for Population Activities, the United Nations regional commissions and other relevant intergovernmental and non-governmental organizations to co-operate with the Executive Director in the implementation of the present decision.

PREFACE

1. One of the main functions assigned to the UNEP Governing Council by the General Assembly in resolution 2997 (XXVII) of 15 December 1972 is:

> "To keep under review the world environmental situation in order to ensure that emerging environmental problems of wide international significance receive appropriate and adequate consideration by Governments".

2. To assist the Governing Council in this task, the Executive Director prepares each year a report on the state of the environment. The first reports (1, 2, 3) discussed a broad spectrum of environmental issues, such as climatic change, the condition of the biosphere, the effects of toxic substances, food, energy and raw materials, population growth, stress and social tension and pollution. At its fourth session, the Governing Council decided (decision 47 (IV), sect. IV, para. 10) that the annual state-of-the-environment report should be selective in its treatment of subjects and that an analytical, comprehensive report on developments regarding each of the issues should be prepared every fifth year. Accordingly, subsequent annual state-of-the-environment reports (4, 5, 6, 7, 8) dealt with some selected topics: the ozone layer, environmental cancers, soil degradation, firewood, chemicals and the environment, malaria, the use of agricultural and agro-industrial residues, energy conservation, schistosomiasis, resistance to pesticides, noise pollution, tourism and the environment, carbon dioxide and climate, heavy metal hazards, transport and the environment, military activity and the environment, the child and the environment, ground water, toxic chemicals and human food chains and environmental economics. The criteria for the selection of these topics were set out in the state-of-the-environment report for 1977 (4). These and other issues dealt with in the annual reports were covered in greater depth in the first comprehensive analysis of the state of the environment, which was carried out on the occasion of the tenth anniversary of the 1972 Stockholm Conference (9). In 1983, hazardous wastes, acid rain and energy farms were dealt with (10), while in 1984, the topic was "the environment in the dialogue between and among developed and developing countries" (11).

3. This year, in accordance with Governing Council decision 12/3 C, paragraph 2, the state-of-the-environment report deals with two topics: environmental aspects of emerging agricultural technologies, and population and the environment. The two topics are closely interrelated. While technologies have been developed and applied to increase agricultural production to feed a growing world population, population growth has been exerting increasing pressures on the world's limited natural resources that constitute the base for further agricultural development. In some areas, these pressures combined with mismanagement have led to marked deterioration of the natural resource base, in some cases to the point of near-uselessness. By the year 2000, a world

Part One

ENVIRONMENTAL ASPECTS OF EMERGING AGRICULTURAL TECHNOLOGIES

I. INTRODUCTION

1. Part one of the present report deals with modern and emerging agricultural practices and their existing and expected environmental impacts. It deals with crop production only; future reports may deal with other aspects of agricultural systems—livestock production, fisheries and aquaculture, and so on—that contribute to world food-producing capabilities.

2. The 1950s and the years that followed brought a technological revolution in agriculture based on the introduction of high-yield varieties (HYVs) of grain and modern agricultural management. The fact that this "green revolution" spread far more widely in developed than in developing countries can be attributed to two main reasons. First, the recommended technologies tend to be area-specific; a technological package developed for specific climatic, soil and water conditions can seldom be successfully transplanted to another region without substantial modification. The process of transfer and adaptation of technologies to local conditions in the developing countries has been very slow. Second, in an economic sense the types of technologies that are beneficial in the conditions prevailing in most developed areas may not be beneficial in the conditions encountered by most farmers in developing countries.

3. In spite of these constraints, modern agricultural practices have been spreading rapidly in areas in the developing countries where they are suitable. It has been estimated that about 55 million hectares (35 per cent of cultivated land in the developing countries) are planted to HYVs of wheat and rice (13). The new wheats were largely responsible for India's increase in wheat production from 11.4 million tons in 1964 to 35

million tons in 1980. Similarly, rice production in Indonesia rose from 12.2 million tons in 1970 to over 22 million tons in 1981 (13).

4. The environmental, demographic and economic trends recorded in the 1970s and early 1980s indicate that, if widespread improvements in human nutrition are to be secured, major adjustments in public policy will be required. Some analysts see the food problem almost exclusively as a population issue, noting that wherever population growth rates are low, food supplies are generally adequate. Others view it as a problem of resources—soil, water and energy. Many economists see it principally as a result of underinvestment, while agronomists see it more as a failure to bring forth new technologies on the needed scale. Still others see it as a distribution problem. To some degree, the food problem is a combination of all of these. To achieve a more satisfactory balance between world food demand and supply, there is a need for a reordering of social and economic priorities—giving agriculture and family planning the emphasis they deserve—especially in the developing countries, which could set the world on a path that will reduce hunger and malnutrition rather than increase them.

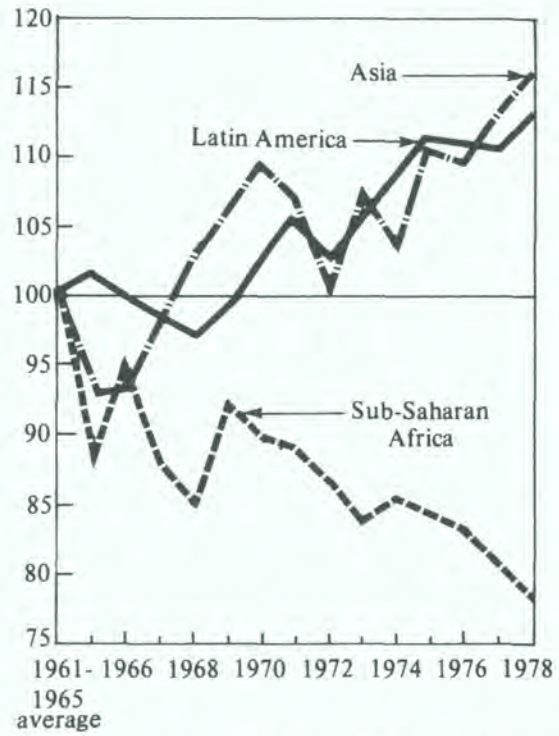
5. Several basic criteria govern the management of ecosystems for sustained productivity. Efficient use of water and the maintenance of soil fertility are crucial. The need for protection against damaging pollution is self-evident. A third need is to regulate the harvest man takes from the system. If overcropping depletes the nutrients in circulation so that they are not fully replenished by natural processes or by the addition of fertilizers, if pastures are grazed so heavily that palatable forage species can no longer sustain themselves, or if harvested organisms are depleted beyond optimal sustainable yield, the system becomes at best inefficient and at worst may change through relatively rapid processes of ecological degradation to one no longer useful to man.

II. SOME RELEVANT FACTS AND FIGURES

6. World-wide, the rate of growth of agricultural output was 3.1 per cent a year in the 1950s, 2.6 per cent in the 1960s, and 2.2 per cent in the 1970s (14). However, substantial regional differences exist. There was an acceleration of growth in agricultural output in South-East Asia from 2.9 per cent per year in the 1960s to 3.8 per cent per year in the 1970s; in Latin America there was a slight increase, from 2.9 per cent to 3.0 per cent; but in Africa the rate of growth declined from 2.7 per cent per year in the 1960s to 1.3 per cent per year in the 1970s (14). Indices of food production in some developing regions are presented in figure I.

7. Although the total calorie and protein content of today's food production is more than twice the minimum requirement of the world population, famine and malnutrition remain widespread. The situation has been created and aggravated by a combination of social, economic, environmental and political factors, ranging from inequitable access to resources and products to the often primitive conditions of production and processing of agricultural output in many areas. FAO has estimated (15) that 450 million people in developing countries were seriously undernourished in the mid-1970s, and if present trends continue the figure will reach 600 million in the year 2000. In other

Figure I. Index of per capita food production in some developing regions (1961-1965 average =100)



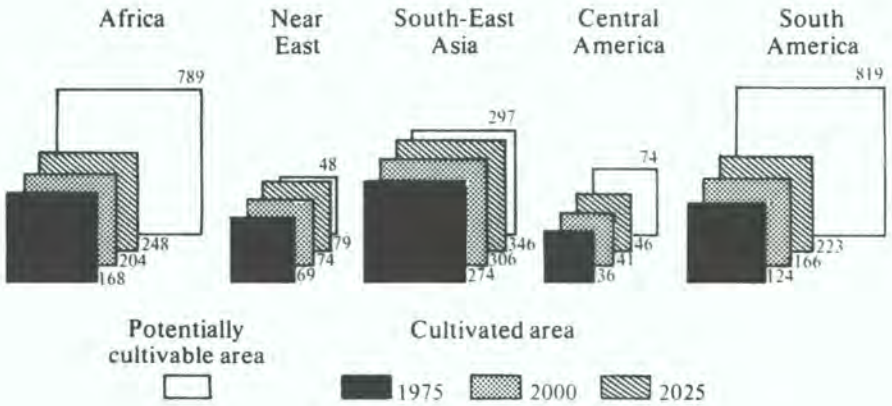
Source: G. Bixler and L. W. Shemilt, eds., *Chemistry and World Food Supplies, CHEMRAWN II* (Los Baños, Philippines, International Rice Research Institute, 1982).

words, about 10 per cent of the world population will remain seriously undernourished unless agricultural output is increased in the developing countries. FAO has also pointed out that a world population of more than 6 billion in the year 2000 will require a level of agricultural output some 50 to 60 per cent higher than in 1980. Demand for food and agricultural products in developing countries will double.

8. There are two main approaches to the task of raising agricultural output: increasing the area of cultivated land, and increasing the yield per unit of land (15, 16, 17, 18). In the past two decades, increased acreage has accounted for less than a fifth of the growth in agricultural production in developing countries, and for an even smaller fraction in developed countries (14). By the year 2000, the greatest contribution to increased crop output—no less than 60 per cent of the total—will come from increases in yields obtained by improved inputs and land management (15).

9. The total area of potential arable land in the world is about 3,200 million hectares, about 44 per cent of which (1,500 million hectares) is already under cultivation (9, 19). It has been said that very large areas of new land could be brought under cultivation (20, 21). But unused arable land is not always available to people who need it most, and opening up new areas remains an expensive means of increasing agricultural production. FAO estimates that about 10 to 15 per cent of unused arable land (170 million to 255 million hectares) might be cultivated by the year 2000 (14). Other estimates are 100 million hectares (22) and 300 million hectares (19). Estimates of areas cultivated and potentially cultivable are illustrated in figure II.

Figure II Land reserves and cultivated area (Millions of hectares)



Source: *Land, Food and People* (Rome, FAO, 1984).

10. The alternative to increasing the area under cultivation is to use existing land more efficiently. Efforts to do so have been successful: productivity gains have been achieved largely by improving the availability and reliability of irrigation and increasing the use of HYVs and fertilizer. In developing countries, cereal yields rose by 2 per cent a year between 1961 and 1980; yields of wheat varieties by 2.7 per cent; yields of sorghum by 2.4 per cent. Although rice yields increased by only 1.6 per cent a year in developing countries as a whole, they rose by more than 3 per cent a year in Indonesia and the Philippines, which were best suited to the new varieties (14).

11. The "green revolution" technological packages require HYVs of seeds and high inputs of water, fertilizers and pesticides. Over the world as a whole 1,300 billion cubic metres of water are used for irrigation every year; but for this, 3,000 billion cubic metres have to be withdrawn. In other words, 57 per cent of total water withdrawn is lost in the process of storage and transport (23). Increases in the use of water for irrigation have

been linked to two factors: growth in the irrigated land area from 163 million hectares in 1968 to 213 million hectares in 1981 (24), and the extent to which techniques of water application and land management have allowed economies in the amount of water used. In some areas, the use of modern irrigation techniques has led to more efficient utilization of water. While irrigation has many advantages, the fact remains that rain-fed areas constitute 80 per cent of the developing world's cultivated land and support nearly two thirds of its farmers (14). Crop yield increases still depend on the subtle interaction between soil, water, seeds and sunlight; and local conditions vary so much that finding solutions to increase yields is often costly, and they can seldom be replicated elsewhere.

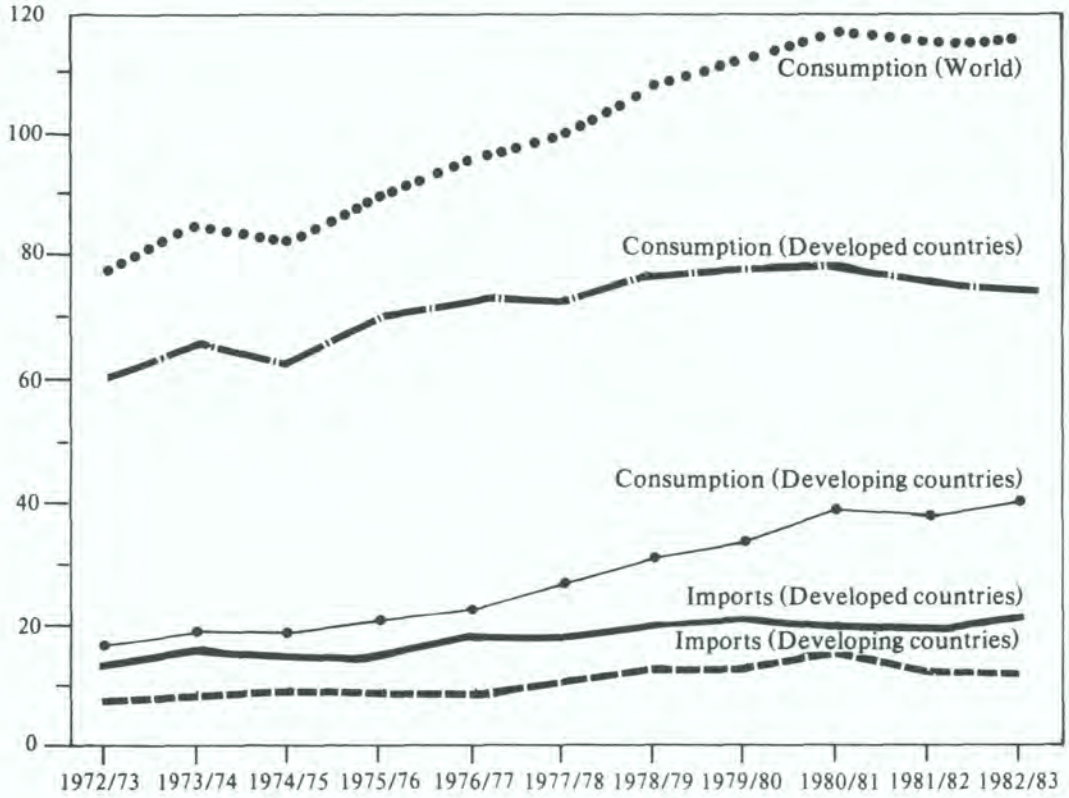
12. The increased application of chemical fertilizers supplying plant nutrients (nitrogen, phosphorus and potassium) is an essential component of modern agriculture. World consumption of chemical fertilizers rose markedly in the 1970s (see figure III). For nitrogen fertilizers, use increased from 32 million tons of nitrogen in 1970 to 61 million tons in 1981; for phosphates, from 21 million tons of phosphorus pentoxide to 31 million tons; and for potash, from 16 million tons of potassium oxide to 24 million tons (24). The rate of application of fertilizers to land increased markedly with the introduction of HYVs of seeds. For example, in the Philippines the nitrogen input was 17 kilograms per hectare (kg/ha) of paddy before the "miracle rice" was introduced; after its introduction the nitrogen input increased to 67-80 kg/ha (25). The use of fertilizers varies widely from one country to another: in India, the figure is 32 kg/ha; in Egypt, 189 kg/ha; in the United States of America, 200 kg/ha; in Japan, 533 kg/ha (26). It has been estimated that the future annual rate of growth of fertilizer use in the world will be about 8 per cent, with agricultural production doubling between 1980 and 2000 (15).

13. However, it has been estimated that only about 50 per cent of the fertilizer is used by crops; the remainder is lost from the soil system with no benefit to the crop (27). Losses occur through leaching, run-off and volatilization. The amount lost varies widely, depending on the crop, the method of application, the type of fertilizer, the soil temperature and other factors. With only about half of the applied fertilizer getting into the crops, there is potential for marked economic losses and for negative environmental impacts (see paragraph 28 below).

14. Estimates of world crop losses due to insects, pests, disease and weeds vary widely—from as low as 5 to 10 per cent to as high as 30 to 40 per cent (14, 15). The enormity of the problem of pest control is compounded by the vast array of pest species: more than 1,500 diseases are caused by about 50,000 species of fungi; more than 10,000 insect species are pests; more than 1,500 nematode species damage crop plants. In addition, there are about 30,000 weed species, of which more than 1,800 are responsible for major economic losses (9). The problem of pests can be more serious in developing countries with tropical climates than in countries in temperate zones. For example, the number of diseases reported in rice grown in the tropics is about 500 to 600, as against 54 reported in rice grown in temperate zones. For maize, the values are 125 and 85 respectively (28).

15. There are four basic methods of pest control: cultivation methods (ecological means) which discourage the build-up of pest populations; chemical control of pests; selection of crop plants and breeding for resistance; and deliberate nurture of the natural

Figure III. Consumption and imports of fertilizers (Millions of tons)



Source: "The state of food and agriculture 1984" (FAO document CL 86/2).

enemies of pests (biological control). Integrated pest management is a combination of these methods tailored to particular situations.

16. Chemical control of pests and diseases is the method widely used in many countries to protect crops. Because different types of pesticides are produced and traded at different costs, the growth of world pesticide use is often measured in terms of world sales rather than in tonnage. World sales of pesticides totalled $5.5 billion in 1975 and $11.8 billion in 1980. This represents about a 15 per cent annual increase in sales, without taking into account the strong inflation during that period (29). In 1980, 80 per cent of the pesticides used in the world were used in the developed countries. It has been estimated that if agricultural output is to be doubled between 1980 and 2000, the consumption of pesticides in the developed countries will have to grow at a rate of 2-4 per cent per year, with a rate of 7-8 per cent in the developing regions (29). Not all the amounts

of pesticides used control pests. The amount lost varies widely, depending on the pest population and its characteristics, such as its degree of resistance to particular pesticides, the method of application, and so on. Losses of pesticides constitute not only economic losses, but also potential hazards to man and his environment (see paragraph 29 below).

17. Although agriculture is highly mechanized in developed countries, it is still labour-intensive in developing countries (see figure IV). In 1980, machinery accounted for only 8 per cent of power inputs in agriculture in developing countries. This percentage is expected to reach 19 per cent in the year 2000 (15), while the share of draught animals is likely to fall from 25 per cent in 1980 to 18 per cent. The share of labour will fall only slightly, from 67 per cent to 63 per cent, but the fall will be steepest in areas where a high degree of mechanization is introduced, for example in Latin America (15).

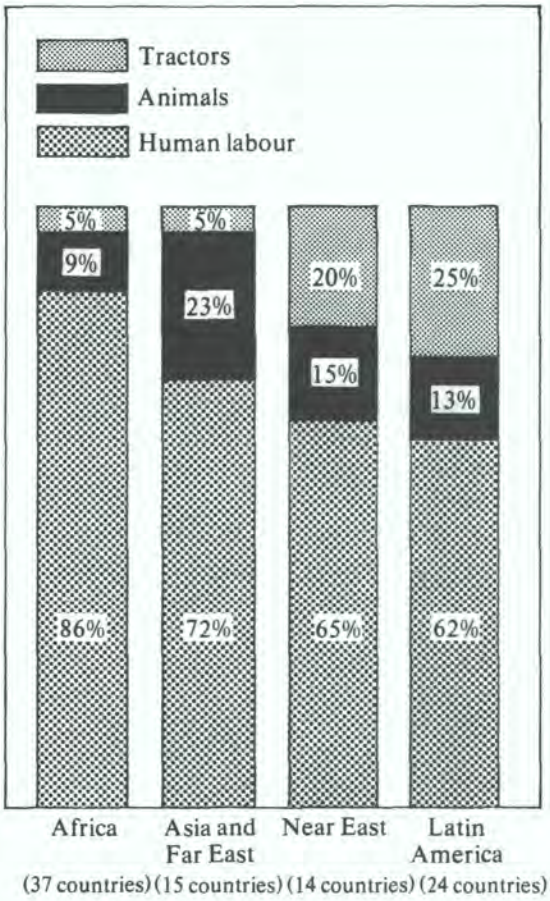
18. The "green revolution" has come a long way since its beginning. By 1980, some 27 per cent of seed use in the developing countries is estimated to have been from improved varieties, but there were large disparities between countries. In Latin America, 44 per cent of seeds were of improved varieties, whereas in the Near East the share was 32 per cent and in the Far East 23 per cent. In Africa improved varieties made up only 9 per cent of seeds used in 1980 (15).

19. Plant breeders have helped increase the productivity of many important crops by successfully developing cultivars (cultivated varieties) to fit specific environments and production practices. New and improved cultivars offer practical means of overcoming agricultural production constraints. In germ-plasm collections around the world the tens of thousands of crop cultivars offer remarkable variability regarding tolerance of adverse water and soil conditions, resistance to or tolerance of major insect pests and diseases, nutritional quality, and agronomic characteristics such as height, stem strength and growth duration. For example, by using the genetic diversity in the more than 60,000 accessions in the International Rice Research Institute (IRRI) germ-plasm bank, IRRI scientists have incorporated resistance to six major rice insect pests and diseases, shortened the 150-to-160-day growth duration to 90-110 days, and discovered accessions with some tolerance to adverse soil and climatic conditions. Nearly 5,000 crosses are made each year to achieve these results (13, 30). Similar outstanding results have been achieved at other national and international research centres.

20. In spite of all these developments in agricultural technologies, two areas seem to be still lagging behind: post-harvest food losses and the use of agricultural residues. Harvested crops may be subject to damage or loss, which occurs during transfer from the land to the consumer. Even with sophisticated technology, 10-30 per cent of vegetable production is lost between harvesting and consumption in the United States. About 10 per cent of the world's harvest of cereal grains is wasted. If this figure could be reduced even to 8 per cent, about 22 million tons of grain would be saved each year, enough to feed 60 million people (9).

21. Technologies to reduce such losses have been developed in the past few years, but there is still a need for more efforts, especially in the developing countries. Throughout the world, farm crops leave substantial residues, the extent of which is seldom appreciated. Over the world as a whole, about 1,700 million tons of cereal straw and 50 million tons of sugar-cane tops are produced annually, little of which is utilized (9). Such

Figure IV. Relative importance of human labour, animal power and tractors in agriculture



Source: As for figure I.

remains may be returned directly to the soil, but in many areas maize, rice and wheat straw and sugar-cane residues are burned, with a loss of the nutrients they contain and the creation of air pollution. Opportunities to use and recycle agricultural residues more efficiently and beneficially are enormous, and limited only by lack of incentives and appropriate research and development (9).

III. ENVIRONMENTAL IMPACTS OF MODERN AGRICULTURAL TECHNOLOGIES

22. From a technical point of view, agricultural production systems can be viewed as consisting of three interrelated components: resources, technology and environment. The quantity, quality and terms of availability of resources condition the kinds of technology available to farmers and their choices among them. The technologies employed, in turn, may damage the environment, generating demands for policies to reduce the damage, and they may also affect the future terms of availability of resources. The realization that resource availability may place significant constraints on the future of croplands sharpens the need for care in selecting agricultural technologies which might lead to yield improvements.

23. Further expansion of agricultural land is constrained in many parts of the world. In tropical Africa, for example, agricultural and livestock development is severely hindered because of such diseases as river blindness (onchocerciasis) and human and animal trypanosomiasis. The latter renders livestock production virtually impossible over some 10 million square kilometres of high-rainfall areas—45 per cent of all the land in sub-Saharan Africa. In arid regions, shortage of water for irrigation constitutes a major constraint on further expansion of the cropland area.

24. Increasing pressures to expand the land under cultivation in certain areas have led to serious environmental consequences. Cultivation on steep hillsides and increasing rates of deforestation, especially in the tropics, have led to soil degradation, declines in productivity and desertification. Recently, world-wide excessive soil loss has been estimated at about 22,500 million tons each year (31). Further information on soil degradation and desertification appears in the annual UNEP state-of-the-environment reports for 1976 and 1977, the review of the state of the world environment conducted for the tenth anniversary of the Stockholm Conference, and the recent UNEP assessment of desertification (3, 4, 9, 32, 33).

25. In the tropics, where the areas are biologically richer than in temperate zones, land clearing can cause the destruction—perhaps the extinction—of plant and animal species. The draining of inland wetlands for conversion to agricultural uses can have detrimental effects on fish, wildlife and wetland habitats. Increased agricultural use of estuarine areas, the nurseries for most of the coastal fish stock, may affect bay, river mouth and shallow coastal habitats (34).

26. Water for irrigation is becoming more and more valuable because of the increasing cost of irrigation projects and the limited supply of good-quality water. Excessive irrigation wastes large amounts of water, leaches out soil nutrients and micro-nutrient trace elements, and creates problems of secondary salinization and alkalinization, which have damaged millions of hectares of productive lands. It is estimated that the irrigated land area will double by the year 2000, and the problems of salinization and alkalinization are likely to increase. In several regions of the world badly designed irrigation schemes have often created favourable ecological environments for such water-borne diseases as schistosomiasis, liver fluke infections, filariasis and malaria. These diseases are not new,

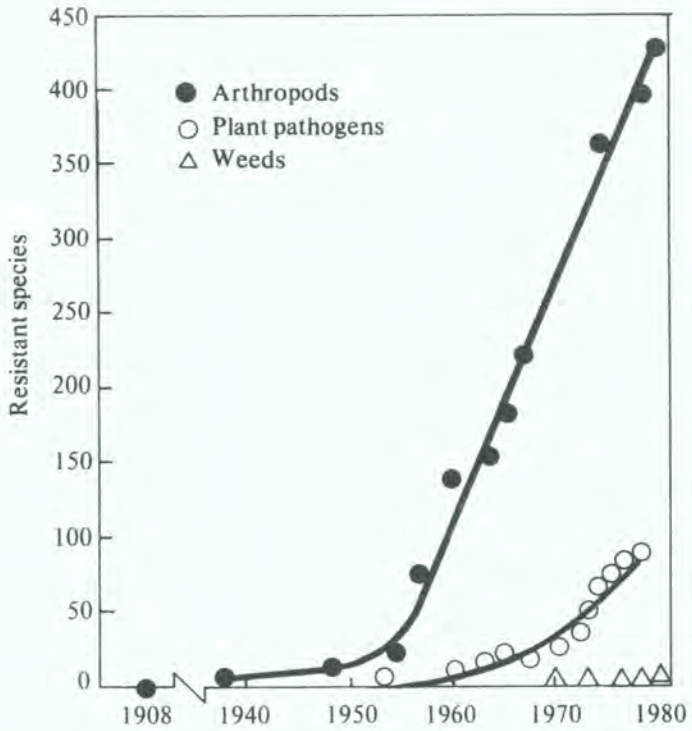
but their incidence has markedly increased with the introduction of various water management schemes. In addition to contributing to health hazards, dams built for irrigation and other purposes pose other ecological and environmental problems (35).

27. Ground water is extensively used in some parts of the world for irrigation. Excessive exploitation of ground water has led to the depletion of resources in several areas where due consideration was not given to natural replenishment rates. A further possibility is deterioration of the quality of the water through, for example, encroachment of saline water. The net result in many cases is that after a short period of increased agricultural output, yields drop significantly, and in some cases farming has had to be abandoned.

28. Excessive use of fertilizers has created a number of environmental problems. Chief among these problems are the contributions of phosphate and nitrogen fertilizers to eutrophication of surface waters, and the excessive concentration of nitrogen compounds in water and the atmosphere. Ground water in many regions has been contaminated with nitrates: the high nitrate levels (over 40 milligrams per litre) in wells in the Mosel valley in the Federal Republic of Germany have been attributed mainly to the application of nitrogenous fertilizers in vineyards; nitrates have also contaminated ground water in the Central Sands region in Wisconsin in the United States (36). Nitrate levels in many rivers have followed a rising trend over the past two decades (9). If present in excessive amounts in drinking-water or food, nitrates may pose hazards to health (9). In some areas where fertilizers are used in excessive amounts, the law of diminishing returns has been found to apply. Although the biological constraints on fertilizer responsiveness can be pushed back with continued plant breeding, further declines seem inevitable. These negative effects of excessive fertilizer use can largely be rectified if fertilizers are applied properly in the correct quantities needed by plants.

29. The continued large-scale use of pesticides has led to the appearance and proliferation of resistant strains of pests, as a result of the operation of natural selection. Increasing the dosage of pesticides merely delays the evolution of resistant races. The application of different types of pesticides has led to the evolution of pests that are immune to a wide array of chemicals (see figure V). FAO reported in 1980 (37) that 392 species of arthropods (insects, mites and cattle ticks) had become resistant to pesticides. About 50 species of plant pathogens had so far been reported resistant to fungicides and bactericides, and 5 weed species resistant to herbicides. Continued use of pesticides may kill non-target species, including useful organisms that could naturally keep the pest population down. The increased use of pesticides has also caused a number of well-documented environmental problems: pollution of soils through pesticide residues, contamination of surface and ground water, extinction of many insect, bird and other species, contamination and build-up in human food chains, and the resurgence of some diseases, such as malaria, through the evolution of resistant strains of mosquitoes. The environmental aspects of pesticide use are discussed in the UNEP state-of-the-environment reports for 1977, 1981 and 1982 and in a study by the World Resources Institute (4, 8, 9, 38).

Figure V. Chronological increases in numbers of pests, plant pathogens and weeds that became resistant to pesticides



Source: Based on M. Dover and B. Croft, *Getting Tough: Public Policy and the Management of Pesticide Resistance*, Study No.1 (Washington, World Resources Institute, 1984).

30. Besides its economic and energy costs, increased mechanization accompanying the "green revolution" has caused a number of environmental impacts, especially in ecologically sensitive areas. Compaction of agricultural and forested soils is a concern throughout the world whenever the level of mechanization is high. It was estimated in 1971 that crop yield reductions due to soil compaction ranged from 1 per cent in the northern United States to 10 per cent in the southern United States, resulting in an annual economic loss in excess of $1 billion. In 1980, the estimated crop loss was valued at $3 billion (39). These losses result from reductions in infiltration of water into and through soils, reduced effectiveness of drainage, reduced plant rooting depth, increased incidence of disease and reduced root efficiency. Farm mechanization in developing countries in which draught animals are replaced by machinery not only involves high capital and operational costs but also leads to the loss of inputs of animal droppings, which are valuable organic fertilizers. These have to be replaced by increasing amounts of costly chemical fertilizers, which create a number of environmental impacts (see paragraph 28 above).

31. Almost all of the steps which have led to the enormous increase in agricultural productivity in the last 30 years have a high energy requirement. This is particularly true of mechanization in agriculture and in fertilizer production. Agricultural production, excluding food processing, storage and transport, accounts for 4.5 per cent of total commercial energy use in the developing countries and 3.5 per cent in the developed countries (15). FAO has estimated (15) that the total commercial energy consumption in agriculture in the developing countries will increase by almost 50 per cent between now and the year 2000. Fertilizer will account for about 60 per cent of this increase, while the rest will be shared by mechanization, irrigation and pesticide use. There is considerable scope for conserving the fossil fuels used in agriculture and increasing the efficiency of energy utilization. One approach is to support and promote the wide use of different renewable sources of energy, especially in the developing countries: organic farming, solar irrigation, wind irrigation, solar crop drying, and so on. Another is to price all inputs in the agricultural system at values based on long-term supply and demand considerations, so that farmers will appreciate their true value and strive to use them in a non-wasteful manner.

32. The extensive use of HYVs of seeds leads to a marked decrease in genetic diversity. This causes two kinds of problems. First, the uniformity of the genetic background of HYVs opens up the possibility that a new disease or pest to which they are not resistant could sweep through an entire area, causing a large crop failure. The second problem is that the reserves of genetic diversity that allow breeders to produce varieties resistant to new diseases and other stresses are being lost as farmers in the developing countries, who grew many varieties and thus were a major source of genetic variability, switch to HYVs (40, 41, 42).

33. Some of the limitations of HYVs that have received increasing attention in recent years stem from their dependence on the presence of a whole package of complementary inputs (water, fertilizer, pesticides, etc.) which are not always readily available in developing countries. In areas with conditions favourable to the adoption of the new varieties, especially as far as water availability is concerned, the use of the new seeds spread rapidly. In areas with less favourable conditions, the new varieties offer little or no advantage over traditional farming methods (5, 43).

34. Furthermore, HYVs of grains (e.g. rice) that have been produced so far have not delivered the range of adaptability to agro-climatic conditions that they promised, and they have failed to outperform the traditional varieties in conditions where inputs of water, fertilizer, and pesticides have not been optimal. The performance of rice in the best national programmes in rural Asia is still far below what has been achieved in the temperate industrialized regions. Furthermore, the gap between potential and actual production levels is very wide: the potential yield in temperate zones is 15-17 tons per hectare, while the actual yield is only 25 to 40 per cent of that, i.e. 4.5-6.0 tons per hectare; in the humid tropics, the potential yield is 13-15 tons per hectare, whereas the actual yield is 10 to 20 per cent of that, i.e. 1.5-2.5 tons per hectare (43).

35. A major socio-economic impact of the "green revolution" has been the shift of farmers, in some developing areas, from the cultivation of traditional indigenous crops to the new HYVs to achieve economic gains. This increasing neglect of indigenous crops

has caused nutritional problems in some areas, and has also led to marked increases in the prices of such crops. In addition, in some developing countries, especially in Africa, societies have been shifting from the native crops like yams, cassava, millet and sorghum to consumption of wheat, which is imported through aid programmes and/or purchased and subsidized by Governments. This has greatly increased the dependence of some countries on grain imports. This situation can be rectified only through the introduction of appropriate and environmentally sound technologies to improve the yields of indigenous crops.

IV. EMERGING AGRICULTURAL TECHNOLOGIES

36. Existing agricultural technologies are being improved, or are being applied in new situations, in attempts to increase food production and to reduce both costs and adverse environmental effects. Among the modern and emerging agricultural technologies which have a potential effect on the environment are: conventional plant breeding, genetic engineering of plants, biological nitrogen fixation, increased photosynthetic efficiency, increased mechanization, minimum tillage, organic farming, monocultures and polycultures, sequential cropping, expansion of irrigation and improved irrigation technologies.

37. Many of the current constraints on production cannot be removed by traditional plant breeding techniques. Genetic materials with tolerance to some of the most serious crop pests and diseases and other production constraints have yet to be discovered. The hope for the future is that modern biotechnology will help provide the cultivars needed to overcome some of the production constraints: excess salt in soil or water, very acid soils, drought, high and low temperatures, etc.

38. Plant genetic engineering, that is to say the manipulation of plant genes, opens up possibilities for extending new genetic information to diverse plant species, overcoming the limits of conventional breeding programmes. However, it should not be considered as a technology that will wholly replace plant breeding. Rather, it should be used along with existing methods in an integrated manner, each being used when it will be most effective and economical. If genetic engineering techniques can be mastered, it will be possible to make use of them in the design of plants that are hardier, more nutritious or less expensive to produce, or offer higher yields. Other possibilities include plants that can thrive in marginal conditions, on soils that are very salty, very acidic, very wet or very dry (45). The successful application of genetic engineering to plants will require fundamental breakthroughs in the understanding of gene expression and regulation, as well as increased knowledge of plant physiology, biochemistry, development and metabolism. It is too early to assess with accuracy either the potential or the limitations of genetic engineering as far as crop improvement is concerned. At this stage, gene transfer is not expected to have a significant effect on agricultural production practices until the late 1990s (45).

39. Efforts are now under way to apply genetic engineering technologies to specific agricultural problems. For example, the herbicide Atrazine is used to kill weeds in maize

fields. Maize can tolerate Atrazine. However, where maize is planted in rotation with soya beans, the latter are susceptible to residues of Atrazine and their yield is affected. An Atrazine-resistant soya bean would be ideal for growing in rotation with maize. Although some Atrazine-resistant strains of plants have been created by classical plant-breeding methods, the development of such strains is not feasible with many crops. The most powerful technique will be to transfer the resistant gene into a crop plant using recombinant DNA technology (45).

40. Tissue culture—the multiplication of plants through *in vitro* micropropagation—holds special promise. It produces plants that are genetically identical in every respect with the parent plant. Tissue culture permits very much faster multiplication rates than those attainable by seeding or conventional propagation techniques such as budding and grafting. Moreover, the genetically identical material derived from these cultures gives uniformity of yield, quality and rate of ripening.

41. Nitrogen is an essential plant nutrient and a key determinant of crop productivity. Most plants are unable to draw the nitrogen they need directly from the air, and must therefore obtain it in combined form from the ground. Hence they depend entirely either on fertilizers or on bacteria capable of fixing nitrogen from the atmosphere. These bacteria, which live freely in the soil or are found in the roots of certain plants (mainly legumes), fix considerable amounts of atmospheric nitrogen using energy extracted from organic matter in the soil (free-living bacteria) or produced by the host plant (symbiotic bacteria). Biological nitrogen fixation through micro-organisms has traditionally been achieved by introducing legumes into crop rotation. Farmers have long grown the water fern Azolla in rice fields; it provides a habitat for blue-green algae that help supply the rice with nitrogen. It is estimated that the fixation of atmospheric nitrogen by well-nodulated soya beans can supply between 25 and more than 50 per cent of the total needs of the crop.

42. Agricultural yields can be sustained at tremendous savings if biological nitrogen fixation can be improved and extended to major crops, such as maize and wheat, that now depend on costly nitrogen fertilizer. Therefore, researchers are looking into the possibility that the genes for nitrogen fixation present in certain bacteria, such as *Klebsiella* and *Rhizobium*, can be transferred to the major crops using genetic engineering techniques (45). Root organisms such as mycorrhizae can improve the ability of plants to utilize soil phosphorus and other mineral nutrients, and can increase plant resistance to drought and salinity. Improved understanding of the association between micro-organisms and plant roots may allow plants to obtain more of the phosphorus they require from native soil sources rather than fertilizers.

43. Through photosynthesis, plants are able to produce their own organic matter from carbon dioxide, water and solar energy. Yet the efficiency of photosynthesis, expressed as the ratio between chemical energy fixed by plants and the energy contained in the light rays falling on the plants, is less than 1 per cent. Such a low rate should be capable of improvement. The common limiting factors are: light intensities, carbon dioxide concentration, water availability, supply of nutrients, respiration (light and dark) and response of plants to stresses (46). Utilizing available knowledge of the characteristics of

plants and of photorespiration may allow the breeding and selection of more efficient photosynthetic plants (30, 46).

44. Given adequate solar radiation, soil nutrient availability and irrigation, increased atmospheric carbon dioxide should act as a fertilizer for crop plants, raising both photosynthetic production and the efficiency of water use. Greenhouse experiments have indicated that a doubling of carbon dioxide under good crop management can increase biomass yields by about 40 per cent (30). Structural adaptations in farming systems will be necessary, both to take advantage of the favourable consequences of increased carbon dioxide and to tackle its negative repercussions.

V. ENVIRONMENTAL IMPACTS OF EMERGING AGRICULTURAL TECHNOLOGIES

45. Genetic engineering can affect not only what crops can be grown, but where and how they are grown. It usually acts in conjunction with other biological and mechanical innovations, whose deployment is governed by social, economic, environmental and political factors. Although our knowledge of the environmental consequences of plant genetic engineering is in its infancy, researchers and the public are becoming increasingly concerned about the safety of the new technology. One cause for such concern is the risk posed by the release of novel organisms into the environment. The introduction of any species into an ecosystem it does not normally inhabit can have unexpected negative results. Guiding or perhaps accelerating the course of evolution can lead to changes which disrupt an ecosystem and, hence, may undermine man's reverence for life.

46. The introduction of genetically engineered plants, like the introduction of cultivars through normal plant breeding, should have beneficial environmental effects—for example, the reduction of chemical fertilizer and pesticide use, increased tolerance to salt and drought, and so on. However, if drought tolerance leads to the expansion of dryland cropping into ever-drier regions where rainfall variations from year to year are extreme, increased wind and water erosion could result in severe soil degradation during dry years. The introduction of salt-tolerant cultivars could prompt increased use of saline water for irrigation, with the subsequent contamination of shallow ground water and increased salinization of soils. This in turn would narrow the choice of crops for cultivation in rotation. Increased tolerance to herbicides could make it difficult to eradicate crop plants that have become weeds.

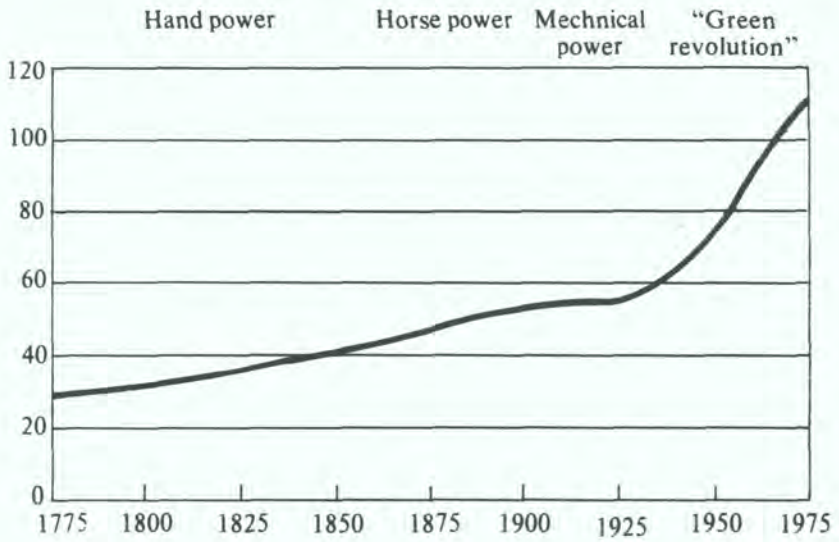
47. The environmental impacts of improved biological nitrogen fixation should all be beneficial, with perhaps minor exceptions. Yields should rise, thereby increasing crop vegetative growth and providing protection against water and wind erosion in addition to making crop rotations more effective and reducing the need for commercial nitrogen fertilizers. In turn, the reduced fertilizer use should diminish the likelihood of excessive nitrogen applications and of subsequent pollution of ground and surface water supplies. With certain high-value crops such as vegetables, biological nitrogen fixation may not lead to any significant reduction in fertilizer use.

48. The introduction of minimum tillage should generally be highly beneficial in reducing soil erosion. There are, however, two main potentially adverse effects, one arising from greater insect and disease presence in crop residues (which may require greater use of pesticides), and the other from heavy use of herbicides to control weeds. Herbicides are indispensable for minimum tillage to be successful, but they have several adverse impacts on the environment.

VI. THE THIRD AGRICULTURAL REVOLUTION

49. The world will have to increase its agricultural production to feed a human population which is now projected to reach some 6.3 billion in the year 2000, and must somehow accomplish this without affecting the environment adversely or the perpetuity of natural resources too seriously (36). To meet such a challenge, rich and poor countries should work together to develop and pursue a joint policy. As both groups of countries are faced with the energy crisis and increasing degradation of their environment, they have a common interest in laying the foundations for what might be called the "third agricultural revolution" (47). This revolution should be based on the introduction of environmentally sound agricultural development to achieve sustainable yields, and should incorporate the appropriate elements of its predecessors: the agricultural revolution of the seventeenth and eighteenth centuries, and the technological revolution of the early twentieth century.

Figure VI Chronological increase in farm productivity (1967 =100)



Source: Based on H. Calvin, "Basic chemical research and future food supplies", *Chemistry and World Food Supplies, CHEMRAWN II*, G. Bixler and L.W. Shemilt, eds. (Los Baños, Philippines, International Rice Research Institute, 1982).

50. Agricultural practices which lead to environmental degradation will trigger or exacerbate the neglect of land and of rural development, prompting an increase in rural-urban migration. This in turn will aggravate the already dire problems of urban areas, and—most importantly—will negatively affect indigenous food production, thereby increasing national dependence on imported food. Ultimately, this will create or aggravate national instability. It is therefore in the interest of national stability and security that countries should pursue the development and implementation of environmentally sound agricultural development plans.

VII. RECOMMENDATIONS FOR ACTION

A. Research needs

51. A great deal of research activity is under way in many research centres around the world to study ways and means of increasing agricultural productivity. A number of international and regional organizations are also supporting various research and development activities to achieve the same goal. The activities of FAO, the International Fund for Agricultural Development, UNEP and bodies like the International Board for Plant Genetic Resources (IBPGR), the Consultative Group on International Agricultural Research (CGIAR), the International Rice Research Institute (IRRI), the International Centre for Maize and Wheat Improvement, the International Centre for Insect Physiology and Ecology (ICIPE) and several others are well documented. However, there is still a great need for accelerated research and development efforts, at the national and international levels, to develop appropriate and environmentally sound agricultural practices and technologies. Special emphasis should be given to the modernization of indigenous technologies.

B. Other lines of action

52. Several lines of action, at the national and international levels, are urgently needed to achieve sustainable agricultural development. The major actions are outlined below.

1. At the national level

53. National development plans should emphasize the formulation and implementation of environmentally sound agricultural policies and practices. Priority should be given to conservation and the non-wasteful use of resources. In this respect, special attention should be given to:

(a) The formulation and implementation of national soil conservation policies;

(b) The development of national water management plans;

(c) The formulation and adoption of measures—regulations, incentives, pricing and control mechanisms, etc.—to conserve different agricultural resources;

(d) The further development and modernization of indigenous agricultural technologies;

(e) Environmental impact assessment of new local and imported agricultural technologies;

(f) Education and training of farmers and agricultural workers;

(g) Efforts to enhance public awareness about the environmental costs of unsound agricultural development, so as to encourage the conservation of resources and the non-wasteful processing and use of products;

(h) The establishment of national gene banks to foster the preservation of indigenous crops and wild plants;

(i) The protection of primitive cultivars and wild species within their native habitats;

(j) The development of plans for the rational use of agrochemicals and energy in the agricultural sector;

(k) Continuous monitoring of the quality of soils and irrigation waters, to make it possible to deal with deteriorating situations as soon as they are detected;

(l) Reduction of post-harvest losses;

(m) The development of technologies which make use of agricultural and agro-industrial residues;

(n) Encouragement of the social groups concerned—farmers' associations, non-governmental organizations, and so on—to participate in the formulation and implementation of environmentally sound agricultural policies and practices.

2. At the international level

54. The following measures are required at the international level:

(a) Governments should work towards the rational and environmentally sound utilization of shared natural agricultural resources;

(b) Co-operation between developed and developing countries and among developing countries themselves should be strengthened, with particular emphasis on facilitating the transfer of appropriate and environmentally sound agricultural technologies and ensuring the unrestricted movement of special varieties of seed, germ-plasm, traditional cultivars, and so on;

(c) Bilateral and multilateral agricultural aid should be geared to enhancing environmentally sound agricultural policies and practices and countering environmentally destructive and non-sustainable approaches;

(d) There is an urgent need to facilitate exchanges of information on modern and emerging agricultural technologies and their environmental impacts, in which existing mechanisms for information exchange, such as INFOTERRA, the FAO International Information System for the Agricultural Sciences and Technology (AGRIS) and others, could play useful roles;

(e) The global monitoring networks within GEMS which are concerned with assessment of human exposure to chemical substances in the environment—water, air and food—should pay special attention to monitoring the effects on human health and ecosystems of emerging agricultural technologies.

Part Two

POPULATION AND THE ENVIRONMENT

I. INTRODUCTION

1. The International Conference on Population held at Mexico City in August 1984 recognized that a major immediate challenge for population policy was "the disequilibrium between rates of change in population and changes in resources, environment and development" (48). It also observed that "in many countries the population has continued to grow rapidly, aggravating such environmental and natural resource problems as soil erosion, desertification and deforestation, which affect food and agricultural production" (48). This global assessment provides a perspective for consideration by the Governing Council of the 1985 state-of-the-environment topic of population and the environment.

2. Population growth is outpacing the capacity of a number of developing countries to provide for their economic and social well-being. The pressures thus generated are depleting natural resources faster than they can be regenerated, and reducing their productivity, and hence are undermining development.

3. There is no simple correlation between population and the environment. Population, environment and development factors interact in different ways in different places. Not only the pace of development, but its content, location and the distribution of its benefits determine, in good measure, the state of the environment. These factors also influence the growth and distribution of population. Environmental resources provide the basis for development just as environmental factors constitute part of the improvement in the quality of life that development is meant to bring about. Similarly, the size of population, the rate of its growth and the pattern of its distribution influence the state of the environment, just as they condition the pace and composition of development.

4. Population growth need not necessarily lower levels of living, impair the quality of life or cause environmental degradation. Global and historical assessments of the

Earth's capacity and man's ingenuity to produce goods and services have prompted some experts to project an optimistic outlook (49). Growth of world population has, in the past, been accompanied by a steady increase in the world's capacity to provide for the necessities and amenities of human life. People have to be fed, clothed and provided for, and this is achieved by people themselves. In that process, they use and develop the resources of the environment. Yet, just as some patterns of development have improved the human environment, others have tended to degrade it, at times irreversibly.

5. In a large number of countries, notably in Africa, rapid growth of population over the last decade has been accompanied by a steady decline in average levels of living, as reflected in per capita incomes. It has also been accompanied by a decline in the quality of life, as measured by indicators such as per capita availability of food and nutrition, drinking-water and sanitation. Furthermore, the last decade has witnessed an increase in the number of people with inadequate or no access to essential services (such as health care) or amenities (such as shelter) in Africa, Asia and Latin America.

6. On the other hand, even though, over some stretches of the decade, rates of economic growth appeared to be satisfactory in some developing countries, they did not necessarily bring about noticeable improvements in the levels of living of the majority of their peoples. Environmental conditions in rural as well as urban areas in many developing countries have deteriorated as their populations have grown. Generally speaking, the quantity and quality of their natural resources, which provide the foundation for sustained development, have steadily declined (26, 50).

7. Projections of population, development and environmental trends over the next 20 to 50 years make it clear that, in a number of developing countries, the intended demographic transition to stable populations, with low birth and death rates, may not come about unless co-ordinated measures are taken now, based on a recognition of the interrelationships between people, natural resources, environment and development.

8. A fundamental concern shared by population, environment and development policy makers is the responsibility of present generations to provide for the well-being of generations that will follow them. Patterns of development have to be such as to meet this concern. A major goal of policy makers in all three fields is to achieve a better quality of life and rising standards of living, with sustainable use of the natural resource base. Recognition of the potential mutual support between population and environmental policies should facilitate earlier and smoother achievement of the demographic transition to population equilibrium as well as of the chosen development goals.

9. Understanding of the relationship between population and environmental factors has grown since the Bucharest Population Conference of 1974. An examination of the manner in which population and environmental policies have been evolving over the last decade or so reveals certain parallels as well as an emerging consensus on the nature and scope of interrelationships between people, resources, environment and development, and on the best way of addressing them so as to improve the quality of human life in sustainable ways. Some countries have made definite progress towards their population goals and their environment and development goals alike. The experi-

ence they have gained needs to be extended, as appropriate, to other countries that could learn from it. The present report is guided by such a pragmatic approach.

II. ISSUES FACING POPULATION POLICY MAKERS

A. Uncertainty in population projections

10. Population projections are not predictions. Though they can be useful for the purpose of estimating likely environmental stress or development needs, they may not be borne out by actual events if the assumptions underlying them prove incorrect (51). For this reason, demographers often make three sets of estimates (high, medium and low) to indicate the range of uncertainty involved. The likelihood of a reasonable correspondence between projected and actual trends depends on the time-scale of the projection, among other things. For example, present projections of population size for the year 2000 are likely to be very close to the mark, because all those who will be aged 15 and above at that time have already been born. Uncertainties in long-term projections also arise because greater awareness of the magnitude of the challenge implied by projected population growth may lead to implementation of demographic policies that would, in fact, render the projections invalid. Moreover, long-range population projections tend to be based on the assumption that fertility trends in all countries will converge upon replacement levels. This is an assumption that finds no support in current fertility trends in several developing countries. On the other hand, the very large future populations expected may not materialize because the resource base might not be adequate to support such large numbers and, consequently, the levels of mortality might be higher than estimated.

B. Global outlook

11. It took more than a million years for the population of the world to reach its first billion, whereas the second billion was added in only 120 years; the third billion in 32 years; and the fourth billion in 15 years (50). Large additions are being made to already high levels of population over short periods of time: population growth during the last three decades has been larger than the entire world population in 1900.

12. The 1984 Conference on Population took note of the projection that, by the year 2000, the world population would be 6.12 billion (medium estimate); that is, would increase by about another 1.36 billion from the 4.76 billion of mid-1984, having already increased by 770 million over the previous decade (52). In fact, although the rate of population growth has been steadily falling over the last few years, the net absolute annual addition to the number of people is expected to increase from the present 78 million to about 90 million by the year 2000. Thereafter, with declining net annual additions, the world population may be 8.2 billion by 2025—according to the medium estimate—and reach a stationary level of 10.5 billion by 2110. The low and high estimates of the stationary population level are 8 billion by the year 2080 and 14.2 billion by the year 2130 respectively (52).

13. Population growth rates have steadily declined, both globally and in the developing countries as a group (53). While birth, death and infant mortality rates have fallen consistently, life expectancies have risen in a large number of countries. Some developed countries have already made the demographic transition to population equilibrium, as defined by low birth and death rates and high life expectancies. Many other developed countries, and a few developing countries also, show definite movements toward stationary populations (52, 54).

14. In very many developing countries, both the rate and the momentum of population growth have been such as to produce continuous absolute increases in population every year. Even if it were possible to reduce fertility to replacement levels, the momentum of the population would be such that it would continue to grow for many years. This is due to the predominance of a young age structure in most developing countries, which means that the number of couples entering their reproductive years will, for a considerable time, remain greater than the number moving out of that age group. Thus the number of births will continue to be large and to exceed the numbers of deaths.

15. Fertility and birth rates in most developing countries have, in the past, been much higher than the rates in pre-modernization Europe and, although their mortality rates have fallen dramatically and consistently since the 1950s, their population growth rates are still sizeable and operate on a much larger total population than did the rate prevailing in the industrialized countries during the early stages of their modernization (26, 50, 54).

C. Regional differences

16. In terms of the availability of natural resources and the technology and investment needed, the world has the capacity to provide for the projected global population. In actual fact, however, there is not necessarily any correspondence between the projected population levels by regions, or by countries, and the physical or economic capacity to meet the requirements of those populations. Some consideration of interregional and intraregional differences in population trends is thus essential to identify the urgent needs for international co-operation in this field.

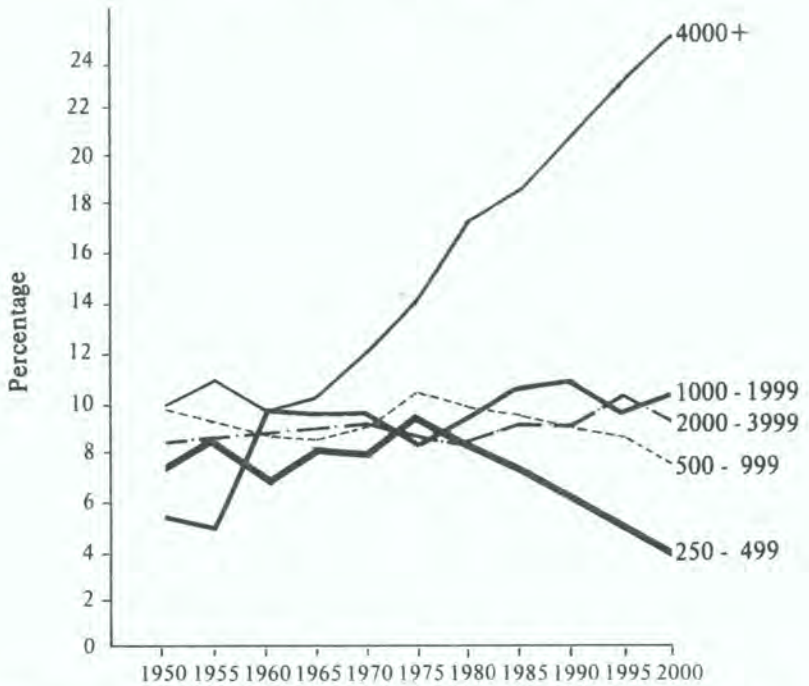
17. In East Asia, South-East Asia, Central America and the Caribbean, there have been marked declines in population growth rates. In Africa, by contrast, there has actually been an increase in the population growth rate over the last decade. Of the 58 countries and territories of Africa, 19 show annual growth rates of 3 per cent or more, which imply that populations will double every 23 years, or even earlier.

18. Population growth rates have continued to decline in tropical Latin America, apart from a few countries; but the declines have been small. In temperate South America, population growth rates have remained nearly constant—at a moderate level—over the last two decades.

19. In Asia, growth rates show significant differences from one subregion to another. China, with a quarter of the world's population, has dramatically halved its population growth over the last decade. The Republic of Korea has, likewise, markedly reduced its population growth rate. In South-East Asia and South Asia, the declines have been small. In view of the already large population sizes and decidedly young age structures, the populations of several of these countries are expected to continue to grow

substantially. The population densities per unit of arable land, and of urban land, are already very high in most of these countries.

Figure VII. Urban population as a percentage of total population, by size of city*



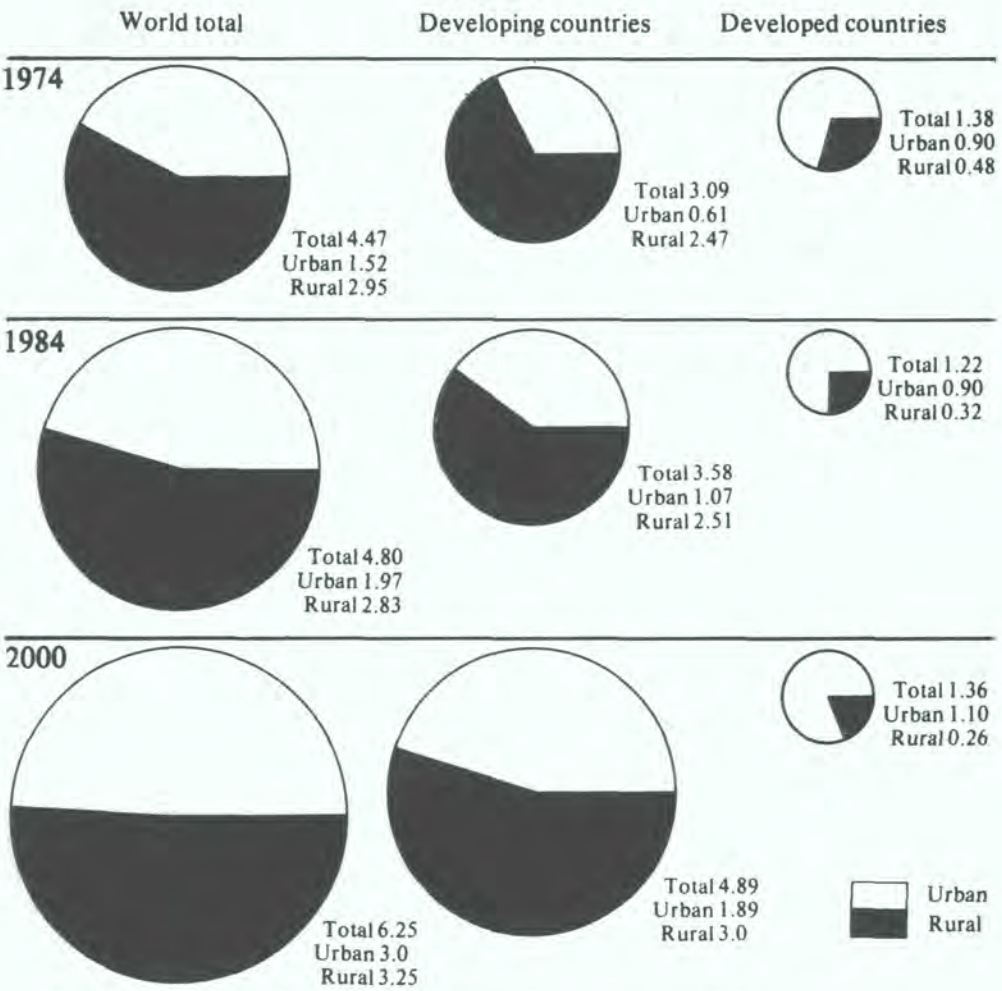
Source: Adapted from W.H. Weiche, "Life expectancy in tropical climates and urbanization", report presented to the Technical Conference on Urban Climatology for Tropical Regions, Mexico City, October 1984.

* City population (in thousands) is indicated on the right.

D. Spatial distribution

20. Another factor that is relevant to international co-operation in both population and environment matters is the spatial distribution of the population (55, 56). Figure VII shows the trends in the spatial distribution of the world's population in urban and rural areas. It is expected that the greatest growth in urban population will occur in the developing countries. If the present trends continue, by the year 2000 the urban population of the developing countries will have grown by 100 per cent. This growth would be the combined result of internal migration and natural increase. A remarkable, quite recent, phenomenon in the developing regions is the emergence of very large cities (4 million or more inhabitants). It is estimated that the proportion of the urban population residing in such cities will rise from 16 per cent in 1980 to 20 per cent in the year 2000. On the other hand, it is expected that the percentage of the urban population residing in intermediate-size cities will continue to decline significantly (see figure VIII).

Figure VIII Population distribution in urban and rural areas (Billions)



Source: Based on "Global review of human settlements - statistical annex", document presented to the United Nations Conference on Human Settlements, Vancouver, Canada, May - June 1976 (A/CONF.70/A/1/1 Add.1), table 1.

21. As for the global distribution, 80 per cent of the increase in the world's population during the last 30 years occurred in the developing countries (50). What is more, 95 per cent of the entire projected growth to 2110—prior to reaching a stationary-level population of 10.5 billion at that date (medium estimate)—is expected to take place in the countries that are currently regarded as developing (54). It is estimated that about 86 per cent of the world's people will be living in today's developing countries when the global population reaches its stationary level (52). Several developing countries will double, triple or quadruple their populations over the next 50 to 60 years. Africa's relative share of the world population is expected to more than double during the same period (26).

22. There is significant correspondence between the areas of high population density and the areas at serious risk of environmental degradation, particularly in the form of desertification, deforestation and poor access to fuelwood and fresh water (see figure IX). Areas showing signs of stress are the Sahelian countries, the Horn of Africa, East Africa, the Andes, north-western Brazil, El Salvador, Guatemala, Haiti, a large part of south-west Asia and Afghanistan, and parts of South Asia, Java and the Philippines (12, 57).

E. Consumption patterns

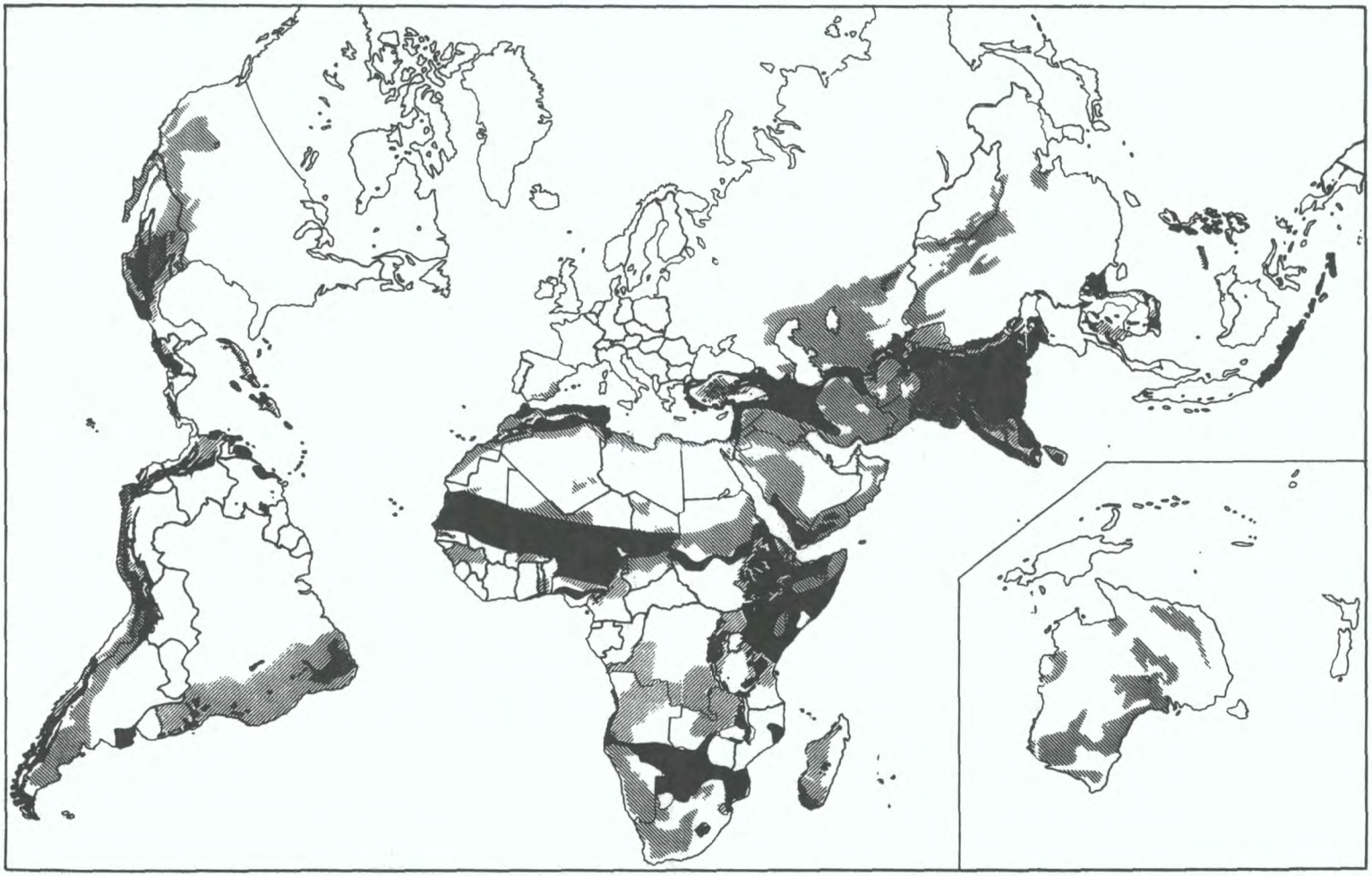
23. A significant factor which often fails to receive the attention it deserves in relation to population policy is the extent of environmental stress, including over-use of scarce natural resources, caused by patterns of consumption (58). Quite apart from the short-sighted exploitation of scarce natural resources as a result of the pressing need for immediate survival in situations of dire poverty, such resources may be wasted—or not used optimally in terms of a society's development objectives—through extravagant consumption by a few people. What is more, local environmental resources may be misused in response to the demands of resource-wasteful consumption patterns in another country. It does not necessarily follow therefore that, just because population sizes are large or population densities high, environmental stress will be intense, since the latter is determined not only by the size and density of the population but also by consumption patterns.

F. Key issues of population policy

24. Population sizes and the rates of their growth cannot be controlled independently of socio-economic development. Thus, at the 1974 World Population Conference, governmental positions tended mainly to fall into one or other of two lines of policy: (a) that family planning had a vital role to play in lowering the rates of population growth so that social and economic development might be accelerated; and (b) that an acceleration of social and economic development was urgently needed to lower population growth, because income levels and fertility were inversely correlated. Since 1974, population policies have been increasingly adopted in the developing countries, and governmental and international interest in population programmes and family planning practices has become widespread. Greater access to knowledge and means of family planning has also contributed to progress towards the desired population goals, since the very personal decision regarding family size is reached largely on the basis of existing needs and future expectations of well-being in a given socio-economic and cultural context (59). There is also a growing realization, however, that population policies are not a substitute for social and economic development policies and that socio-economic development has helped to change attitudes towards family size and fertility in many countries. Thus the International Conference on Population of 1984 recognized that appropriate population and development policies were mutually supportive (48, 60).

25. Developing countries are currently encountering serious obstacles to the achievement of the demographic transition. The developed countries achieved the transition to low rates of population growth over long periods of sustained socio-economic

Figure IX
Environmental hazards



Areas with very high or high risk of desertification

Areas with acute scarcity or deficit of fuelwood

Areas unable to support their populations at minimum levels of nutrition with low-input agriculture (1975)

Source: Based on *Land, Food and People* (Rome, FAO, 1984).

development, but most developing countries have not yet experienced any rapid or sustained socio-economic development. Moreover, these countries are, for the most part, already suffering from the environmentally and socially deleterious effects of widespread poverty.

26. The main reasons why the gap between growing populations and the environmental management capabilities needed to provide for them may be widening in several developing countries include the following (26, 50, 55, 56, 61):

(a) Major additions to large populations are occurring over short periods of time, making it hard for societies and countries to cope with the needs and demands of their people. Sizeable additional public outlays have to be made every year to provide for essential services and amenities for the extra numbers; and these are costly in terms of forgone opportunities to invest in enhancing the productivity of land and labour;

(b) In many developing countries, innovation, entrepreneurship, technological progress, savings and investment are sluggish. This is in part due to inappropriate domestic policies of economic, social and environmental management. The present world economic situation also renders it increasingly difficult for the developing countries to escape from economic stagnation;

(c) In a large number of developing countries, the benefits of economic growth have not spread as widely as would have been necessary to reduce the extent of absolute poverty. This, in its turn, has had an adverse effect on the momentum of economic growth, environmental conditions and the effectiveness of population policies;

(d) As populations have grown, the marked inequalities in land ownership and in access to essential amenities and services on account of social stratification, together with the persistence of widespread poverty, have led large numbers of people to overexploit scarce natural resources and facilities that are in the public domain. This has tended to undermine the environmental foundations of economic development;

(e) Many developing countries no longer have any good land in reserve which could be used to settle, or provide for, large numbers of extra people. What is more, even where significant untapped natural resources exist, the large amounts of public capital that would need to be invested in order to establish the infrastructure and facilities to use them are often not available;

(f) Today's developing countries, unlike the countries of nineteenth-century Europe, have not the possibility of large-scale international emigration;

(g) Patterns of urbanization and area development in most developing countries have been such that any economies of scale in the use of infrastructure and public services have been increasingly overwhelmed by the social costs of congestion, noise, air and water pollution and insanitary conditions of living. The absence, in most countries, of a clear policy to guide spatial distribution of population, including rural-rural and rural-urban migration, and promote cities of intermediate size, has resulted in settlement patterns of a kind which are not conducive to sustainable development. A large

number of small widely scattered settlements and a small number of highly congested cities are common features in many developing countries;

(h) In view of the high rates of population growth and its momentum, many developing countries are faced with the challenge of urgently introducing, and sustaining, programmes aimed at achieving optimum population growth and distribution. On the other hand, the same facts require them to make urgent provision for the well-being—in terms of nutrition, health, shelter and employment—of much larger populations than those at present existing.

G. Changing orientation of population policies

27. A number of initiatives have been taken to come to grips with the dynamics of interaction between population growth and environmental degradation in the developing countries. National population policies and programmes themselves have constituted a major course of action which has had some of the desired effect. At present, 87 countries, representing 90 per cent of the people of the developing countries as a whole, provide publicly subsidized family planning programmes. About $2 billion (1980 dollars) is spent each year on public family planning programmes in the developing countries. For every $1 of external assistance, $2 to $4 are spent by the Governments of the developing countries themselves on population programmes. Access to family planning knowledge and to contraceptives has been steadily growing. However, in many of the developing countries of Africa and western Asia, family planning programmes have not yet become widespread (54). Moreover, in several of the countries of Asia and Latin America where such programmes have, in fact, become widespread, they have not been effective in bringing about rapid progress towards the desired population goals.

28. Family planning programmes are becoming increasingly responsive to the needs and preferences of the potential users, to cultural and religious sensitivities, and to the significance of voluntary acceptance and popular participation. The programmes are extending their scope so as to encompass the spread of literacy and education, including health education and awareness-building among women (62, 63). Improvements in the social status of women and the expansion of paid employment opportunities for them have also begun to receive attention as part of population programmes. Attempts are being made to relate the dissemination of family planning information and services to the work of community development workers, co-operatives, health workers and teachers (59, 64). In many countries, such programmes have also begun to be designed and implemented as parts of health and social services programmes.

29. Actions on the fronts of national development planning and international development co-operation have also been undergoing change, notably since the early 1970s. Special attention is now being given in some countries to the provision of basic health services, water and sanitation, basic education, and expansion of employment and income-generating opportunities in economically depressed areas. International assistance to projects and programmes of rural development and social development, including population programmes, has grown steadily in both absolute and relative terms. Attempts are also increasingly being made to design and monitor development projects with an eye on their potential impacts on productivity and on the income-

earning capabilities of the poor and women. These development initiatives are expected to have second-order desired effects on the choice of family sizes and migration patterns and, consequently, on population growth and distribution.

30. Evidence concerning the direct co-ordination of population and environment policies and programmes has, however, been rather meagre. Although the interrelationship between environmental change and socio-economic development has been discussed at length since the Stockholm Conference on the Human Environment, and the connection between environmental change and population growth has been a subject of some recent writings (57, 65, 66, 67), there has been no definitive work to date on the practical application of our growing understanding of the interrelationships between people, natural resources, environment and development.

31. In 1982-1983, the United Nations Population Division carried out the fifth of a series of Population Inquiries, in the form of a questionnaire survey. About 40 per cent of the 109 countries that took part in the survey indicated that there was a need for discussion on how best to integrate population policies into social and economic development policies (68). A total of 59 countries, of which 45 were developing countries, reported that they had designated a single agency as being responsible for the formulation and co-ordination of population policies, while 81 countries, of which 62 were developing countries, reported that they had some governmental arrangement to take population variables into account in the social and economic planning process. The survey did not, however, identify the ways in which population policies and programmes had been taking account of environmental and natural resource factors. The 1984 Population Conference urged Governments "in countries in which there are imbalances between trends in population growth and resources and environmental requirements ..., in the context of overall development policies, to adopt and implement specific policies, including population policies, that will contribute to redressing such imbalances and promote improved methods of identifying, extracting, renewing, utilizing and conserving natural resources" (48). The Conference also recommended that "population distribution goals ... should be pursued to the extent that they help to achieve broader societal goals, such as ... protecting the environment and improving the quality of life" (48).

32. In short, while the linkages between population and development policies are increasingly being reflected in policy, efforts have only just begun to come to grips with the challenge of integrating population and environment policies. The Third Members' Assembly of the International Planned Parenthood Federation (IPPF) recognized that the integration of population and environmental planning would enhance the effectiveness of family planning efforts. A resolution adopted at the sixteenth General Assembly of the International Union for Conservation of Nature and Natural Resources (IUCN) in November 1984 notes that, in most countries, no serious attempt has yet been made to introduce measures for the joint management of population and natural resources (69). IPPF is now collaborating with IUCN, the World Wildlife Fund (WWF) and UNEP in preparing a supplement to the World Conservation Strategy which would reflect the linkage between population factors and conservation goals. The 1984 Population Conference suggested giving an environmental orientation to population programmes by stressing that in order "to achieve the goals of development, the formulation of national population goals and policies must take into account the need to contri-

bute to an economic development which is environmentally sustainable over the long run and which protects the ecological balance" (48).

III. POPULATION-RELATED ISSUES FACING ENVIRONMENTAL POLICY MAKERS

A. Carrying capacity

33. As populations grow, the task of providing for their needs and well-being through environmental management becomes more challenging. The concept of carrying capacity is relevant, in general terms, to consideration of the relationship of population growth to the natural resource base. It is a concept associated with the work of Malthus, which represents a general perception of the numbers of people that can be supported by the resources of the Earth. The carrying capacity would, of course, differ from area to area, and is determined, in part, by such factors as life-styles and patterns of consumption, the progress of—and access to—science and technology, and economic and social development. One aspect is the carrying capacity of animal and plant populations and their complementarity, or competition, with the needs of human beings. When an attempt is made to apply the concept more specifically, to particular ecological zones for example, several difficulties appear. The number of variables or choices involved can be very large, while other factors such as trade and the transfer of technology may significantly alter the estimates.

34. As the number of people increases, there is a growth in demand for food, water, health, sanitation, housing, energy, transport, education, recreation and the like. What is more, demand also becomes more sophisticated, as expectations of levels of living and quality of life develop, and knowledge and information about possible changes in consumption patterns become widespread.

35. The capacity of the developing countries to produce food, and its geographical distribution, has recently been examined in connection with the growth and distribution of population, in a study on "Land resources for populations of the future" conducted by FAO, the United Nations Fund for Population Activities and the International Institute for Applied Systems Analysis (12, 57). There are, of course, limitations to a study based on strong assumptions which are used to simplify reality for the purpose of interrelating ecological, economic and human factors, and projecting likely outcomes of their interaction into the future, but the study is a significant one since the resource base of food and agricultural production in many developing countries has been showing signs of depletion and degradation. Moreover, most developing countries have been unable to transform their economies industrially, and are thus unable to import sufficient food in exchange for non-food exports.

36. The study finds that, in 1975, about 500 million people—or about 48 per cent of the people of the 117 developing countries studied—were excessive to the carrying capacity of the land, with low-input agriculture. Even with the use of intermediate-level inputs, the total population of the developing countries that could not be supported at minimum levels of nutrition would rise from 76 million in 1975 to 486 million in 2000.

37. The study further shows that potentially excessive densities of population in relation to levels of development in certain geographical areas pose serious ecological threats to agriculture. In 1975, about 2,450 million hectares, or 38 per cent of the entire area studied, were supporting more people than could be sustained thereon, with low inputs, on a long-term basis. More than 1,100 million people were living in such areas.

38. Although the *irrigated area* in developing countries could be expanded from 95 million hectares to 148 million hectares by the year 2000, *rain-fed cropland* could shrink by 544 million. The former has steadily increased, but not as fast as population. There are marked differences between countries in respect of investments in improving and sustaining the productivity of land. Very large increases in population have often occurred in areas where there has been significant land degradation and loss of agricultural productivity. Such trends have been most pronounced in sub-Saharan Africa, where agricultural productivity and per capita food production have declined steadily over the last decade. They correspond closely to the trends in environmental degradation of cropland and grassland in the region, as manifested in desertification and soil erosion.

39. *Soil erosion* now appears to have reached extraordinary proportions; it is estimated that about 23 billion tons of soil are lost annually from croplands in excess of new soil formation. If the present trends continue, almost 20 per cent of the rain-fed cropland of developing countries could be reduced to poor pasture, while other areas could become even less productive. In Africa north of the Equator, 35 per cent of such land is believed to be affected by wind or water erosion or salinization. In western Asia, the proportion is estimated at 65 per cent (26). The irretrievable loss or serious degradation of land through desertification continues at the rate of 6 million hectares annually, and the rate at which land is declining to zero or negative net economic productivity has increased from 20 million hectares to 21 million hectares a year. Desertification of rangeland is on the increase: more than 3,000 million hectares are at present affected (33).

40. Another indicator of the association of population growth and environmental change is the *availability of firewood*. There are 1.3 billion people in the developing countries who depend on firewood for fuel. The evidence available indicates that firewood is being cut faster than its rate of replenishment, most notably in Africa and Asia, the result being severe hardship to families (50, 70).

41. *Deforestation* in the developing countries has assumed grave proportions which, if not seriously attended to, will greatly undermine the well-being of the countries affected in several ways (71). High rates of deforestation entail tremendous social costs in terms of floods, soil erosion, landslides, waterlogging, siltation of reservoirs and loss of hydroelectric capacity. Moreover, they can upset the ecological balances (e.g. fresh water and soil moisture availability, changes in microclimate) of entire areas and subregions, thus depriving millions of people of their livelihood. The clearance of forests and nature reserves also eliminates species of plants, insects and animals, thus impairing *biological diversity*, whose contribution to human well-being, in medicine and agriculture for example, could be far-reaching, but is as yet little understood (72). The economic and social impacts of the loss of genetic reserves are suffered not only locally and nationally, but also globally. This is made clear, for example, by the extent of the dependence of the developed countries on the developing countries for natural products such

as dyes, resins, pectins, tannins, fats and waxes, and for pyrethrum and other natural pesticides (73).

42. *The availability of fresh water* for irrigation and industrial development has not kept pace with population growth in large areas of the developing regions. In terms of both its direct use and its role in agriculture, water availability is a constraint on the number of people that an ecosystem can support on a self-reliant basis (74). In some developing countries, wells have been drying up and ground-water aquifers are not being recharged at adequate levels, on account of excessive run-off due to loss of vegetation and excessive withdrawal of limited supplies as a result of high demand. What is more, the availability of surface water has become distinctly irregular in some developing countries—with droughts and floods alternating—in the absence of direct action for the environmental management of soil, water and forests, and as a result of rapidly growing populations and a build-up of demand pressures.

43. Notwithstanding increased governmental attention to the broadly based provision of *drinking-water and sanitation* in the developing countries over the last few years, the target of the International Drinking Water Supply and Sanitation Decade that clean water and sanitation should be provided for all by the year 2000 is unlikely to be attained, unless there are substantial changes in the attitudes of Governments, both nationally and globally, specifically aimed at its achievement.

B. Increases in the number of "absolute poor"

44. One consequence of the environmental impacts associated with underdevelopment and rapid population growth is a reduction in the productivity and income-generating capacity of people in general and an increase in the number of "absolute poor". There are hundreds of millions of people today who are unable to live in dignity as human beings because they cannot acquire the necessary food, housing, health, sanitation and education. Their numbers have grown since the adoption of the World Population Plan of Action in 1974. There were probably 750 million such people in the developing countries in 1980 and, even assuming rapid economic growth, there are likely still to be 630 million by the year 2000. If economic growth remains sluggish, the number of the absolute poor could rise to 850 million (26).

C. Increased inequality of access to productive resources

45. Another consequence of rapid population growth leading to intense competition for environmental resources is the marginalization of small-scale farmers and landless labourers. Capital-intensive and technology-intensive forms of agriculture have tended to replace traditional patterns in some countries on account of their immediate effects on the productivity of the land. A few landlords with access to these inputs have tended to extend their land ownership in the process. Increased concentration of land ownership and the displacement of labour from the land have further accentuated the pressures of people on the natural resources in the public domain, e.g. wood-lots, forests, mountain slopes and hillsides. The struggle for survival by the landless peasant and marginalized small farmers has also intensified social unrest and migration.

D. Creation of environmental refugees

46. Large-scale migrations of people in search of better economic opportunities from rural areas to the urban centres have made it practically impossible for the civic authorities to ensure adequate supplies of fresh water, sanitation and waste disposal facilities for the rapidly growing urban populations in many developing countries (75). Serious environmental degradation and depletion of natural resources have also tended to create a group of people which is uprooted from its traditional habitat because it is no longer able to earn even a minimally decent living there. Such situations can be a source of serious social and political conflict between the regions within a country, and also between countries.

E. Increase in environmental diseases

47. Major diseases and causes of death in the developing countries are mainly related to the inadequacy of clean water and environmental sanitation. Rapid population growth aggravates the pressures on limited public outlays for the improvement of environmental sanitation in rural and urban areas. The crowding of settlements exacerbates already unhygienic conditions, especially in the absence at the local level of organized programmes to improve the situation. Trachoma, elephantiasis, schistosomiasis, malaria, diarrhoea and river blindness are some such diseases. To these may be added typhoid, cholera, dysentery, gastro-enteritis and hepatitis, which are spread by contaminated water or dirty hands, as well as scabies, yaws, leprosy and conjunctivitis, diseases which are aggravated by insufficient water for washing purposes.

48. The conditions described above hamper efforts at economic development which might improve the productivity of land and of people, and reduce absolute poverty in sustainable ways. This is partly due to the fact that some public resources which could have been deployed to enhance the availability of natural resources and to purchase capital equipment are diverted to welfare measures to deal directly with the immediate effects of acute poverty. A vicious circle starts because, unless development results in an expansion of output, employment, incomes and productivity, the extent of "absolute poverty" cannot be reduced in a sustained manner, while the persistence of mass poverty places severe pressures on environmental resources, public amenities and services and infrastructure. There is thus a race between development and the destruction of resources for development, with an ever-increasing risk of irreversible damage to the resource base, as the number of the absolute poor grows in tandem with the rapid population growth.

49. To sum up the situation, in many developing countries today rapid population growth, mass poverty, environmental degradation, natural resource depletion and slow economic growth seem to be interacting with one another in ways that are harmful to both the immediate and the long-term well-being of the people (66). Although most of the immediate costs of environmental degradation are borne by the weaker sections of society in particular, in due course they are also transmitted, in various forms (e.g. slow economic growth and social strife) to the other sections. Moreover, these costs do not remain confined to the countries or regions in which they originate, but tend to be

transmitted, directly or indirectly, to other countries. Conflicts relating to management of freshwater resources, mountain ecosystems, tropical forests and coastal waters tend to have their origins in the nature and scope of the interaction between people and the environment arising from the search for a better life (76, 77).

50. *The World Environment 1972-1982*, prepared by UNEP to commemorate the tenth anniversary of the Stockholm Conference, found that environmental concerns in general, and population and environment relationships in particular, had not been satisfactorily dealt with by development models (9). The United Nations review and appraisal of the World Population Plan of Action (51) found that experience with integrating population factors into comprehensive econometric models of development was rather disappointing. Consequently, the 1984 International Conference on Population declared that "priority should be given to action programmes integrating all essential population and development factors, taking fully into account the need for rational utilization of natural resources and protection of the physical environment and preventing its further deterioration" (48). Similarly, the General Assembly of IUCN decided at its sixteenth session (November 1984) that IUCN should actively promote policies designed to attain a balance between population and resources within national conservation strategies and, through field activities, to preserve nature and natural resources (69). The environmental policy statement of the United States Agency for International Development reflects a similar recognition of the interdependence between population, environment and development factors (78). The success of regional development planning in several centrally planned economies also reflects a recognition of the linkages between population, environment and development factors (79).

IV. THE INTERFACE BETWEEN POPULATION AND ENVIRONMENT POLICIES

A. Lessons learnt

51. The experience gained by a number of developed market economies, developed centrally planned economies and developing countries in dealing with the issues of environment, population and development suggests some significant lessons. When looking to the further action that is needed, policy makers should first ascertain the suitability of the various standard approaches to their countries' specific resources, people, culture and social organization, in the light of the insights offered by the experience gained to date.

52. In the first place, population and environment interact in terms of population size. The latter encompasses both natural growth and migratory movements, which often lead to uneven population distribution, including congestion. The need thus arises to manage population size and growth by means of family planning, and other measures going beyond family planning, aimed at lowering fertility levels. There is also the need to manage and direct migratory movements with due regard for such environmental factors as natural resource availability, carrying capacities and man-land ratios. These policies have to take into account development needs, including priorities for resource allocation, land use allocation and the geographical spread of development projects.

53. Population and environment also interact in terms of the behaviour of people and their endeavours to meet their needs. Production and consumption patterns have an impact on the environment. They are influenced by social and cultural factors and by the prevailing levels of economic well-being or poverty. Also relevant are the processes, directions and rates of industrialization.

54. Furthermore, population factors also influence the environment in terms of the capabilities of the people. The physical qualities of strength, resilience and endurance, together with knowledge and skills, help to determine the levels of productivity and the ability to sustain the environment. Social and participatory awareness and responsibility can lead to practices of resource management and thus an increase in resource productivity through community-level action to bring about sustained improvements in the quality of life. Programmes designed and implemented at the community level may contain elements of family planning, conservation of natural resources and environmental improvement as well as measures addressed to social and economic reform, e.g. women's education.

B. Strategic issues

55. There are some strategic issues and factors which can exercise a leverage for the more effective achievement of both environment and population objectives. The aim of both population and environment policies is to bring about lasting improvements in the quality of people's lives. In order to enhance their own effectiveness, both population and environment policies have evolved in ways designed to relate better to the larger issues of social and economic development. In this evolutionary process, a certain interface between the two policies has emerged (80).

56. Measures for improving the status of women, supplying drinking-water and sanitation, generating employment and providing basic education and health care, together with programmes designed to improve the productivity and quality of natural resources, can exert leverage in a system of dynamic interaction. Hence measures to improve the effectiveness of population, environment and development policies need to take into account factors such as the following:

(a) The effects of basic education and literacy campaigns on opening up avenues of productive employment, on changes in total fertility rates, and on resource use practices;

(b) The effects of more equitable land ownership, and direct measures to improve the access of disadvantaged groups to essential services, on the conservation and productivity of natural resources, on improvement of environmental conditions and on population capabilities, distribution and growth;

(c) The effects on natural resource use practices and the quality of life in rural and urban areas of government-sponsored incentives and disincentives relating to family size, settlement and territorial development patterns, and migratory movements;

(d) The effects on per capita incomes, efficiency in resource use (e.g. fuelwood), fertility rates and environmental conditions, including natural resource availability, of rais-

ing the status of women through increased opportunities for their paid employment, better education and legislative enactment of their rights;

(e) The effects on labour productivity, incomes, infant mortality, life expectancy, family size and the quality of the environment of improved provision of drinking-water and sanitation facilities;

(f) The effects of waste-land development and the relocation of settlements from densely populated fragile ecosystems to sparsely populated and underdeveloped areas on employment, incomes, levels of living and the spatial distribution of population densities.

57. In view of the large projected absolute increases in populations over the next 20 to 40 years and the simultaneous deterioration in natural resource availability and environmental conditions that is expected in many developing countries, there is an urgent need for making population and environment policies more effective. Widespread conditions of drought and famine in large areas of Africa and the unprecedented starvation, migration in search of food, suffering and deaths that they have brought in their wake, constitute a harsh reminder of the urgency of co-ordinated action, at various levels, on the fronts of population, natural resources, environment and development.

V. RECOMMENDATIONS FOR ACTION

A. Action at the national level

1. Action in the short term

58. Public works programmes which will generate employment and, simultaneously, enhance the availability and productivity of natural resources need to be designed and implemented in rural areas experiencing acute environmental stress and population pressures. The potential of food-for-work programmes needs to be fully realized in this undertaking. Such initiatives may include the reclamation of cropland and grassland; the plantation of wood-lots and forests; building canals, wells, dikes, reservoirs and water catchments; and terracing, bunding, levelling and draining land.

59. Efforts by governmental and voluntary organizations aimed at awareness-building and the popularization of family planning need to be reinforced, at the community level, by information on the nature and prospect of environmental degradation, its relationship to population pressures, its likely impact on people's lives, and how local action can improve the situation. Such an extension of population programmes will help place them more firmly, in the minds of the people, in a perspective of sustained, environmentally sound development.

60. Priority attention needs to be given to establishing programmes of basic education for women, especially in areas that are undergoing acute environmental stress. Women must develop a full awareness of the choices available to them as regards family size and life-style in their own environment. Legislative support needs to be provided, as

appropriate, to facilitate the observance of women's rights. Improvement in the social status of women can play a pivotal role in accelerating the progress of societies towards their desired population, environment and development goals.

2. Action in the medium and long term

61. Developing countries need to identify critical areas which are experiencing, or are likely to experience, acute population pressures on environmental resources, in both rural and urban contexts. Specific development plans should be prepared and implemented for such areas, priority attention being given to the elements of: population distribution and natural increase, capital investment to restore natural resources and develop infrastructure, and community-level involvement to improve health, sanitation and other environmental conditions.

62. Monitoring and forecasting of changes in the status of key natural resources, e.g. cropland, grassland, woodland, forests, ground water and surface fresh water, need to be undertaken with particular reference to the critical areas. In addition, economic and social appraisals of the anticipated changes in key natural resources must be fed back into national and subnational development plans, especially with regard to the allocation of public investment capital and expenditure among sectors and among geographical areas.

63. Physical planning *(aménagement du territoire)*, with a view to bringing about a balanced, and broadly based, distribution of the benefits of development, should be given priority attention. Correspondingly, incentive systems for the appropriate location or relocation of industries, resettlement from fragile and vulnerable ecosystems, the development of intermediate-sized towns and the environmental management of desired modifications to relatively undisturbed ecosystems should, where warranted, be given close and careful attention.

64. Countries experiencing severe environmental stress connected with population growth and distribution need to re-examine carefully their commercial, technological, pricing and taxation policies, with particular reference to their bearing on sustained agricultural development. Factors such as the replacement of cash crops for export by food crops for subsistence, the use of efficient input mixes in agriculture (e.g. optimum use of the biological fixation of nitrogen for fertilizing purposes, employment-generating methods of tilling, sowing and harvesting rather than the use of big machines) and agricultural prices designed to ensure a reasonable return to the small farmer rather than provide unwarranted subsidies prompted by an uncritical urban bias, should be looked at again in the light of the impacts that past policies have had on the patterns of population distribution, the use of natural resources and environmental stress.

65. Tenurial reforms to improve the access of the poor to land must be legislated, where needed, and implemented with a clear intent of sustaining the quality and availability of key natural resources for the well-being of populations at the projected levels.

66. Research and development, industrial licensing, product pricing, import taxation, economic and technical co-operation and economic incentive systems for

producers and consumers need to be so designed, co-ordinated and monitored that high levels of efficiency in the use of scarce natural resources can be attained. They should actively encourage consumption and production patterns that would, for example, promote recycling, multiple uses, minimum recourse to non-renewable resources, and high efficiency in energy use.

67. Efforts need to be intensified in all developing countries, at both governmental and community levels, to effect sustained improvements in both drinking-water supply and sanitation facilities, especially in markedly deficient areas.

68. Private enterprise, and industry in particular, may identify practical ways of strongly supplementing, and complementing, governmental efforts aimed at realizing the full potential of the inherent supportive relationship between population and environment programmes.

B. Action at the international level

69. Bilateral and multilateral development assistance agencies need to take into consideration the implications of their programmes for natural resource regeneration, environmental improvement and population growth and distribution, prior to determining their composition and location. Especially in areas experiencing environmental stress and population pressures, such programmes should provide for built-in mutual support between the elements of population, natural resources, environment and development.

70. International economic and monetary problems, which have aggravated recessionary conditions in many countries, need to be addressed urgently in a spirit of global interdependence. This will facilitate achievement of the demographic transition, especially in geographical areas that are experiencing extraordinary population pressures and environmental stress. Sustained development of these areas will, in turn, further accelerate world economic development.

71. International agencies which provide support to population activities in developing countries need to give priority attention to those geographical areas which are likely to suffer acute environmental stress during the next 20 to 30 years. In addition, they should promote awareness of the linkages between population and environment factors and the need to design and execute population programmes which would respond effectively to such linkages.

72. International support to programmes aimed at arresting environmental degradation (e.g. desertification control) needs to be urgently intensified, with special emphasis on areas which are experiencing, or are likely to experience, acute population pressures. The success of environment programmes in these areas would help ensure the success of the corresponding population programmes.

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