

RESOURCES AND POPULATION

*Natural, Institutional, and Demographic
Dimensions of Development*

Edited by

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*Based on the Study Week on
"Resources and Population"
17–22 November 1991*



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The opinions expressed with absolute freedom during the presentation of the papers and in the subsequent discussions by the participants in the Study Week, although published by the Academy, represent only the points of view of the participants and not those of the Academy.

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To the memory of

*His Excellency, Monsignor Pietro Rossano
(1923–1991)*

*Auxiliary Bishop of Rome for Culture
and*

*Rector of the Pontifical Lateran University who
first presented the proposal for the Study Week
“Resources and Population” and guided the
formulation and development of the program*

The Pontifical Academy of Sciences is glad to present to a wide range of readers the results of the Study Week dedicated to "Resources and Population," held in Casina di Pio VI, in the Vatican Gardens, from 17 to 22 November 1991.

The Study Week was the first such meeting organized by an international Scientific Academy on this theme. The approach was multidisciplinary, in order to show the complex and intricate mechanisms that bring about the large inequalities that characterize the present world. Approximately fifty experts on the theme, from about fourteen different countries, participated in the meeting. They were convinced that the demographic problem must be studied with the widest possible interconnection between all the components which may contribute to define the problem and to project possible solutions. The meeting was concluded with an important address by John Paul II (here enclosed, pp. xviii–xxi), who has underlined that only in light of respect for the dignity of the human person will humankind be able to face the demographic challenge.

The theme of population and its relationship to the problem of resources (not only material but also human ones) is certainly an urgent theme, of great importance and concern. It will be only necessary to recall the International Conference on the same topic that the UN convened in Cairo in September 1994. The Pontifical Academy of Sciences wishes to offer its contribution, with this publication, to an ongoing scientific study concerning the various problems. The papers presented here address only the scientific issues. They are not intended to represent the official teaching of the Catholic Church, nor do they address the moral and pastoral issues related to the theme of the meeting. The Academy has already organized or planned numerous meetings dedicated not only to the aspect of resources (with special attention to energy and ecology problems in developing countries) but also to the demographic aspect (with meetings on the various scientific aspects of fertility and breast feeding).

The Academy is particularly grateful to Professors Bernardo Colombo, Paul Demeny, and Max Perutz, who have assumed the onerous task of editing the present volume, to Dr. Ethel Churchill, who has administered the editing, and to Oxford University Press, which has accepted the conference report for publication. Finally, the Academy wishes to remember H.E. Mons Pietro Rossano, who first proposed the Study Week, and the person to whom this volume is dedicated.

Renato Dardozzi
Chancellor, Pontifical Academy of Sciences

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Introduction

Aspects of the interface between socioeconomic change and demographic phenomena have been occasionally among the subjects discussed at meetings of the Pontifical Academy of Sciences. The Academy's decision to devote a special Study Week to the relationships between population and resources led, however, to the first sustained and systematic examination by the Pontifical Academy of this complex and still inadequately explored topic. That decision grew out of an initiative taken by one of the editors of this volume, Max F. Perutz, a member of the Academy. His proposal to address the question of the implications of population growth for human well-being was embraced by Giovanni Battista Marini-Bettòlo, then President of the Academy, who convened a small planning group to prepare the scientific program of a meeting devoted to the topic. The resulting Study Week on Resources and Population took place 17–22 November 1991 at the headquarters of the Academy in Vatican City.

“Study Week” is the Academy's designation for its specialized scientific meetings that for a week-long session of discussions bring members of the Academy who have special expertise and interest in a chosen field of study together with a select group of internationally recognized researchers working in that field. At such meetings papers prepared for the Study Week are presented by their individual authors, and followed by extensive discussion by the invited participants. Authors subsequently revise their papers in the light of the discussion; their contents remain, however, fully the responsibility of the individual contributors.

The revised version of the nineteen papers prepared for the Study Week on “Resources and Population” form the core of the present volume. The aims of the meeting that oriented the individual contributions are succinctly described in the Foreword by Professor Marini-Bettòlo. The proceedings were framed by a broad subdivision of the topic into six parts, examining, first, demographic history and global population prospects, followed by discussion of the relationships between population and physical, biological, and human resources. The substantive proceedings concluded with considerations of issues of human health and human settlement. In line with the tradition of Study Weeks, presentation of papers in each subsection was preceded by introduction of the subject matter by a participant designated by the Academy. Abbreviated versions of these introductory remarks, which do not follow a standard format, open five of the six subsections presenting the individual scientific contributions to this volume. Following the conclusion of the plenary sessions, which occupied the first five days of the proceedings, participants of the Study Week met for informal discussions in subgroups to consider four broadly defined topics: population problems, and issues related to health, resources, and economics. Brief rapporteur's reports describing some of the discussions at these group meetings are printed in the concluding section of the volume.

A special event on the fifth day of the Study Week was the audience granted by Pope John Paul II to the participants of the meeting. The address of His Holiness delivered on this occasion appears below, following the Foreword by Professor Marini-Bettòlo. The address, given in English and subsequently published in *Osservatore Romano*, is a statement of exceptional interest concerning the topic of the meeting.

At this point we would like to express our deep appreciation to the Pontifical Academy of Sciences for organizing the meeting on "Resources and Population," and for the Academy's support toward this publication. In addition to the Academy's then President, Professor Marini-Bettòlo, special thanks are due for the crucial contributions made by Ing. Renato Dardozi, Director of the Chancery of the Academy, and his colleagues at the Chancery, to the preparation and conduct of the Study Week and for their encouragement in the preparation of this volume. We also thank Ethel Churchill, managing editor of the quarterly *Population and Development Review*, who attended the Study Week and made a most valuable contribution to the editing of this book.

Finally, we express the hope that publication of the proceedings based on the Study Week on "Resources and Population" will advance understanding and further discussion of the complex issues addressed by the contributors. Although specific manifestations of population problems no doubt will change, the relevance of these issues for human well-being is unlikely to diminish in the coming decades. We also hope that accumulation of knowledge will help to clarify issues that are as yet unsettled and in due course prompt the Pontifical Academy to return to an examination of this subject with renewed vigor.

The Editors

Foreword

A Study Week on "Resources and Population" was held at the Pontifical Academy of Sciences, 17–22 November 1991. The purpose of the Study Week was to examine the relationship between resources and population, particularly within the context of mass poverty, rapid population growth, and environmental deterioration. The objective was to bring the best available scientific evidence to bear on this relationship.

Since the beginning of the twentieth century the world's population has increased threefold—from about 1.7 billion to its present size of well over 5 billion. Attempts to absorb this historically unprecedented demographic growth at an improved average level of well-being have met with partial success. Gains have been achieved through the application of human ingenuity and labor, using the advances of science to develop more effective technologies for production and for harnessing natural resources more intensively for human use.

The expansion of human population on such a scale has attendant contradictions and problems. According to a recent World Bank Report, more than one billion people—about one-third of the total population of the developing world—live in poverty, that is, their annual per capita consumption is less than US\$370. Thus, advances in human welfare, exemplified by one of the indicators of improvement in the quality of life, increased longevity, have not contributed to eliminating mass poverty. Sharply diverging rates of population growth have been accompanied by increasing disparities in income and in the quality of life between the economically more advanced countries and the so-called developing world. Concern is also warranted as to the implications of continued rapid demographic growth in many of the poorer countries, particularly those less well endowed with natural resources and, as a result of past history, lacking adequate development of their human resources.

The subject matter of the Study Week called for a historical perspective. The present status of the relationship between population and resources was investigated by taking into account past experience and observed trends—broadly those covering the last 100 years, and especially the 40 years that have elapsed since mid-century (when the global population was 2.5 billion). Discussion of future prospects probed an equally ambitiously designated time span: roughly the next 100 years, but with emphasis on the next 30 to 40 years for which trends in population, resources, and technology can be foreseen with greater confidence. The Study Week drew on insights from a diversity of disciplinary fields, and it involved experts from demography and from the physical, biological, political, economic, anthropological, religious, cultural, and health sciences.

Among the topics that were discussed, the first was the demographic dimension of the population–resources issue. Rapid population growth has been triggered by a decline in human mortality, first in the Western world, but now also experienced

in Asia, Latin America, and Africa. In the West an adjustment in fertility followed after a time lag: in every Western country in which mortality (hence death rates) declined, levels of fertility (that is, birth rates) have also fallen. This latter process has also affected or is now affecting much of the developing world, although to a varying extent and with varying speed. The result of these changes has been rightly characterized as a "demographic revolution": it has not only changed population size but is radically transforming its age structure and its spatial distribution. Rapid urbanization is one of the conspicuous aspects of these changes. Unequal rates of population growth and economic change have also generated movements of people between countries and between world regions. Thus trends in international migration were also examined as part of recent and expected future demographic change.

A second broad topic addressed during the Study Week was the past and present availability of resources and expected future trends. The concept of resources was defined to embrace not only those drawn from the physical world but also as provided by man's capacity to transform physical resources for human use: science and technology, and human skills and aptitudes at large. Attention was focused on those resources that are recognized to be the most critical for human well-being. Among physical resources these include soil, water, and energy. Among human resources, emphasis was placed on the role of education (including the changing roles of women) and on the capacity of people to cooperate effectively in social organization and economic management.

The final topic of the Study Week was the significance for human life of past and future trends in population and resources. There was particular emphasis on assessing welfare trends in a global perspective: especially international inequalities in welfare and their meaning, the conditions responsible for these differences, and the prospects of their being lessened in the coming decades. In addition, four salient aspects of social well-being were examined. These are problems that lie in the forefront of developmental concerns or are likely to become such in the near future: (1) providing employment for the young generations entering the labor force; (2) providing the elderly population with material and social support; (3) eliminating all extreme and dehumanizing forms of material poverty; and (4) providing adequate energy resources and nutritional security for all inhabitants of the earth.

Thus, the Study Week sought to identify, analyze, and understand the elements relevant to the problems of "resources" (both material and human) and "population," and to assess the situation relative to mass poverty, which, combined with rapid population growth, can seriously endanger the environment, the quality of life, and humanity itself. Understanding these mutual relationships is essential if effective development policies are to be adopted.

The Pontifical Academy, by means of this Study Week, also sought to assemble a reference base that is factual, amply documented, and as scientifically indisputable as possible, and one that can be submitted to religious authorities for their information. The objective of this Study Week was primarily that of gathering facts and findings from multidisciplinary analysis. Possible instruments and means of

intervention to counter existing North–South imbalances were, however, also examined in an atmosphere of open discussion and free exchange.

In the final instance, and with a view to countering the enduring imbalance between North and South, the Study Week sought to highlight a fundamental necessity: that of striving to ameliorate the negative effects of individual and societal egotism and to further the true well-being of mankind.

Giovanni Battista Marini-Bettòlo

Address of His Holiness Pope John Paul II to Participants in the Study Week on “Resources and Population”

Ladies and Gentlemen:

1. I extend to each of you a cordial welcome. I greet you and I thank you for having accepted the invitation of the Pontifical Academy of Sciences to take part in a scientific discussion on a problem which is of great concern to society today: the relationship between the accelerated increase in world population and the availability of natural resources.

The close connection between the world's resources and its inhabitants must be evaluated, as you have opportunely done, by also taking into account the present imbalances in demographic distribution, in movements of migrants, in the allocation and consumption of resources.

The increase both of population and of available resources varies from place to place, to such an extent that different parts of the world are presently experiencing and can be expected to experience unequal trends.

The data emerging from your research and discussions will therefore prove important and very useful in enabling the Holy See to formulate and clarify—in accordance with its proper mission and responsibilities—appropriate guidelines and suggestions. The Academy's independence and scientific competence enable it to provide a valuable service to the Church. The Church in turn can then make use of the Academy's analysis of reliable data in order to develop—in the field of her own competence and autonomy—a carefully considered judgment of a religious and ethical nature.

2. Although the starting point of your research is the current world situation, you have rightly chosen to look at the past as well. You have highlighted the causes which have produced the earth's present situation and led to the notable growth of the world population in recent decades. You have then looked to the future, in order to make certain projections based on the connection between the dynamics of demography and the dynamics of available resources, particularly with regard to their impact on the environment.

It is a well-known fact that the availability of resources is obstructed by various social, economic, and political factors, to the extent that some people fear that the point will even be reached when it will be impossible to feed all the world's people. It is important, however, not to be guided by fear; instead, what is needed is a careful evaluation of the various aspects of the problem.

3. An analysis of the different situations points to a growing diversification with regard not only to basic natural resources, but more specifically to those resources capable of actually being used by man, through the application of his intelligence,

enterprise, and labour. Science and its relative applications have made new resources available and hold out the promise of alternative forms of energy. But, centers of scientific research are not evenly spread, and the propagation of skills and technologies is conditioned, and at times slowed down, by various factors which make the practice of international solidarity difficult. Yet, such solidarity is the fundamental premise for full and balanced development.

What we are speaking of, then, is a problem of social organization and hence also a political problem. Various aspects of life in society are involved here, from family rights to the regulation of land ownership, from social welfare to the organization of labour, from public order to ways of establishing a consensus in society.

Human society is first and foremost a society of persons, whose inalienable rights must always be respected. No political authority, whether national or international, can ever propose, much less impose, a policy that is contrary to the good of persons and of families (cf. *Gaudium et spes*, 25–26; *Dignitatis humanae*, 3).

4. There is a widespread opinion that population control is the easiest method of solving the underlying problem, given that a worldwide reorganization of the processes of production and a redistribution of resources would require an enormous amount of time and would immediately give rise to economic complications.

The Church is aware of the complexity of the problem. It is one that must be faced without delay; but account must also be taken of the differing regional situations, some of which are the complete opposite of others: some countries show a massive population increase, while others are heading towards a dwindling, aging population. And often it is precisely the latter countries, with their high level of consumption, which are most responsible for the pollution of the environment.

The urgency of the situation must not lead into error in proposing ways of intervening. To apply methods which are not in accord with the true nature of man actually ends up by causing tragic harm. For this reason the Church, as an “expert in humanity” (cf. Paul VI), upholds the principle of responsible parenthood and considers it her chief duty to draw urgent attention to the morality of the methods employed. These must always respect the person and the person’s inalienable rights.

5. The increase or the forced decrease of population is partly the result of deficiencies in social institutions. Damage to the environment and the increasing scarcity of natural resources are often the result of human errors. Despite the fact that the world produces enough food for everyone, hundreds of millions of people are suffering from hunger, while elsewhere enormous quantities of food go to waste.

In view of these many different mistaken human attitudes, it is necessary to address first of all the people who are responsible for them.

6. Population growth has to be faced not only by the exercise of a responsible parenthood which respects the divine law, but also by economic means which have a profound effect on social institutions. Particularly in the developing countries, where young people represent a high percentage of the population, it is necessary to eliminate the grave shortage of adequate structures for ensuring education, the spread of culture, and professional training. The condition of women must also be improved as an integral part of the modernization of society.

Thanks to advances in medicine which have reduced infant mortality and increased the average life expectancy, and thanks also to the development of technology, there has been a real change in living conditions. These new conditions must be met not only with scientific reasoning, but more importantly with recourse to all available intellectual and spiritual energies. People need to rediscover the moral significance of respecting limits; they must grow and mature in the sense of responsibility with regard to every aspect of life (cf. *Mater et magistra*, 195; *Humanae vitae*, passim; *Gaudium et spes*, 51–52).

By not taking steps in this direction, the human family could well fall victim to a devastating tyranny which would infringe upon a fundamental aspect of what it means to be human, namely, giving life to new human beings and leading them to maturity.

It is the responsibility of the public authorities, within the limits of their legitimate competence, to issue directives which reconcile the containment of births and respect for the free and personal assumption of responsibility by individuals (cf. *Gaudium et spes*, 87; *Populorum progressio*, 37). A political program which respects the nature of the human person can influence demographic developments, but it should be accompanied by a redistribution of economic resources among the citizens. Otherwise such provisions can risk placing the heaviest burden on the poorest and weakest sectors of society, thus adding injustice to injustice.

Man, “the only creature on earth whom God willed for its own sake” (*Gaudium et spes*, 24), is the subject of primordial rights and duties, which are antecedent to those deriving from social and political life (cf. *Pacem in terris*, 5, 35). The human person is “the origin, the subject and the purpose of all social institutions” (*Gaudium et spes*, 25), and for this reason authorities must keep in mind the limits of their own competence. For her part, the Church invites the human family to plan its future, impelled not just by material concerns but also and especially by respect for the order which God has placed within creation.

7. We all have precise duties towards future generations: this is an essential dimension of the problem, and it impels us to base our proposals on solid prospects regarding population growth and the availability of resources.

The conservation of resources presupposes peaceful coexistence, since—as is generally recognized—wars are among the worst causes of environmental damage. Peaceful coexistence in its turn presupposes solidarity, which is the result of a developed moral sense. The basic virtues of social life constitute a favourable climate for world solidarity, about which I wrote in my Encyclical Letter, *Sollicitudo rei socialis* (cf. Nos. 39–40). It is mainly upon solidarity that the solution to the questions with which you are dealing depends.

8. Within this context a strong common commitment to institutional reform is needed, a commitment which aims at raising the level of intellectual and personal maturity by means of a satisfactory educational system. It will also aim at strengthening enterprise and the creation of jobs through adequate investments. The destruction of the environment caused by industry and industrial products must be reduced in accordance with precise plans and undertakings, also at the

international level. A radical effort to change the current state of affairs is now required.

This reform must be based on personal renewal (cf. *Gaudium et spes*, 24). There must be action within the sphere of education and still more in the field of the all-round authentic personal development of individuals. This will be done by educating people in awareness of the values that are proper to human beings, in order to bring about a society in which they take an active part and which offers better living conditions for the whole of humanity. This is certainly not an easy undertaking. It is a task first of all for the family, the basic unit of society. The family draws moral strength from parents' sense of responsibility, about which the Council speaks (cf. *ibid.*, 51), and which includes a balanced attitude towards procreation, an attitude which seeks to build a more united and caring society.

9. The appeal to each individual's sense of responsibility is an urgent one. So is the appeal for solidarity on the part of everyone.

The dynamics of population growth, the complexity of uncovering and distributing resources, and their mutual connections and consequences for the environment constitute a long-term and demanding challenge. It is only through a new and more austere manner of living, one which springs from respect for the dignity of the person, that humanity will be able to meet this challenge adequately (cf. *Dignitatis humanae*, 3).

In short, a renewed way of life is needed, one which will spread by way of an authentic humanism and will therefore be capable of dissuading public authorities from proposing and legalizing solutions which are contrary to the true and lasting common good. It is a manner of living which, by reflecting the real interests of the individual, will help to bring about a world in which love for others is accepted as the general and normative rule.

Ladies and Gentlemen, I thank you very much for the scientific contribution which during these days you have made to a better understanding of such pressing issues. With these sentiments, I invoke divine protection upon each of you and once more offer you a cordial greeting.

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Part I

History and Prospects

1 Introduction

BERNARDO COLOMBO

In 1951–52 at Princeton as a visiting fellow at the Office of Population Research, I enjoyed the opportunity of contact with a brilliant young demographer, John Hajnal. While attending lectures at the Department of Mathematics, he was mainly engaged in preparing documentation for a “Conference on Population Problems” to be held in June 1952 at Williamsburg, Virginia, under the sponsorship of the US National Academy of Sciences. The importance of this initiative is well known among demographers.

Hajnal produced two papers that were submitted to the conference participants (*Documentation*, 1952). The first presented the latest available information and guesses on population growth, natural resources, and economic development. The second addressed the controversies in the field. This second paper was divided into two parts: “Is there a problem?” and “Policies to influence population growth.” Both were structured as dialogues, along the lines followed by Plato and Galileo.

The fire, at the beginning, was ignited by a statement by a “First pessimist” and the opposite views by an “Absolute optimist,” and continued with assertions, objections, qualifications, by a second, third, and fourth pessimist, and a qualified optimist. The absolute optimist had the last word: “I don’t think you should ever try to influence population growth. Encouraging economic and social change and technical progress—that’s what needs to be done and nothing else.” This poured petrol on the fire and the debate was resumed with new participants, or perhaps partly with the former ones but with a new characterization: an expert in economic development, a birth-controller, a migrationist, a malicious skeptic, a solid realist, a romantic idealist, a technologist, and a slightly bored scientist whose comment was: “How can we ever come to sound decisions if our discussion continues at this level of generality?” and who concluded with the remark: “We have to get down to specifics, and we’ll probably have to start some experiments if we really want to replace speculation by knowledge.”

Those familiar with Hajnal’s writings can well imagine how rich in content and insights was the scenario he created to revive in modern garb an age-old controversy. A little more than ten years later what was fiction came to life before my very eyes. It was during the discussion of papers treating similar themes in one of the sessions of the United Nations World Population Conference in Belgrade in 1965. One after the other, those taking the floor started their speech with a declaration: “I am an optimist” or “I am a pessimist.” The sad conclusion of the Chairman was: “Many theories but few hard facts.” On the same occasion, in a background

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paper on the demographic aspects of modern economic growth by Simon Kuznets (1965), I read:

The difficulty involved lies in linking demographic trends with the institutional patterns of economically relevant behavior, which, in different ways, may be affected by these trends—in addition to whatever effects the latter may have on the relation of numbers to other available resources. Given the variety of possible qualifying conditions, it is difficult to establish unequivocal quantitative relations between demographic trends in numbers and quantitative aspects of economic growth. Thus, under some conditions higher rates of population growth may, in the long run, induce higher rates of increase in per capita product; under others, lower; and quite often we cannot tell. (1965: 23)

It is only in the extreme cases, according to Kuznets, that we have enough information to evaluate what might be beneficial and what not. So, the quoted conclusion of Hajnal's scientist—apart from the problem of designing experiments, which seems like wishful thinking in this field—could find only relatively rare applications.

If I am permitted to go on a little further with personal experiences, I might mention how surprised I was to read in the report of the Commission on Population Growth and the American Future (1972) that an active abatement policy could be by far the most important factor in reducing pollution from generated and emitted hydrocarbons, definitely outweighing the impacts of available technology and plausible alternative demographic assumptions. Or to read in a Report prepared by the Secretary General of the United Nations for the Bucharest Conference (United Nations, 1975) that the carrying capacity of the Earth could be 38 to 48 billion people, if techniques equivalent to those used in Iowa corn farming were applied to the potential gross cropped area. Or, in another paper from the same source (United Nations, 1975), I saw quoted estimates “for some 40 to 75 billion people or even more,” according to some expert's opinion. And in a paper of the Food and Agriculture Organization (FAO 1974) I noted estimates from 50 to 130 billion people—estimates that could be “even larger if based on diets involving the processing of less cereal through livestock” and “are increased still further on the basis of unconventional foods using little land in their production.” By the way, 130 billion people would mean, excluding polar ice caps and Greenland, a density of about 1,000 inhabitants per square kilometer.

Skipping a few years, I arrive at the publication by the US National Research Council (1986) of a report on population growth and economic development, referred to as a National Academy of Sciences report. Its conclusions departed substantially from those of a 1971 National Academy of Sciences report dealing with similar themes. Evidently working groups with different membership followed very distinct paths. This might mean a reassessment on a difficult subject matter, but it could also point to the influence of pre-constituted ideological orientations.

But, someone might observe, we are not expected in this volume to treat the whole matter of the relations between economic and demographic growth, but only of those between population and resources. May I note, on this point, that I like very much a statement found in the previously mentioned Report of the UN Secretary General at

the Bucharest Conference. I quote: "Though natural resources can be thought of in one sense as physical phenomena, their dynamic relationship to technology implies a metaphorical definition: resources are ideas about the way in which things can be used." In fact, in the past there was more coal and oil on Earth than nowadays, but 1,000 years ago coal was not a resource nor was oil 200 years ago. Nor is the huge amount of deuterium present in the oceans a resource at present. From this point of view one may add to the material resources, renewable or not, the human resources of knowledge, culture, attitudes, behavior, and so on, besides those of societal organization: the different fates of Eastern and Western Europe today are a dramatic example of this.

This volume starts with the lessons of history, and goes on with the framing of prospective schemes, with contributions from a variety of fields. We are too well conscious that we are moving on a thorny ground, harassed by simplistic prejudices, disturbed by political interests. We also realize that we cannot in the short compass of a single book enter in depth into case histories as implicitly called for by the scientist in Hajnal's dialogue and in the quoted text by Kuznets. I am confident that, in spite of difficulties, the contributions that follow provide fresh knowledge and add sound speculation.

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2 A Historical Perspective on Population and Resources

E. A. WRIGLEY

In all living species the size that a population can attain is conditioned by the scale of the food and other resources necessary to sustain life that are available to the population. In all species other than man the scale of such resources may be regarded as given in the sense that the population must adjust to current opportunities and limitations. These may fluctuate widely in the short term, but in the longer term they change very little except on a geological time scale. The antelope has no means of making the grass grow faster or more abundantly, nor the buzzard of influencing the size of the stock of rabbits, or the speed of their reaction to danger.

Over any but the shortest time scale the same is not true of man. With the advent of agriculture, for example, the conversion of virgin land to arable could change radically the number of people capable of finding an adequate sustenance in a given area. Or, within a settled agricultural system, the introduction of new crops, permitting, say, the elimination of fallow from the land-use cycle, could increase the yield of food and other useful raw materials from the land even though the cultivated acreage remained unchanged. Equally, of course, just as the environment can be made to yield vastly more that is useful to man than would an unimproved wilderness, so human misuse of the environment can severely deplete its ability to sustain life. The existence of a material technology in every culture, in brief, and of changes in that material technology, imply that the discussion of human population and resources must be much more complex than a comparable discussion relating to any other living creature.

The Standard of Living

The concept of the standard of living makes a convenient point of entry into a discussion of population and resources in the past. The concept serves to underline the extent of the contrast between other animals and man. All animals are apt to experience periods of plenty and periods of want, often following a clear-cut seasonal pattern, but such fluctuations relate almost exclusively to supplies of food and water. They make no claim upon the environment for other resources, or only trivial claims, such as the need for nesting materials in many bird species.

Mankind is different. Since paleolithic times clothing, shelter, and fuel have become necessities of life almost as fundamental as food itself. And with settled

agriculture a wide range of other artifacts, comprising what the classical economists termed comforts and luxuries, came to be demanded by those fortunate enough to be able to enhance their well-being by purchasing them. Moreover, apart from material objects of use to men and women, services were highly prized and eagerly purchased by the better off, thereby providing a livelihood for occupations as widely different as the barber and the bard.

What determined the standard of living of a community was the ratio between its productive capacity and the size of its population, its productivity per head. Low productivity implied low living standards. Given the normal hierarchy of human need, where incomes were low the great bulk of aggregate expenditure was devoted to the necessities of life, thereby ensuring that employment was almost exclusively concentrated in the production of food, basic shelter, simple clothing, and fuel. Higher incomes per head, by allowing a disproportionately rapid rise in the demand for goods and services other than the four necessities, resulted in a more complex pattern of employment. Joiners, glaziers, pinmakers, wheelwrights, pastrycooks, and innkeepers could find an economic footing beside the husbandmen, carpenters, and weavers who satisfied more basic wants. While no society before the industrial revolution could hope that the majority of its people would be other than poor, there were substantial differences between different times and places in the severity and ubiquity of poverty, and such differences were due in part to the balance between population and resources.

If this balance is viewed in static terms, its nature can be illustrated graphically. In the lower panel of Fig. 2.1 at point *A* population has risen to such a level in relation to resources that living standards have been reduced to basic subsistence. Any further increase will result in starvation for the marginal, additional person. At point *B* the balance of population and resources is optimal and living standards are at the maximum attainable in the prevailing circumstances of the day. Larger or smaller populations than *B* imply a reduced level of economic well-being. The falling off to the right of *B* reflects increasing pressure on resources that cannot be expanded commensurately with population, while the falling off to the left reflects the difficulties associated with a sparse population. For example, infrastructural investment in facilities like bridges and well-made roads may be feasible only where the population is sufficiently dense to be capable of generating traffic on a scale to justify the heavy initial expenditure. But without such facilities economic development may remain arrested.

In the circumstances depicted in Fig. 2.1 there is also a simple relationship between the prevailing demographic regime and the standard of living. The two panels in Fig. 2.1 illustrate the potential connection between them. The line F_1 represents a situation in which fertility is high and does not vary as population rises, what Malthus was inclined to term a "Chinese" situation (Malthus, 1798: 321–326). Where marriage for women was early and universal, for example, fertility in a preindustrial society was likely to have this character. Assuming that mortality was lower than fertility initially, population would rise but could not do so indefinitely, given the constraints upon increasing output and especially on increasing the supply

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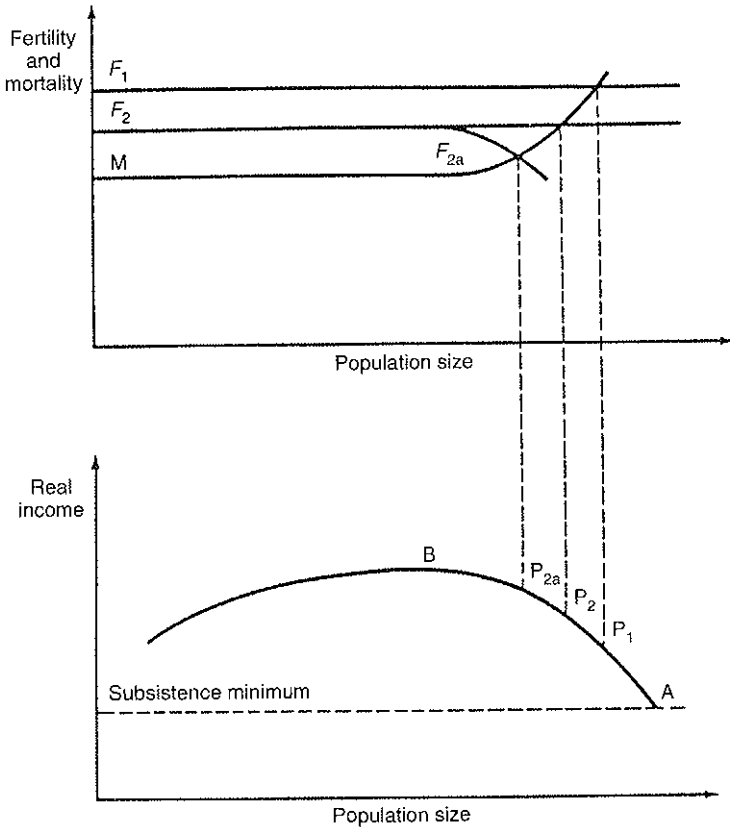


FIG. 2.1. *Schematic relationship between fertility, mortality, and real income*

of food. At some point, therefore, population growth had to cease, and could do so only by mortality rising to equal fertility as the circumstances of life deteriorated. This happens at P_1 and implies a depressed standard of living as shown in the lower panel of the figure. The line F_2 represents a lower level of fertility but one that is also invariant with respect to population size (and hence to prevailing living standards). F_2 might represent a population where marital fertility was the same as in F_1 but where women married later in life and a higher percentage of women never married. The result, other things being equal, will be a somewhat higher standard of living (P_2). Finally, F_{2a} represents a still more favorable outcome in that fertility is now also responsive to rising population density, falling as population rises, and causing population growth to arrest at an even earlier point and with further benefit to living standards (P_{2a}).

This last possibility might be held to capture something of the difference between a west European population and that of most other preindustrial civilizations. Whereas elsewhere marriage normally meant joining an existing household, in

most of western Europe it meant establishing a new one. Marriage was possible only when a couple could command, by saving or transfer, sufficient resources to establish and equip a new household. The household was commonly more than a simple dwelling place: it was also a workshop or the center of a farming unit, and commensurately expensive. Since the newly formed household was to be economically independent, bad times meant greater difficulty in marrying. In western Europe, marriage was triggered, delayed, or made impossible by economic circumstances; elsewhere it was largely determined by the process of physiological maturation, since shame attached to a family that had a sexually adult daughter who remained unmarried.

Individual marriage decisions usually reflect a wide variety of pressures and constraints, and any account as simplistic as the one just given requires much shading to make it match reality at all closely. But models can assist in initial investigations by enabling the nature of a set of relationships to be grasped.

As an illustration of how ideas embodied in Fig. 2.1 can throw light on historical change, consider a country of new settlement where by convention no two married couples may share the same household and where, whether by custom or legal provision, individual farms are not divisible. As long as new land is available to be taken up by successive generations of young people, marriage can take place comparatively early in life and few need remain unmarried. But, when the land is fully settled and the number of holdings is therefore fixed, and on the assumption that this is a peasant society with little opportunity to make a living except on the land, the total stock of married couples is also fixed and no new marriage can occur until an existing marriage has ended. The rate of mortality among married couples determines the pace of marriage. An improvement in mortality will automatically cause a commensurate decline in nuptiality and hence in fertility (Schofield, 1976; Ohlin, 1961). Fertility is sensitive to increasing population pressure, and population growth will cease at a lower level than where marriage is not responsive to economic conditions. Living standards will be higher than would be the case if marriage for women was essentially governed by the attainment of menarche.

While this illustration is artificially simple, it illustrates the manner in which both custom and legislation, no less than a particular material technology, may influence both the size and the prosperity of a population. With different conventions concerning the coresidence of married couples, different customs about the timing of marriage, or different rules about the subdivision of landholdings, the ratio between population and resources might be very different.

Population and Resources

Treating the relationship between population and resources in this fashion affords some insight into its nature, but it is essentially a static form of analysis, whereas the historical relationship between the two was dynamic. For example, although technological advance may alter the relationship between population and resources,

it may also itself be influenced by their interaction. Through this mechanism and in other ways there may be a degree of feedback between population and resources. Necessity may prove to be the mother of invention. Indeed, Boserup made an argument of this type the linchpin of her influential treatment of the topic, suggesting that increasing population density both obliged and encouraged societies to develop more and more intensive methods of cultivation as numbers rose, so that increases in population were broadly matched by corresponding increases in food output (Boserup, 1965). Thus, a growing population, paralleled by a rising intensity of land use, connected slash-and-burn methods of cultivation, where the land was cultivated for a few years consecutively and then abandoned for a generation to recuperate, with, say, forms of paddy rice cultivation where the land is in permanent use and two or even three crops may be raised each year. The course of such change might extend over many centuries, but the continuing ability of the land to support the rising numbers was not simply a happy accident. More intensive methods of cultivation were adopted as a direct result of rising population pressure. Population density might ultimately rise from fewer than 10 persons per square mile to a level up to 50 or even 100 times greater.

An ingenious feature of Boserup's original argument was that, while output of food per head each year was not envisaged as either rising or falling significantly as methods of cultivation intensified, output per hour worked was viewed as falling steadily. Under slash-and-burn, a man or woman working on average for a couple of hours a day might produce as much as could be produced in a working day four or five times as long with crop rotations and methods of cultivation well suited to maximizing output per acre. Higher output per acre was achieved only at the cost of much higher labor inputs (Boserup, 1965: esp. chs. 3-5). Thus, even where a community was aware of the possibility of adopting more intensive methods of cultivation that would greatly increase output from the land, there was never an incentive to move to more "advanced" agricultural methods unless under urgent compulsion of prospective hunger, since to do so involved a sacrifice of leisure without offsetting economic gains. A society not experiencing rising population, therefore, would be unlikely to embrace or develop new techniques. Population growth in this model becomes the progenitor of technical advance, no sooner looming as a potential problem than providing a solution.

Boserup's views have proved controversial and it should not be assumed that her model has been successful in "saving the phenomena" (Grigg, 1979), but it serves very well to illustrate the importance of viewing the relationship between population and resources in dynamic terms. Resources are not invariant in nature but are progressively modified by changes in material technology and in institutional frameworks; and such changes not only permit parallel changes in population totals but may themselves in turn be provoked by population changes.¹ Improved technology has an effect rather like viewing an object through an adjustable telescopic lens.

¹ Goldstone has much of interest to say about the pervasiveness and central significance of the interactions between population movements, social and economic change, and political tensions in the early modern world (Goldstone, 1991).

Viewed through plain glass the image remains unchanging. This is the prospect confronting an animal population, or our ancestors before they became tool users, learned to control fire, invented the wheel, domesticated animals, and discovered how to plant crops and suppress weeds. Viewed through a telescopic lens scales change: a blade of grass may seem as massive as an oak; an area of land that previously supported, say, a few deer and a single hunter may suffice to grow wheat for a village. The pace of change was slower before the industrial revolution than it has become in the last 200 years, but cumulatively if irregularly over many centuries there were both large increases in population and major changes in material technology.

What do we know about the dynamic relationship between population and resources in preindustrial times; how were standards of living affected by the ebb and flow of population; and how did the industrial revolution change matters?

The Population Dynamics of the Preindustrial Period

Lack of data about key variables normally prevents detailed analysis of these questions, but sufficient information has recently been assembled for England in the early modern period to offer some instructive, if partial answers. Fig. 2.2 shows the relationship between rates of population growth and rates of change in an index of prices based on a basket of consumables dominated by food between the mid-sixteenth and the mid-nineteenth centuries. Each point represents the average rate of change over a 25-year period. Over a quarter of a millennium from c.1550 to c.1800 the elasticity of response of food price to population change was remarkably stable at about 3 : 2. The points are closely grouped around a straight line and would probably be still more tightly grouped if there had not been, both at the beginning and the end of this very long period, government action that affected the value of money (the "great debasement" of 1544-49 and the issue of paper money after the suspension of specie payments in 1797). The graph provides strong evidence that rising population produced pressure upon food supplies and therefore drove up food prices, and that, symmetrically, when population was declining prices fell back.² It also reveals a dramatic change around 1800 in what had been a notably constant relationship, since early in the nineteenth century population growth rates rose to the highest level ever attained in England (about 1.5 percent per annum) but food prices ceased to rise.

It is not surprising that trends in food prices and trends in real wages were closely linked in the early modern period, since food was a very large part of the budget of most families and money wages were slow to change. Fig. 2.3 illustrates this point.

² The existence of a close relationship between population growth and price changes does not in itself, of course, throw any light on possible causal links between the two. This issue would merit greater discussion but lack of space prevents going beyond the remark that there seems no reason to doubt the commonsense view that population growth at any but the most modest rate tended to exert pressure on prices.

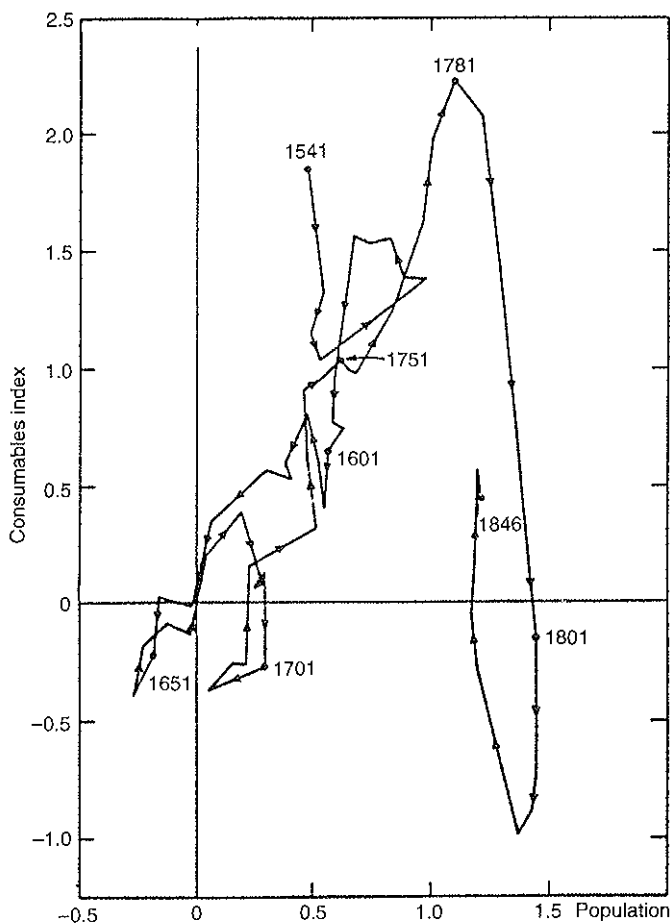


FIG. 2.2. *Annual percentage rates of growth of population and of a basket of consumables index, England*

Note: The population growth rate was measured between any given "census" date and the "census" 25 years later. The rate of growth of the price of consumables was measured using readings on a 25-year moving average of the index for the same dates as for the population totals. Where the date is indicated it shows the beginning date of a 25-year period. There are individual data points at 5-year intervals.

Source: Wrigley and Schofield, 1981: 405

Periods of rapid population growth brought about a deterioration in the standard of living, but when population was stationary or growing very slowly living standards rose. In Fig. 2.3 as in Fig. 2.2 the end of the eighteenth century saw a radical change in a previously clearly marked relationship.

In many respects Fig. 2.3 is almost a mirror image of Fig. 2.2, but one difference is worth stressing. The path of points in Fig. 2.2 passes through the origin of the graph; that is, when population growth was zero, prices neither rose nor fell. But in

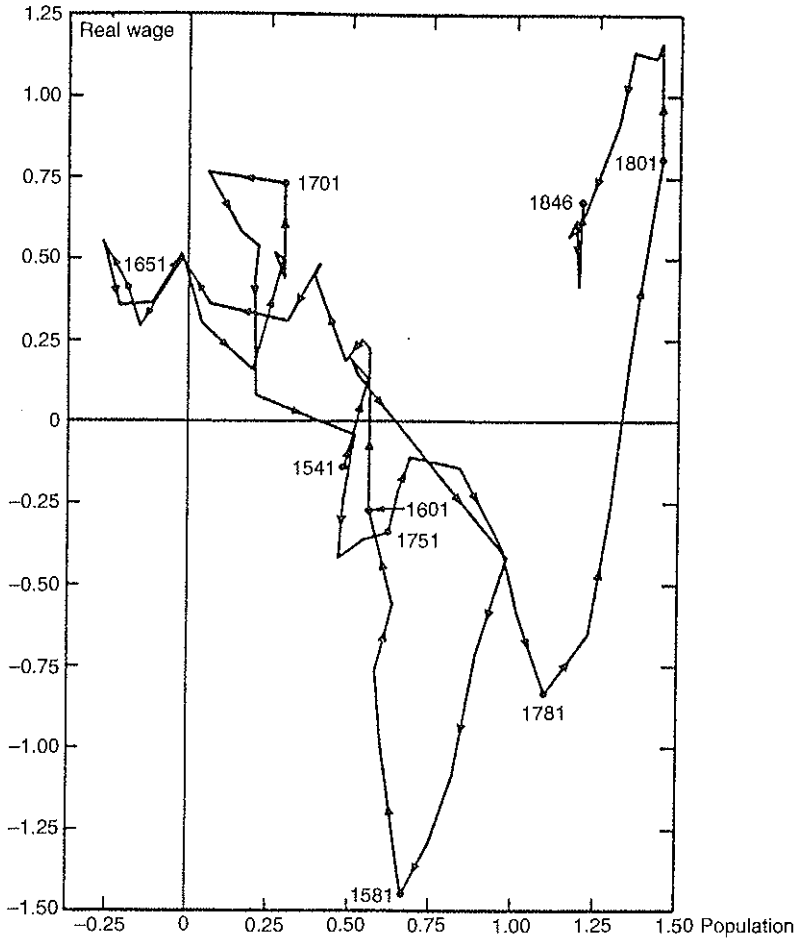


FIG. 2.3. Annual percentage rates of growth of population and of a real wage index, England

Note: The population growth rate was measured between any given "census" date and the "census" 25 years later. The rate of growth of the real wage index was measured using readings on a 25-year moving average of the index for the same dates as for the population totals. Where a date is indicated it shows the beginning date of a 25-year period. There are individual data points at 5-year intervals.

Source: Wrigley and Schofield, 1981: 410

Fig. 2.3 when population growth was zero real wages were rising slowly, or, a development of the same point, early modern England was able to sustain a rate of population growth of about 0.5 percent per annum without suffering a fall in real wages, though any move to higher rates of growth was associated with sharp falls in real wages. A slow rise in the productivity of the economy was taking place throughout the sixteenth, seventeenth, and eighteenth centuries sufficient to support a rising standard of living provided that population growth was slight, absent, or

negative, or to support a rising population while maintaining living standards provided that growth was modest. "Resources" were not static even before the transformation of the industrial revolution.

Because of the nature of the institution of marriage in England there was a characteristic feedback between the economy and demography of the country in the early modern period. Fig. 2.4 shows the close, if lagged relationship between nuptiality and real wages. The apparent simplicity of the link is delusive. Down to the end of the seventeenth century the sharp fall and subsequent rise in marriage rates was produced largely by changes in the proportions marrying rather than by changes in age at first marriage, whereas in the eighteenth century the marked rise in nuptiality came about chiefly because of a marked fall in age at first marriage (Weir, 1984; Schofield, 1985). But, though the proximate cause of the variations in nuptiality may have changed, the effects of the variations were more uniform. Nuptiality rose and fell in sympathy with real-wage changes. Rates of marital fertility changed very little over this very long period (Wilson and Woods, 1991), so that changes in the level of nuptiality were faithfully reflected in parallel changes in general fertility rates. Furthermore, because during most of this period fertility changes outweighed

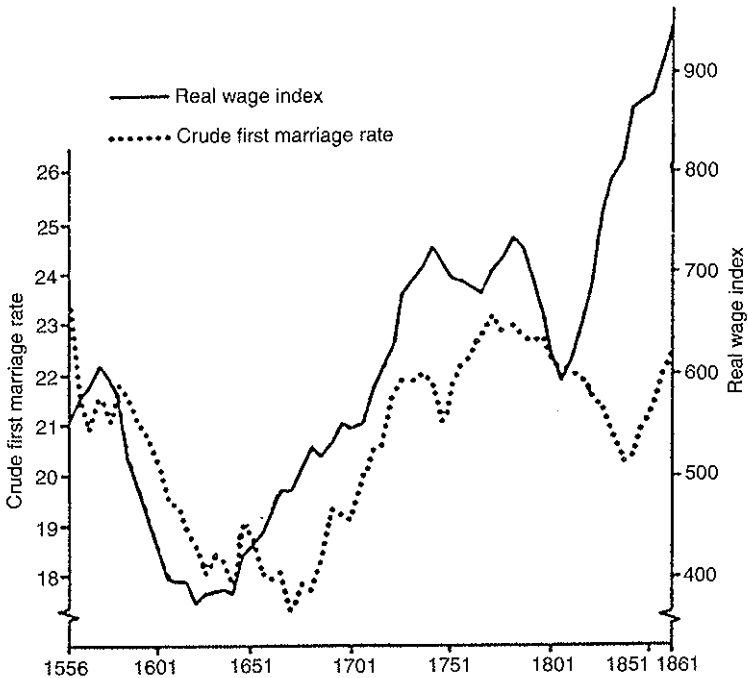


FIG. 2.4. *Real wage trends and crude first marriage rates (first marriages per 1,000 persons aged 15–34), England*

Note: The data are 25-year moving averages centered on the dates shown.

Source: Wrigley and Schofield, 1989: xxii

mortality changes in their effect on growth rates, the ability of nuptiality to “read” economic signals meant that population was able to accommodate to available resources with substantial success (Wrigley and Schofield, 1981: esp. ch. 10).

It is notoriously difficult to make confident assertions about comparative living standards in the past, even if the attempt to do so is limited to purely economic measures of living standards and ignores other factors that impinged strongly on the lives of a people. Nevertheless, it is probably accurate to suggest that standards of living were higher in western Europe in early modern times than was usually the case in other preindustrial societies, and that by the later eighteenth century the standard of living was higher in England than elsewhere in western Europe, though this had not been the case two centuries earlier (Maddison, 1983; de Vries, 1986). The latter point is the more intriguing in that population was growing far faster in England than in its continental neighbors. (Between 1550 and 1820, for example, the population of England grew by about 280 percent, compared with figures in the range between 50 and 80 percent over the same period in Germany, France, Spain, Italy, and the Netherlands (Wrigley, 1983: 122).)

The example of England in the early modern period appears to illustrate several points about the relationship between population and resources in the preindustrial period.

1. Rates of population growth were closely and positively related with prices but negatively related to standards of living.

2. Despite this relationship relatively high rates of population growth were not necessarily incompatible with relatively favorable secular trends in living standards.

3. Points (1) and (2) appear at first sight to be incompatible with each other but the two can be reconciled when it is recognized that what is true of one time scale may not be true of another. In the course of one of the cycles that characterized the relationship of economy and demography in England in the past, the first point holds true, but between successive cycles the second point may be valid.

4. The mechanism that gave its character to the typical cycle appears to have been a function of the marriage system. Nuptiality fluctuated in broad sympathy with real-wage changes, reducing the growth rate when population was rising quickly but accelerating it as real wages rose in periods when population was stationary or rising slowly. The process of adjustment was, however, subject to substantial time lags so that a cycle might take one or two centuries rather than a few decades.³ This resulted in a characteristic pattern of long-term cyclical economic and demographic fluctuation.

The English example should not be taken as typical. The accident of comparatively good data has made it possible to investigate the interplay of population and resources in early modern England more fully than is readily possible elsewhere, but both the economic and demographic history of England at this stage

³ A substantial literature has appeared concerning the measurement and interpretation of this phenomenon. A full listing of publications on the subject up to 1989 and a discussion of the state of the discussion may be found in the Introductory Note to the paperback edition of Wrigley and Schofield, 1989.

in its history were markedly unusual when compared with those of most preindustrial societies. England fits closely to the paradigm Malthus had in mind in writing of the preventive check, where "prudence" assisted the population in escaping from the worst rigors that prevailed where the positive check was the means by which population and resources were kept in balance. The difference between these polar alternatives is summarized in Fig. 2.5, which shows two possible mechanisms for maintaining a balance between production and reproduction in the form of a pair of negative feedback loops.

Common to both loops is a link between population rise (fall), an increase (decline) in food prices, and a fall (rise) in real incomes. Thereafter, since an indefinite fall (rise) in real incomes is impossible in the circumstances of preindustrial society, one of two mechanisms restores a balance between population and resources. Either mortality rises and population is pruned back (the positive check), or nuptiality is reduced, fertility falls, and the same result is achieved by a different path (the preventive check). The former type of equilibrium, however, is apt to be secured only at the cost of a very low standard of living for the bulk of the population, while the preventive check is consonant with much less pressure on material well-being (as illustrated in Fig. 2.1). In societies where the pressure for women to marry early and universally was overwhelmingly strong, as, say, in India in the past, and on the assumption that fertility within marriage was not controlled, it is likely that in fully settled communities the positive check was the prime means

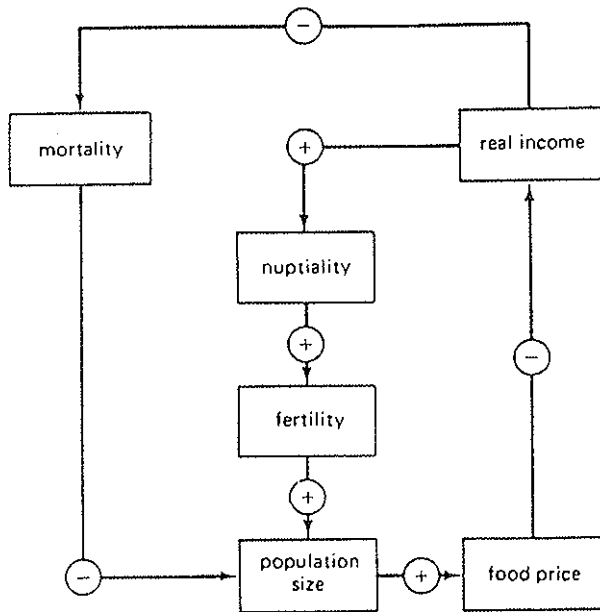


FIG. 2.5. *The positive and preventive checks*

by which a balance was preserved between population and resources.⁴ Where, in contrast, marriage was a moveable feast, responsive to economic circumstances, a milder regime could prevail. In early modern England, for example, there was only a very slight statistical relationship between years of high food prices and the level of mortality whether measured simultaneously or with a lag, though in poorer European countries the relationship was much stronger (Wrigley and Schofield, 1981: ch. 9; Galloway, 1988). The bulk of the population did not live on the edge of starvation.

The two systems shown in Fig. 2.5 represent simplified extreme cases, of course, the two ends of a spectrum of possibilities. In historical reality most societies should be located somewhere in between, displaying an admixture of characteristics. Western Europe probably came closer to one end of the spectrum than any other major cultural region in the preindustrial period, though where infanticide was practiced widely and systematically, as in parts of Japan, a similar effect was secured by a form of the positive check, which shared many of the characteristics of the preventive check (T. C. Smith, 1977: ch. 5).

The Constraints on Preindustrial Societies

The range of possibilities open to preindustrial societies was substantial, but it is imperative nonetheless to stress their similarities. In the penultimate chapter of St. Matthew's Gospel, immediately before the account of the betrayal by Judas, the story is told of a visit that Jesus paid to the house of Simon the leper. As he sat eating, a woman came and poured a precious ointment over his head. The disciples were indignant, saying, in the words of the King James Bible, "To what purpose is this waste? For this ointment might have been sold for much, and given to the poor. When Jesus understood it, he said unto them, why trouble ye the woman for she hath wrought a good work upon me? For ye have the poor always with you; but me ye have not always" (Matt. 26: 8-11). Though to modern ears Jesus' remark may sound unfeeling, Matthew appears to have regarded it as a conclusive dismissal of the disciples' complaint. The problem of poverty was permanent; it was to be regarded as a sad but inevitable feature of life, incapable of cure by human agency (Wrigley, 1992).

Jesus' pessimism was justified in the circumstances faced by all preindustrial societies, with the partial and temporary exception of areas of new settlement where land was abundant. All, or almost all such societies faced the same fundamental difficulty in attempting to achieve a relationship between population and resources that would permit a high and rising standard of living for their populations, to

⁴ The remarkable work of Dyson using the records of British India, above all those relating to the province of Berar, contains much reliable data about the severity of the mortality crises that continued to afflict the Indian population well into the twentieth century, and about the extent to which the crises were linked to harvest failure (Dyson, 1989, 1991; Guz, 1989).

achieve, in other words, what has been achieved by many populations in the wake of the industrial revolution. The maximum attainable rate of economic growth fell short of the rate at which population was capable of growing when unrestricted by either the positive or preventive check. An improvement in command over resources, therefore, however it was secured, was apt to be offset by a commensurate rise in population brought about either by declining mortality, rising fertility, or some combination of the two.

European experience in the colonies of North America perfectly illustrates the manner in which populations might grow in the absence of the restrictions that weighed heavily in long-settled areas. Men and women with substantially the same material culture, religious beliefs, and legal and political institutions as those who remained in England moved to New England or to the Chesapeake Bay area, and, with abundant land within easy reach, began to grow by natural increase alone so rapidly that populations roughly doubled in each successive generation, or by up to 3 percent per annum. This occurred at a time when the comparable rate in England was only in the range between 0 and 0.5 percent per annum.⁵ French settlers along the St. Lawrence River displayed much the same characteristics (Henripin, 1954). Abundant resources made possible rapid growth without the penalty of depressed real incomes or rising mortality. Marriage could be contracted at an early age without fear of future poverty. But such circumstances were most unusual. In general, population growth readily kept pace with economic expansion and was prevented from more rapid increase either by periodic bursts of mortality due to epidemic disease or malnutrition, or by a marriage valve that adjusted population growth to economic opportunity. It was idle to dream of securing rates of economic growth to match the rates of demographic growth readily reached by populations in the past.

There were exceptions to this sweeping generalization. Population growth rates as high as those reached by European colonies in North America were only possible in environments where background levels of mortality were low. In other areas, especially in the tropics, where destructive endemic and epidemic diseases were rife, mortality might be at a very high level irrespective of the ratio of population to resources. Maximum growth rates were therefore low and there might be a much smaller gap between the maximum rate at which resources could be expanded and the corresponding figure for population growth.

In general, however, the tension between population and resources was pervasive and ineluctable. At bottom it sprang from a feature of preindustrial economies that was familiar to the classical economists. If land is a necessary factor in all aspects of material production, steadily rising production must be difficult to achieve because it must involve cultivating existing land more intensively or bringing into cultivation land of poorer quality. This in turn is likely to mean employing larger and

⁵ Between 1631 and 1751, for example, the quinquennial population growth rates in England never exceeded 0.67 percent per annum and fell as low as -0.69 percent per annum. Overall between these two dates the growth rate was only 0.14 percent per annum (Wrigley and Schofield, 1981: 208-209, table 7.8).

larger inputs of capital and/or labor to secure a unit increase in output. Ricardo, who provided the classic account of this dilemma, concluded the passage in which he described the declining marginal returns to capital and labor that resulted from the fixed supply of land by remarking: "This will necessarily be rendered permanent by the laws of nature, which have limited the productive powers of the land" (Ricardo, 1951 [1817]: 126). The tensions that were implied by the fixed supply of land could be ameliorated but not overcome by technical advance. In the longer term even the most prosperous of countries must expect to move toward that "stationary state" which, in Adam Smith's view, must ultimately prevail. "In a country," he wrote, "which has acquired that full complement of riches which the nature of its soil and climate, and its situation with respect to other countries, allowed it to acquire; which could, therefore, advance no further, and which was not going backwards, both the wages of labor and the profits of stock would probably be very low" (A. Smith, 1976[1789]: 106).

This view of the limits to growth carries no conviction today, of course, since recent history has shown conclusively that it does not always apply. But in relation to the preindustrial past its force should not be discounted. Rather, it provides not only a persuasive paradigm for the period between the neolithic food revolution and the industrial revolution, but also a clue as to which of the changes brought about by the industrial revolution were crucial in enabling societies to break free from ancient constraints.

To appreciate the severity and ubiquity of the problems posed by a fixed supply of land, it must be remembered that land was the prime source not only of food but also of the raw materials of industry. The former point can be readily appreciated even in the late twentieth century, but the latter is unfamiliar. Yet all the major industries of the preindustrial world used either animal or vegetable raw materials as their prime inputs. Most of those members of the labor force who were not working directly on the land were refining or modifying its products. Spinners, weavers, tailors, shoemakers, brewers, butchers, bakers, skinners, hatters, sawyers, carpenters, joiners, thatchers, wheelwrights, coopers—trades employing such workers as these provided the great bulk of all employment outside agriculture, forestry, and fishing. All depended on the annual cycle of vegetable growth engendered by photosynthesis of incident sunlight or on the animal food chain established on this vegetable foundation. Even those who worked with metals commonly depended on wood to provide the heat energy needed to smelt and work the materials they used. A period of economic expansion involving industrial growth therefore necessarily meant an increased call upon the resources of the land. Since it normally coincided with a period of population growth, competition for the use of a resource in fixed supply was apt to become acute. A flourishing woollen industry required more land to be used for sheep pasture just when those who manufactured the broadcloths or the worsteds were growing in number and needed bread to eat. Sheep could eat up men, as Sir Thomas More once suggested. The fixed supply of land built negative feedback into the growth process. Each successive step became harder to take than its predecessor.

The Industrial Revolution

The industrial revolution changed these age-old patterns. Both the abruptness and completeness of the change from the past are suggested in Figs. 2.2 and 2.3. The industrial revolution made poverty problematic for the first time in human history. Once it became feasible to increase output faster than population, it was no longer utopian to suppose that numbers could increase and yet that living standards could also rise (Fig. 2.3). The existence of poverty could for the first time plausibly be represented as the result of social and political failure or of human weakness rather than as an unavoidable concomitant of the human condition. If production could be increased faster than population even though population was growing quickly, it was inevitable that it should appear that an appropriate political regime or a suitable form of social engineering could abolish the dreadful privations that poverty entailed.

The critical technical changes that facilitated the productivity increases of the industrial revolution were the discovery of ways of using coal as a source of both heat energy and mechanical energy, and the gradual freeing of wider and wider segments of industry from dependence upon vegetable and animal products by switching to mineral raw materials (Wrigley, 1988). The output of the individual worker in many productive processes is heavily dependent on the amount of energy he commands. Where a production process is necessarily energy-intensive as, say, in working the soil, a man who controls a team of horses can plough many times the area that can be dug by a man with a spade, but his efforts will in turn be dwarfed by a rival sitting behind the wheel of a tractor. Or again, a steadily rising output of iron and steel produced by coke smelting, say to provide a country with a rail network and the engines and rolling stock to make use of it, does not involve competition over land use such as was inevitable if raising the output of iron depended on increasing the area devoted to coppice woodland. The old negative feedback links that had bedeviled economic expansion in the past were finally broken. Growth could assume an exponential rather than an asymptotic form; positive feedback could replace negative feedback.

The industrial revolution made it possible, so to speak, for societies both to eat their cake and have it. Standards of living and population totals could grow in parallel where previously the two had been incompatible. The relationship between population and resources was thus definitively changed. But it was not only the character of economic growth that was changed in the wake of the industrial revolution. Population also came to behave very differently. It had seemed axiomatic to men like Adam Smith or Malthus that increasing economic well-being would tend to raise population growth rates. An increasingly well-nourished population, easily able to gain employment and enjoying rising wages, might confidently be expected to experience both falling mortality and rising fertility, in consequence of improved nutrition and of marriage being encouraged by the favorable economic conditions. In the nineteenth and twentieth centuries it has become clear that only one of their two assumptions was justified. Mortality has fallen steadily. In the main, health and wealth have gone hand in hand, though it has also become clear that prosperity may

bring with it changes in lifestyle, leisure pursuits, and diet that can raise both morbidity and mortality rates.

Fertility, on the other hand, has not followed prior expectation. Until the late eighteenth century there was little control of fertility within marriage among European populations. It therefore followed that if levels of general fertility changed, they were primarily changed *by* marriage rather than *within* marriage, and it was reasonable to assume that if couples were encouraged to marry younger by economic circumstances, or by any other inducement, or if fewer individuals remained unmarried throughout their lifetimes, fertility must rise. By the end of the eighteenth century the close association between the level of nuptiality and the level of fertility had already broken down in parts of France, notably in Normandy and in the southwest. Indeed the association was reversed, since nuptiality rose sharply where marital fertility began to be controlled, as if the knowledge that earlier marriage need not necessarily lead to increased family size encouraged couples to contract a union earlier (van de Walle, 1978; Wrigley, 1985). The rest of Europe did not immediately follow France's example. Before 1870 few other countries showed evidence of a decisive trend toward control of fertility within marriage,⁶ but thereafter the proportion of couples practicing some form of birth control rose rapidly almost everywhere in Europe and more generally in the industrialized world.

By the 1930s overall fertility had fallen below replacement levels in many countries, and it was a commonplace to assert the existence of an opposite relationship between prosperity and fertility to that remarked by Adam Smith and Malthus. Wealthy couples were observed to have fewer children than those at the other end of the income scale, and richer countries to have lower fertility than poorer. Prosperity was associated with low rather than high growth rates. Thus, the tension between population and resources, between reproduction and production, which was a constant feature of life in preindustrial societies, disappeared after the industrial revolution not only because powers of production had been transformed and the old obstacles to growth bypassed, but because populations no longer responded to economic opportunity by expanding commensurately. Prosperity now meant the slashing of growth rates or even the prospect of population decline. Resources might still be put at risk by human greed or carelessness but no longer by rising numbers alone.

Conclusion

As a result of reading Malthus's *Essay on Population*, Darwin hit upon the idea of relentless population pressure as the engine to drive natural selection. It suggested to

⁶ The chief exception to this generalization is New England, where marital fertility started to fall at much the same time as in the parts of France where change came earliest (Yasuba, 1962; Forster and Tucker, 1972).

him the notion that in all animal species far more offspring are born than will survive to the age where they can reproduce and contribute to the composition of the next generation. Those who do survive and breed are not a random selection of those who are born but possess characteristics that distinguish them from those who fail, and may pass on these characteristics to their offspring.

The use Darwin made of Malthus is instructive in that he drew only upon what Malthus might have regarded as a limiting case, treating it as the norm for animal populations. In the first *Essay on Population* Malthus did sketch a relationship between population and resources that could be regarded as foreshadowing Darwin's model of selection, for example when making his famous distinction between arithmetic and geometric growth rates, the former relating to resources, the latter to population (though for Darwin, dealing with animal populations, the rate of growth of resources was zero). But from the beginning Malthus was conscious that the relationship between population and resources in human societies is subtle and complex, and his later writings reveal how greatly his understanding grew. That there is a pervasive tension between population and resources is not a controversial assertion in relation to animal populations. In relation to man it ceases to be uncontroversial as and when the pace of change in material technology reaches a point where resources can readily be increased to match or exceed rising numbers.

As long as such change is absent or slight, as it was in hunter-fisher-gatherer societies, the size of successive generations must be very similar, and, as in animal populations, many of those born will not engage in reproduction, because of premature death. If such change becomes rapid (or if the press of population ceases because fertility in marriage declines), the tension disappears. This has happened in many countries in the last 200 years because of the industrial revolution and of other changes in society, especially the routine and widespread control of fertility within marriage. In between these two extremes, matters are more complicated. Some growth of population may be possible but at a less rapid rate than was easily attainable in the absence of resource constraints. Some of the pressures of which Malthus was conscious and which intrigued Darwin will be present but their analysis is far from straightforward, especially if there is reason to think *either* that population growth itself may serve to stimulate progress in material technology, *or* that population growth may have the opposite effect (a perfectly plausible view if the absence of population pressure helps to raise real income and so alters the structure of demand in ways that encourage innovation and economic growth).

If it is true that each increase in knowledge tends to emphasize how much remains to be learned, then perhaps consciousness of the extent of our present ignorance, which is very striking, may paradoxically suggest that progress in understanding the relationship between population and resources in the past is beginning to gather momentum. It is at least true that the relationship between population and resources in the past is a deeply interesting topic *in se*, and one that needs to be better understood, if only in order to provide an adequate setting for discussion of the same topic in relation to contemporary problems.

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3 World Population Growth: Trends and Prospects, 1960–2020

PAUL DEMENY

Understanding the changing relationships between population and resources presupposes a quantitative grasp on the underlying dynamics of demographic change. This is a tall order, but one that the existing corpus of demographic literature now can fulfill better than was the case just a few decades ago. Magnitudes of the main components of global demographic change—such as the number of entries into the human population by birth and the number of exits through death—are still not known with a high degree of accuracy. But we might claim, for example, that the global number of births in 1993 was 144 million and the number of deaths in the same year was 51 million (thus yielding a net 1993 population increase of 93 million), and be reasonably confident that the true figures lie within 5 percent, plus or minus, of these estimates.

There exists of course no system of worldwide vital statistics, and there is no such thing as a global census. The contemporary global demographic picture is an aggregate of the demography of some 200-odd country-level units, and information on many of these is still badly deficient. Nevertheless, a broad regional picture of global demographic change can be drawn, helped by three relatively recent developments. These are the greatly increased use of sample surveys complementing the traditional sources of demographic statistics; advances in statistical estimating techniques applicable to fragmentary and deficient data; and the systematic assembly and refinement of demographic information from disparate sources carried out in international agencies, most notably by the Population Division of the United Nations.

Using mostly United Nations estimates, the discussion that follows outlines salient features of the most recent trends in global population growth and considers the determinants and likely future evolution of these trends. The focus of the discussion is on the six decades centered on 1990. Comments on demographic change in a more remote past and glimpses to more distant demographic futures are also offered to place the period 1960–2020 into a broader perspective.

For the sake of brevity, estimates of demographic characteristics cited below are mainly for broad geographic regions, rather than countries. This is a serious limitation as the demographic features of the countries that make up each region often exhibit a great deal of variation. Occasional references to country characteristics of special interest, therefore, complement presentation of regional estimates.

The discussion begins with comments on the demographic transition—a descriptive device that summarizes some common patterns of mortality and fertility that

have driven population change over time in the modern era. This is followed by a description of recent regional trends in population growth and its main proximate determinants, mortality and fertility. The concluding sections interpret these trends and consider future population prospects.

Demographic Transition: Early European Experience

In trying to impose some conceptual order on the wide disparity of population patterns that make up the global demographic picture, demographers can claim a degree of success. As a matter of sheer description, modern demographic history can be aptly pictured as a momentous transition: a transition between two regimes of demographic behavior, each yielding rates of population growth that are very near to, or over time fluctuate around, zero. The first, demography's *ancien régime*, accomplishes this by matching a high rate of childbearing (in demographers' parlance, high fertility) to the high rates of death imposed on premodern populations by an environment inadequately tamed by man. The second demographic regime, which now is close to being attained in the economically more developed countries, achieves low or no population growth by combining greatly improved mastery over premature death with low average levels of fertility.

All populations of the modern world are thought to be in transition from the first to the second of these demographic regimes, but arranged on different stages of that process and traveling on the transitional path at differing speeds. A further source of these differences can be traced to the starting point of the transitional path. The demographic attributes that characterized the pretransition state were often greatly different from country to country. Such differences at the onset of the transition—with respect to fertility, mortality, and, not the least, population size—are apt to leave a lasting mark on the demographic status of a population at any later point in time. Finally, the attributes of the post-transition stage to which populations are thought to be converging may also differ appreciably from country to country. Indeed, since for most populations the post-transition state lies still in the future, the specific demographic characteristics of that state are yet to be satisfactorily ascertained. "Low" fertility and "low" mortality can each correspond to a more or less wide range of values, thus permitting a great variety of combinations. These then may yield rates of population growth ranging from the just "slow" to negative rates well below zero. The intricacies of any cross-sectional view of the demographic situation of the contemporary world reflect the diversity of the possible transitional paths permitted by these demographic parameters.

Two simple considerations support the notion that demographic transition, even if strictly speaking it is neither inevitable nor guaranteed, is dictated by the logic of history. The first is the near-universal human desire for a long life. The material achievements of industrial civilization brought that desire much closer to fulfillment than was ever the case in the past. It can be taken for granted that societies

which succeeded in bringing death rates to low levels would not voluntarily compromise that achievement. It is equally evident that societies which are lagging in this regard are eager to secure low mortality for themselves as soon as they are capable of doing so.

The second consideration has to do with the fact that, barring migration, sustenance of premodern levels of fertility (levels that were once necessary to assure simple survival of a population subject to high rates of death) in combination with low mortality inevitably results in fairly rapid, indeed potentially very rapid, rates of population growth. But such rates of growth over long durations are unsustainable.

A counterfactual calculation concerning long-term implications of population growth provides heuristic proof of this proposition. Suppose that rates of fertility, as estimated for broad regional subdivisions of the world's population, remain constant at their 1990 levels indefinitely in the future. Suppose further that mortality rates everywhere continue their convergence to levels near those already achieved by countries with the lowest death rates. This second assumption, while no doubt optimistic, is hardly extravagant: it posits no advances in extending the normal bounds of human longevity.¹ Yet the combination of these assumptions—constant fertility and low mortality—would in time generate a global population of truly stupendous size. It would bring the world's population from its current level—estimated as 5.3 billion in 1990 and 5.7 billion in 1994—to 11 billion by 2025; to 21 billion by 2050; and to 109 billion by 2100. By 2150—a year separated from the present by no greater distance than the beginning of the reign of Queen Victoria—the global population would be 694 billion (United Nations, 1992).²

Notwithstanding even the most sanguine assessments of relationships between population and resources, we can be certain that sustaining a global population growth pattern of this kind is not a feasible option for mankind. It is also likely that estimates of maximum carrying capacity (Demeny, 1989) are in fact largely irrelevant for demarcating plausible future upper boundaries of population size. Such estimates ask the question, "How many people can the Earth feed?," thus ignoring the Biblical reminder that man does not live by bread alone. Well before ultimate physical constraints on accommodating further demographic expansion would be approached, adjustment processes would likely be set in motion limiting population growth. Thus, by *reductio ad absurdum*, projection exercises like the one just cited demonstrate the necessity that human populations learn to adopt and maintain a level of fertility that is extraordinarily low if measured by a historical yardstick—indeed, in the long run, a fertility only slightly higher than an average of two children per

¹ It should be noted that "low" mortality in this context merely requires that the proportion of women surviving from birth to the end of the age of childbearing be near to 100 percent. Death rates beyond that age have only a modest temporary influence and no long-term influence on rates of population growth. (For a demonstration of this point, see Coale, 1959.)

² Maintaining regional fertility levels constant when these levels differ from region to region generates a rising overall fertility, hence a rising overall growth rate. This is because the relative weight of the regional population with the highest fertility necessarily increases over time and eventually dominates the growth rate of the overall aggregate.

woman. Failing to act on that mandate imposed by ultimate resource limits, human populations cannot have and maintain the low mortality now universally desired as well as demonstrably feasible.

Demographers are inclined to seek to explain changes in one type of demographic variable, such as fertility, by changes in some other demographic variable, such as mortality. Thus, the behavioral change—the deliberate limitation of family size by individual couples—that underlies a lowering of aggregate fertility is often interpreted as a parental response to increased survivorship of offspring. But pointing out a necessary linkage between low mortality and eventual low fertility (as was done in the preceding paragraphs) need not imply a simple or especially strong causal connection between these two phenomena. Indeed, in modern history, the dominant causes of all facets of demographic change are found outside the domain of demography proper.

The record of European demographic experience during the nineteenth century demonstrates this proposition convincingly. That record exhibits a great variety in the initial levels of fertility and mortality and in their subsequent time trends that defies simple generalizations. Differences in the initial levels of fertility reflect the fact that past populations in Europe, as elsewhere, were characterized by a wide range of combinations of nuptiality and marital fertility, resulting in substantial differences in birth rates. These differences broadly corresponded to similar differences in death rates, suggesting a social capacity to adjust the birth rate to death rates kept as low as possible or, alternatively, the workings of a Malthusian mechanism whereby death rates came to balance whatever birth rates resulted from a society's institutions and reproductive behavior. But by the nineteenth century European fertility and mortality trends showed no tight linkage: both were shaped, albeit to different extents and at differing speeds, by the social and economic changes generated by the industrial revolution.

Salient aspects of these changes included rising productivity, rising consumption possibilities and aspirations, new patterns of social relations (such as those imposed by industrialization and by urban living), and new options for individuals to acquire better education and improved health. These changes opened up opportunities for social mobility and made those opportunities dependent upon appropriate behavioral responses, including, in particular, parental investment in children's human capital. New institutional arrangements for old-age insurance reduced parental dependence on children. Wider access by women to employment outside the home increased the opportunity cost of childrearing. The influence of such changes on mortality and fertility (and on other demographic phenomena, such as nuptiality and geographic mobility—variables in turn closely related to fertility) was intricately intertwined with political-organizational innovations and cultural and psychological changes generated by the economic and social transformations noted above.

The demographic impact of these transformations was seldom simple; some elements of them tended to increase fertility and mortality while others worked in the opposite direction. The chemistry of the causal nexus just outlined was further complicated by feedback effects from changes in the various demographic variables

to economic, social, and cultural changes and by the geographic spread of such changes from the core areas where they first originated to areas of later industrialization. But over time the *net* effects of these influences on fertility and mortality were unequivocally downward, causing both death rates and birth rates to fall. Because institutions supporting the established patterns of fertility behavior tended to be resistant to change, the fall in birth rates typically lagged behind the fall of death rates.

Thus, in addition to bringing low mortality and low fertility, European demographic transition also resulted in heightened rates of population growth. Despite substantial outmigration, between 1800 and 1900 the population of Europe (excluding the Russian Empire) had doubled—rising from some 145 million to 294 million. This represented a sustained average annual rate of growth of 0.7 percent, a rate appreciably higher than was then experienced in other settled regions of the globe.

Stimulated by the open land frontier, nineteenth-century population growth in the Russian Empire was more rapid, 1 percent per year. In the New World, expanding from initially low absolute levels and enhanced by immigration, the corresponding growth rate was nearly 2 percent. All in all, as a result of Europe's entering the path of demographic transition first, the populations of the area of European settlement—Europe, including Russia, the Western Hemisphere, and Australia and New Zealand—grew from an estimated 220 million to some 590 million during the nineteenth century. Correspondingly, the share of the population of this area within the world's total population rose from 23 percent to 36 percent (Demeny, 1990).

Population Growth: 1960–1990

With respect to its fundamental driving force—socioeconomic changes that generate lower death rates and lower birth rates—nineteenth-century European demographic transition prefigures the demographic experience of that large majority of mankind that after World War II came to be referred to as the (economically) less developed countries, or LDCs.³ But the quantitative dimensions of the two transitions are strikingly different. Noting these differences, as well as comparing contemporary LDCs with the more developed countries (MDCs), provides useful perspectives on the global demographic dynamics of the most recent decades. Estimates of population characteristics cited below are drawn from, or are calculated on the basis of, estimates published by the United Nations (1993*a*, 1993*b*).

³ LDCs are conventionally defined as all countries of Africa, Latin America and the Caribbean, Asia, and Oceania, with the exception of Japan, the Asiatic portions of the former Soviet Union, and Australia and New Zealand. The more developed countries, or MDCs, are the rest of the world. Such a classification, by seeking simplicity in the geographic division, clearly makes the two groups of countries overlapping in terms of levels of economic development: the MDCs, for example, include Albania while Singapore is classified as an LDC. The various successor states of the former Soviet Union would also be logically divided between the two groups.

Population growth, expressed in terms of rates of change and as absolute increments, is the paramount manifestation of those dynamics. Table 3.1 presents a summary of the relevant figures for 1960–90. As the table shows, and as is noted below, this 30-year span—roughly the length of a single generation—was a momentous period in world demographic history. Selecting this particular span of years for special attention is also warranted by both the beginning and the closing dates that demarcate it. By 1960, disturbances directly traceable to World War II were greatly attenuated. In MDCs, in particular, the sharp resurgence of birth rates—the postwar baby boom—was mostly spent. Similarly, the rise, from much higher initial levels, observed in the birth rates of many LDCs, especially in Latin America, largely came to an end by 1960. Such a temporary rise, also observed in earlier transition experience (Dyson and Murphy, 1985), often precedes the leveling-off and incipient decline of fertility. For the large majority of LDCs, 1960 marked the beginning of the maximum growth phase of their demographic transition. Concerning the closing year of the period, preparation of population estimates beyond 1990, especially for LDCs, often requires increasingly tenuous extrapolation of observed data.

As to relative rates of population change, the first of these three decades marked the historic all-time high—at the average of 2.0 percent per year—in the global rate of population growth. Up to the 1960s peak, that global rate had been accelerating steadily at least since the early seventeenth century. The rate of population growth for the LDCs as a whole also peaked in the 1960s—at the average annual figure of 2.4 percent. For the MDCs such a peak—at 1.27 percent—occurred in the preceding

TABLE 3.1. *Population growth, 1960–1990, world regions*

	Population size (millions)		Change in population size, 1960–1990		
	1960	1990	Absolute increase (millions)	Percent increase	
				Total	Annual average
Africa	280	643	363	130	2.8
Asia	1,668	3,118	1,450	87	2.1
Europe	431	509	78	18	0.6
Latin America	217	441	224	103	2.4
Northern America	199	277	78	39	1.1
Oceania	16	27	11	69	1.7
USSR (former)	208	281	73	35	1.0
LDCs	2,074	4,084	2,010	97	2.3
MDCs	945	1,211	266	28	0.8
World	3,019	5,295	2,276	75	1.9

Source: United Nations, 1993a

decade; by the 1960s the annual growth rate was 1.05 percent. MDC population growth rates declined appreciably during the next two decades, averaging 0.80 percent during the 1970s and 0.64 percent during the 1980s. In LDCs the decline in the growth rate was much slower: the average increase was 2.2 percent in the 1970s and 2.1 percent in the 1980s.⁴ The corresponding global rates for these two decades were 1.8 percent and 1.7 percent.

By regional detail, as Table 3.1 shows, population growth was especially rapid in Africa and Latin America,⁵ at the average annual rate of growth of 2.8 percent and 2.4 percent, respectively, during the three decades. In Asia,⁶ too, the growth rate exceeded 2 percent per year. The other extreme, reckoned by broad regions, is represented by the growth rate for Europe⁷ at the average rate of 0.55 percent.

Country-by-country population growth rates for the period show, of course, a wider range of differences. Even ignoring very small countries and countries where growth was heavily affected by international migration, rates exceeding 3 percent were not uncommon. The average rate for Kenya, for example, was 3.5 percent, extraordinarily high for a sizable population over a sustained period. At such a rate of growth a population doubles in less than 20 years. Among the largest countries, only Nigeria's rate of growth is estimated to have exceeded 3 percent, its population having increased at the average annual rate of 3.1 percent, or by a total of 157 percent during the period 1960–90.⁸ Similarly rapid increases occurred in Pakistan and Bangladesh. These countries added an estimated 137 percent and 121 percent to their 1960 populations during the three decades that followed.

Considering changes in the absolute size of population, the period 1960–90 stands out as one of extraordinary expansion. These three decades added two and a quarter billion persons to the world's population, 88 percent of which, or 2 billion, occurred in LDCs. Unlike the rates of growth, the size of decadal increments to the global population was steadily increasing, from 678 million in the 1960s, to 750 million in the 1970s, and 848 million in the 1980s. The corresponding figures for LDCs alone were 574 million, 662 million, and 774 million. For MDCs the trend, in contrast, was downward: 104 million, 87 million, and 75 million. The regional growth picture reflects the large initial size of the population of Asia: nearly 1.5 billion, or some 64 percent, of the 1960–90 global increase accrued to the population of that continent. Nine hundred million of that increase was contributed by the two most populous

⁴ The different levels of precision in the rates given for the two groups of countries reflect the greater accuracy of the underlying population estimates for MDCs.

⁵ The label "Latin America" is used here and elsewhere in this chapter to denote the area Latin America and the Caribbean.

⁶ Asia excludes the Asiatic portion of the former Soviet Union.

⁷ Europe excludes the European portion of the former Soviet Union.

⁸ Population figures for Nigeria are subject to an especially large margin of error. The 1991 census enumerated a population of 88 million: a count some 30 million short of the then commonly accepted estimate. However, the accuracy of the enumeration is questionable, as is the accuracy of the population counts obtained in the two previous censuses, held in 1963 and 1973. (Results of the latter were officially declared invalid.) As is often the case when demographic statistics are deficient, estimates of the rate of growth are more robust than estimates of absolute population size.

countries of the world: China's population size grew by 496 million, India's by 404 million, between 1960 and 1990.

Comparisons between the growth experiences summarized above show that the rate of population increase was appreciably more rapid during the last three decades than was the case in nineteenth-century Europe. But the more striking contrast is brought out by comparing increases in absolute terms, which reflect the combined influence of high rates of growth and initial large population size. In any two years during the 1980s, for example, population increase in LDCs was greater than population increase in Europe during the entire nineteenth century.

Differences between regions with respect to rates of population growth cause changes in the spatial distribution of the world's population. Although 30 years is a rather short period to generate major shifts in relative population size, between 1960 and 1990 the share of MDCs in the world total dropped from 31 percent to less than 23 percent. Within this, Europe's share decreased by nearly 5 percentage points: from 14.3 percent to 9.6 percent. At the same time, Africa's demographic weight within the global total went from 9.3 percent to 12.1 percent and Asia's grew from 55.3 percent to 58.9 percent.

Another important facet of changing demographic characteristics is age composition and its dynamics, reflecting differential rates of growth of the population as disaggregated by age. A full description of a population's age structure is somewhat laborious (United Nations, 1993*b*), but simple indicators can give an impression of the overall character of the age structure and its evolution over time, while also highlighting changes of obvious economic and social interest.

One such indicator is the proportion of persons in the young dependent ages—those under age 15 years. Among LDCs in 1960 this fraction was 40.8 percent; among MDCs the corresponding figure was 28.6 percent. These proportions have decreased in both LDCs and MDCs, but the contrasts between the two groups of countries have sharpened: by 1990, the percentages of those under 15 were 35.5 and 21.4. This shift toward a less youthful population meant that in MDCs the number of persons under age 15 has actually declined: from 270 million in 1960 to 260 million in 1990. In LDCs this age group comprised 847 million persons in 1960 and 1,452 million persons in 1990. Large as this growth was, in percentage terms it represents a figure—71 percent—appreciably below the growth of the LDC population as a whole during the period.

The share of old persons—conventionally defined as 65 years of age or older—showed a dynamic opposite to that exhibited by the young ages. In MDCs the proportion of those 65 and older grew significantly, from 8.5 to 12.0 percent. In LDCs the increase in the percentage share of the old was less marked: it went from 3.9 to 4.5 percent. Changes in the numbers of old persons show another aspect of the process of population aging. In 1960 those aged 65 and over comprised roughly the same number of persons, 80 million, in both MDCs and LDCs. In 1990, the corresponding figures were 146 million and 182 million, representing proportionate increases of 83 and 128 percent, respectively.

A significant increase in the proportions of persons classifiable as of labor force

age—those between 15 and 65—is implicit in these figures. In LDCs that percentage went from 55.3 to 60.0, in MDCs from 62.9 to 66.6. In absolute terms this meant an increase from 595 million to 805 million in MDCs and from 1,147 million to 2,450 million in LDCs. Thus, in 1990 the number of persons of labor-force age exceeded the corresponding number in 1960 by some 210 million in MDCs and by 1.3 billion in LDCs.

Another indicator of this type, with important bearing on the reproduction of the population, is the percentage of women who are of childbearing age—those aged 15–49. In LDCs, during the 30-year period in question, this percentage increased from 46.2 to 50.7. In terms of absolute figures this means that in LDCs the number of women of childbearing age grew from 471 million in 1960 to 1,017 million in 1990—an increase of 116 percent. In MDCs the shift in the percentage share of women aged 15–49 was modest: it went from 47.9 in 1960 to 48.8 in 1990. In absolute terms this corresponds to an increase from 235 million to 305 million, or some 30 percent.

Differences in population age distributions can have a strong bearing on population growth because the two proximate determinants of such growth—the number of births and the number of deaths—are generated by demographic phenomena, fertility and mortality, whose incidence is strongly age-specific.⁹ Under normal conditions, whatever the overall level of mortality may be, age-specific death rates tend to be relatively high early in life, reach low levels in later childhood and young adulthood, and then rise monotonically and rather steeply at higher ages. As a result, depending on how a population of a given overall size is distributed by age, a particular schedule of age-specific death rates can be associated with quite different numbers of annual deaths.

Fertility, usually defined as the probability that a woman of given age will have a child during a given year, is of course even more pronouncedly age-specific, being limited, roughly, to ages 15 to 49, and within that span exhibiting wide differences by age.

As a result, the size of the “natural increase” of a population in a given year—the difference between the number of births and the number of deaths during that year—will be influenced not only by the levels of fertility and mortality as described by the prevailing schedules of age-specific fertility and mortality rates but also by the age distribution of the population. The same applies to the corresponding rate of natural increase, calculated as the difference between the “crude” birth and death rates—called “crude” because such rates, relating the total number of births and deaths to total population size, incorporate an unspecified influence of the age distribution.

⁹ Here, as elsewhere in this chapter, no account is taken of international migration. In addition to the balance of births and deaths, movements across national frontiers are of course a factor affecting population growth. Although often an important phenomenon for a variety of economic and social reasons, international migration in most cases has only a minor influence on population growth as compared to the influence of natural increase. In sheer numerical terms, the impact of contemporary international migration has been especially weak as a factor moderating rapid population growth in the countries from which such migrants have originated. This is even more so when, as in this chapter, the focus is on regional aggregates rather than on individual countries.

When interest is focused, as in the following two sections, on mortality and fertility as the two main factors underlying population growth, it is preferable to use measures that do not reflect the influence of the age distribution.¹⁰

Mortality Trends: 1960–1990

The most common comprehensive measure of mortality is the expectation of life at birth. Despite its somewhat misleading name (a frequent source of popular misinterpretations), the measure is not a gauge of future prospects for length of life. It characterizes, instead, mortality conditions in a given year (or other time period) by indicating the average number of years a cohort of newborn would live if subjected to the age-specific rates of death prevailing during the year (or other time period) to which the measure refers. If, to illustrate the calculation of this index by an extreme hypothetical example, death rates in a population were 50 percent at age 0 (i.e., if among the newborn half die very shortly after birth), zero percent from age 1 to age 69, and 100 percent at age 70 (i.e., if every surviving infant lived up to age 70 but none beyond), the expectation of life at birth in that population would be 35 years. Unrealistic as this example is, it suggests the strong sensitivity of the measure to changes in infant and early childhood mortality. Since overall high mortality is invariably associated with high rates of death in infancy and early childhood, when mortality in those ages is sharply reduced, life expectancy at birth can rise very rapidly. The example also highlights the fact that the measure need not have—and, indeed, when overall mortality is fairly high, it does not have—a close resemblance to the typical age at death or the typical length of life prevailing in a population.

Regional estimates of the expectation of life (e_0) at birth in 1960 and 1990 are shown in Table 3.2.¹¹ In 1960 the region of highest mortality was Africa, with an e_0 of just slightly above 40 years. High mortality also characterized Asia, with life expectancy around 46 years. Low as these figures are in comparison to the lowest mortality regions, they signal considerable improvements in mortality that occurred prior to 1960 in these, as in all other regions. From indirect evidence we know that early in the twentieth century life expectancies as low as 25 years were still common in much of the less developed world.

The improvement in mortality that has taken place between 1960 and 1990, however, is without historical precedent. Life expectancy increased in all regions by substantial margins, whether reckoned in absolute or relative terms.¹² Not surprisingly, gains tended to be greater when the initial (1960) level of mortality was

¹⁰ At any given time, the age distribution of a population is a function of past fertility and mortality trends (and, when relevant, of in- and outmigration). By the same token, its future evolution is shaped by the trends in these factors.

¹¹ In Table 3.2, as well as in Tables 3.3, 3.4, and 3.5, estimates for the indicated years were calculated by averaging the corresponding estimates for the bracketing quinquennia.

¹² The former USSR is probably an exception. The relatively modest improvement in mortality shown in Table 3.2 may be largely a statistical artifact, due to overestimation of life expectancy around 1990.

TABLE 3.2. *Mortality change, 1960–1990, world regions*

	Expectation of life at birth (e_0) (years)		Change in e_0 , 1960–1990	
	1960	1990	Years	Percent
Africa	40.9	52.4	11.5	28
Asia	46.4	63.9	17.5	38
Europe	69.1	74.8	5.7	8
Latin America	55.7	67.3	11.6	21
Northern America	70.0	75.7	5.7	8
Oceania	64.0	72.1	8.1	13
USSR (former)	68.3	69.8	1.5	2
LDCs	45.8	61.6	15.8	34
MDCs	69.1	74.2	5.1	7
World	51.0	64.0	13.0	25

Source: United Nations, 1993a

relatively high, but they were significant even in the lowest mortality regions, Northern America and Europe. The most spectacular gain was registered in Asia (an increase in e_0 of over 17 years, or nearly 40 percent during the period),¹³ but the improvement was also substantial in Africa, Latin America, and Oceania. As a historical comparison, around 1840 Western Europe had the life expectancy found in Africa in 1960, but in Western Europe the improvement that occurred in Africa between 1960 and 1990 took nearly 70 years to achieve. A progress in life expectancy equivalent to Asia's in the 1960–1990 period required about a century in Western Europe.

As a result of the mortality trends observed in the decades prior to 1990, regional differences have narrowed considerably. Taken as a whole, in 1960 MDCs had a life expectancy some 23 years higher than LDCs. By 1990, despite the substantial decrease of mortality in MDCs, this gap was reduced to less than 13 years.

Country-level disparities in mortality are of course much higher than the regional differences shown in Table 3.2. In 1990, a number of countries in Africa still had a life expectancy at birth estimated as below 45 years. On the other end of the scale, around 1990 Japan had the highest e_0 —78.5 years. The averages in Table 3.2 also conceal differences in mortality by sex. The Japanese figure just cited, for example, is the average of male and female life expectancies estimated as 75.7 years and 81.4 years, respectively. The 1990 estimate of 64 years as the global life expectancy at birth is the average of 62 years for males and 66 years for females.

¹³ The Asian average is strongly influenced by the figures estimated for the two largest countries of the world, China and India. Between 1960 and 1990, China's e_0 increased from 47 years to 70 years; for India the corresponding figures are 44 and 59.

Fertility Trends: 1960–1990

The most familiar summary measure of fertility is the total fertility rate (TFR), often referred to as the number of children per woman. As with the expectation of life as a measure of mortality, such a label can be misunderstood. Analogously to e_0 , the TFR is based on age-specific observations (or estimates) of the probability that a woman will give birth during a given year. It indicates the number of children that by age 50 a cohort of women would have on the average if, surviving from age 15 to 50, they had births according to the same age-specific probabilities. Thus, TFR summarizes the childbearing experience of a particular year (or other period of time); it is not meant to suggest the average number of children women will actually have by the time they complete their childbearing years.

Table 3.3 presents TFRs for 1960 and 1990 by world regions. The estimates for the former date range from a low (for Europe) of 2.6 to a high (for Africa) of 6.8. By 1990, this range, still marked by the same two regions, has widened: from 1.7 to 6.1. But the most conspicuous feature of a comparison between those two dates is the rapid decline of fertility in every region during the intervening period. The exception is Africa, where the decline that did occur was relatively minor, less than 10 percent. The largest drops in TFR in absolute terms have been registered for Latin America (a decrease of 2.7 children) and for Asia (a decrease of 2.3 children).¹⁴ In percentage terms, the decline in Northern America was 44 percent, nearly as large as in Latin America, albeit from a much lower initial level.

TABLE 3.3. *Fertility change, 1960–1990, world regions*

	Total fertility rate (TFR) (number of children per woman)		Change in TFR, 1960–1990	
	1960	1990	Number of children per woman	Percent
Africa	6.77	6.13	–0.64	–9
Asia	5.64	3.33	–2.31	–41
Europe	2.61	1.71	–0.90	–34
Latin America	5.93	3.23	–2.70	–46
Northern America	3.53	1.97	–1.56	–44
Oceania	4.00	2.52	–1.48	–42
USSR (former)	2.68	2.34	–0.34	–13
LDCs	6.02	3.77	–2.25	–37
MDCs	2.76	1.92	–0.84	–30
World	4.93	3.35	–1.58	–32

Source: United Nations, 1993a

¹⁴ As with mortality, fertility change in China and India influences the average Asian figures heavily. Between 1960 and 1990, TFR in China declined from 5.7 to 2.3; in India from 5.9 to 4.0.

To assess the significance of these declines a useful reference point is "replacement fertility"—the level of childbearing that, if sustained, in the long run would result in zero population growth. In such a population, each generation of parents would replace itself with a succeeding generation of the same size. Obviously, replacement fertility is a measure of reproduction, rather than just fertility: it depends also on the level of mortality. Replacement fertility would be roughly 2 children per woman if all women survived from birth to age 50, and 4 if only half survived. Once mortality is very low (e_0 about 70 years or more) the proportion surviving to the average age of childbearing is approximately 95 percent or higher. For such low-mortality populations a TFR of 2.1 thus corresponds to replacement fertility. Since, as suggested by the evidence presented in Table 3.2, many populations have already attained such low mortality levels, or are approaching them rapidly, it is convenient to designate 2.1 as the TFR level that would be required for long-run population stability in all regions of the world.

Starting from 1960 as a reference point, how far have the various regions progressed toward replacement fertility? The question is ill-addressed in the case of Africa; there, mortality is still relatively high and fertility has declined only modestly. In other regions of the less developed world the shift from high fertility to replacement level has been remarkably rapid. In Asia, roughly two-thirds of the distance between 5.6 (Asia's TFR in 1960) and 2.1 (the replacement TFR) has been covered during the 30-year period in question. In Latin America this proportion was even higher, about 70 percent.

As for the two low-fertility regions, Europe and Northern America, the question is not quite apposite. The stylized description of demographic transition, according to which fertility declines to replacement level and then stabilizes, eventually generating zero population growth, was already contradicted by the fertility experience of these regions during the decades prior to 1960. Fertility in the United States and in Canada reached replacement level by the early 1930s, as did fertility in most countries in Western Europe. Yet fertility subsequently recovered, reaching in some cases TFR levels well above 3.0 during the years of the baby boom after World War II. But demographers could still interpret that deviation from the expected course of fertility transition as part of the adjustment process to a replacement level TFR (Ryder, 1982). Once fertility resumed its downward course around 1960, a TFR in the immediate neighborhood of 2.0 seemed again a plausible floor to the minor fluctuations around replacement level that the simple model of demographic transition would have predicted.

But such predictions proved incorrect. By 1990, the average TFR in Europe was about 1.7 and in a number of countries well below that level. It was, for example, 1.5 in Portugal, 1.4 in Austria, Germany, and Greece, and 1.3 in Italy and Spain. Furthermore, by 1990, several countries in East and Southeast Asia registered similarly low total fertility rates, notably Japan, South Korea, Hong Kong, Taiwan, and Singapore.¹⁵ Such low fertility levels notwithstanding, an age composition that

¹⁵ With the exception of Japan, each of these countries is still conventionally classified as "less developed."

reflects the influence of earlier, higher levels of fertility and ongoing gains in reducing mortality at older ages still keep birth rates above death rates in most of these countries, or result in only a small excess of the number of deaths over the number of births. If sustained, however, such low fertility levels would eventually shrink total population size rapidly. For example, a TFR of 1.3 in the long term would make each successive generation some 40 percent smaller than the preceding one, a shrinkage corresponding to a rate of population change of nearly -2 percent annually. Such a low level of fertility, if sustained, would also cause population aging far beyond any large population's experience up to now.

When fertility is low, there is a good deal of flexibility in the timing of births over the course of each individual's reproductive span. The total fertility rate in any one year, therefore, is not a reliable predictor of the average number of children women will have when their fertility is completed. Some European countries that earlier had below-replacement fertility have more recently experienced a notable recovery. Sweden's TFR, for example, was 1.7 in the mid-1980s but rose slightly above 2.1 by 1990. Indeed, expecting marked fluctuations of fertility around a low average value would be consistent with the postwar record of countries that have reached the last stage of the demographic transition. But that record warrants no conclusion as to the precise value of that average apart from suggesting that it may well fall appreciably short of replacement-level fertility.

Demographic Transition: 1960-1990

The rapid decline in mortality and the rapid and nearly general decline of fertility between 1960 and 1990, summarized in Tables 3.2 and 3.3, contrast sharply with the very slow decline of overall population growth during that period. Looking at growth rates alone, especially at growth rates in the less developed countries, conveys the impression that during these three decades there has been little change in demographic dynamics globally, and within LDCs as a whole. But such an impression is erroneous. The two main forces that shape population growth work in opposite directions: mortality decline increases it, fertility decline reduces it. Between 1960 and 1990, these two forces were to a large extent compensating. In 1960 the global rate of population growth was approximately 1.9 percent and in 1990 it was 1.7 percent. But these not very different growth rates were the product of very different birth and death rates. The global birth rate was 3.5 percent in 1960 but only 2.6 percent in 1990. The global death rate was 1.6 percent in 1960 but only 0.9 percent in 1990. In the LDCs alone, the birth rate dropped from 4.2 percent to 3.0 percent and the death rate from 2.0 percent to 0.9 percent. The nearly identical rates of natural increase at the beginning and at the end of the period 1960-90 thus conceal a major shift in the balance of factors determining demographic change.

The overall pattern of this change fits broadly into the general frame described by the model of demographic transition. Only the briefest characterization of the forces at work can be adduced here.

In the more developed world, the decline of mortality since 1960 continued a well-established secular trend. Historically, factors directly related to economic development played the key role in sparking and sustaining that trend—especially improvements in nutrition, water supplies, environmental sanitation, and housing (McKeown, 1976). Only at a later stage did advances in public health, medicine, and pharmacology come to amplify and eventually surpass the effects of development in lowering death rates. Once mortality due to infectious and parasitic diseases is greatly reduced, as was the case by 1960 in the more developed countries, such advances, along with individual health-affecting behaviors, are responsible for the lion's share in extending the average length of life. Since the scope of further increase in survivorship up to around age 60 is limited in low-mortality countries,¹⁶ the improvement that does take place primarily affects the population at older ages, contributing, along with fertility decline, to the aging of population. Reductions in death rates at older ages in the more developed countries during the three decades in question generally exceeded expectations held by demographers at the beginning of the period.

The same is true for mortality improvements at large in the less developed countries. Explanation of the rapid decline of death rates in LDCs must invoke the same range of factors noted above but with different weights. Economic development and the concomitant advances in food supply, better access to clean drinking water, and improved sanitation were crucial ingredients in reducing mortality, but with effects greatly strengthened by public health measures and medical technologies imported from the West, notably immunization. The historically observed broad positive relationship between income levels and expectation of life continued to hold in the less developed world, but any given income level was now associated with a higher average level and a wider range of e_0 values than was the case earlier in the more developed countries (Preston, 1980). The higher variability of mortality at any given development level reflects the fact that public policies that improve access to health services and enhance their quality, as well as education that promotes better health-related personal behavior, can have a strong ameliorative effect on mortality even at relatively low levels of income. During the last three decades many countries have effectively exploited the opportunities afforded by this historically new type of relationship between development level and mortality, with great benefit to human welfare.

The behavioral motor force of the demographic transition can be summarized in a single sentence. In demographic matters, as in others, people tend to act in accordance with their interests as they best see them, subject to the values they hold and to the constraints imposed upon them by society and by their objective environment. The degree of freedom for effective personal action is often narrow with respect to

¹⁶ This is to be understood from a population, rather than from an individual or from a public health perspective. The difference between, for example, an infant mortality rate of 10 (calculated per 1,000 births) and an infant mortality rate of 20 is of course great. But the factor affecting population growth—the proportion surviving from birth to age 1—is nearly identical in the two cases: approximately 99 percent in the first instance and 98 percent in the second.

controlling mortality; indeed, death being inevitable, eventually nil. In the domain of fertility, within the limits allowed by human biology, the scope of personal choice is in principle far wider, even though such choice can be severely restricted by internalized values and by social institutions regulating individual behavior.

Differences in these conditioning circumstances among individuals and across countries explain why fertility behaviors under seemingly similar developmental circumstances can differ greatly. In particular, how changes in objective economic and social circumstances are reflected in human consciousness are powerfully influenced by cultural factors. Thus, for example, parents' perceptions of their obligations toward the upbringing of their children, and what they regard as adequate shelter, education, or nutrition for their children and for themselves—perceptions that are bound to influence fertility profoundly—are matters culturally as much as objectively determined, at least above a critical minimum level of material comforts. The frequently advanced proposition that a straightforward negative relationship exists between “development” and fertility is, therefore, misguided. Just as behavioral responses, individual and collective, to similar changes in the pattern of economic opportunities can exhibit great differences from person to person and from economy to economy, there is no reason to expect a close inverse relation between the level of fertility and any particular index of development, such as income per capita. Nor is it warranted to assume that attainment of certain identifiable threshold values of development represents a generally valid precondition for achieving low fertility.¹⁷

These considerations suggest that the potential range of variation in fertility trends among countries entering the path of fertility transition is wide. This is confirmed by the actual experience of the LDCs during the last 30 years. At the same time, the logic of the ultimately overweining influence on fertility exerted by the changes brought about by development and its concomitants (discussed above with reference to the earlier European experience) did generate a broad pattern of correspondence between economic advance and observed declines in fertility in these decades. This is evident both in the regional trends summarized in Table 3.3, and in country-by-country fertility changes. Rapid fertility decline in the less developed world started about 1960 in the dynamic economies of East Asia—Taiwan, South Korea, Hong Kong, and Singapore.¹⁸ At the other end of the spectrum, fertility decline around 1990 had yet to commence in the countries that may be classified as least developed, notably in most countries of sub-Saharan Africa.¹⁹

From the perspective of individual choices, decisions leading to lower fertility can be interpreted as originating in economic motivations. Two types of fertility-reducing incentives may be usefully distinguished. One is to seize opportunities that open up in the process of successful development. Examples include the desire for

¹⁷ This discussion draws in part on Demeny, 1974.

¹⁸ Japan, the first country outside the area of European settlement to have entered the process of secular fertility transition, had reached below-replacement fertility in the 1950s.

¹⁹ Not surprisingly, in that region fertility decline has progressed farthest in South Africa, a relatively industrialized country.

acquiring new consumer goods; the desire to launch or expand a privately owned enterprise by acquiring capital goods, including land; the desire to provide better education and upbringing to one's children and to avoid fragmentation of parental bequests to them; and an interest in upward social mobility. The chance of success in such endeavors under institutional conditions that give broad scope to private decisions in the economic and social spheres of life and that internalize most of the costs of rearing children within the nuclear family can be powerfully influenced by delaying marriage and by restricting the number of children born. The effect is reinforced by the decreasing economic benefits parents can derive from children as economic development progresses.

It is clear, however, that economic progress, although the dominant force both in earlier fertility transitions and in the contemporary experience of the less developed countries, is not the sole possible prompter of fertility decline. A second, less benign set of economic incentives can also induce fertility decline: lack of economic progress and increasing economic hardship. Delaying marriage and restricting family size can be means of resisting a lowered standard of living. Such "poverty-driven" fertility response may be triggered by actual worsening of one's objective material circumstances or by a shift in one's relative standing in the income distribution—caused not by lower income but by others' more rapid progress.

Whether economic circumstances are improving, stagnant, or deteriorating, changing fertility behavior can also be shaped by changing perceptions and cultural influences. Exposure to new ideas and styles of living tend to generate new economic and social aspirations whose satisfaction conflicts with having a large family. With the greatly increased frequency and intensity of contacts between the less developed and the more developed countries caused by rapid growth in international trade, cheap transportation, and wide exposure to the mass media—especially radio, films, and television—such influences appear to have played a more important role in inducing changes in fertility behavior in contemporary LDCs than was the case in earlier international experience.

Such developmental changes can affect the desire for the number of children born, hence bear on fertility directly. They can also cause behavioral changes—for example, postponement of marriage—that have a fertility-depressing effect without such an effect being consciously desired. Both types of influences are also socially conditioned, either tacitly or explicitly. While the ultimate fertility-affecting choices are made by the individual couple, those choices reflect spontaneous interaction within the surrounding social milieu that transmits norms and expectations to individuals concerning what society considers appropriate behavior. Fertility choices can also be explicitly construed as affecting the collective interest, hence be made the subject of policies adopted by governments in order to influence fertility behavior in a direction agreed upon as most conducive to the public good.

In contrast to the practice of direct policy intervention to affect certain demographic processes, notably mortality and migration, which have a long history, deliberate attempts to influence fertility are largely a twentieth-century phenomenon. Their earliest manifestations were invariably pronatalist: European govern-

ments, concerned with the implications of sustained low fertility, sought to increase the number of births through a variety of policy measures, mostly consisting of economic incentives, for example, family allowances. By common judgment, the effect of such policies on fertility was at best minor. In recent decades few countries have maintained explicitly fertility-promoting measures. Existing social policies seeking to enhance the welfare of families and to alleviate the financial burdens of childrearing tend to be justified in the political process not because they increase fertility but as valuable in their own right.

Since World War II, concern with perceived deleterious consequences of rapid population growth in the less developed countries led to the adoption of policies seeking to reduce aggregate fertility. In some countries, notably India, such policies were formulated already in the early 1950s; in subsequent decades they came to be adopted, often with international assistance, in countries comprising the large majority of the population of LDCs. Their main manifestation was the launching of family planning programs. Such programs provide information about, and subsidize access to, methods of regulating fertility, so as to reduce the material and psychological costs couples wishing to limit the number of their children would otherwise incur.

The degree to which these programs affected the transition from high to low fertility in the developing world is difficult to ascertain. Western historical experience certainly suggests that such a transition would have occurred as a spontaneous process in any case. But the programs are widely considered to have accelerated the decline of fertility.²⁰ In some instances, notably in China, where the provision of family planning services was combined with direct material incentives, administrative pressures, and formal legal measures aimed at reducing fertility, the impact of government policy on fertility change was probably highly significant. Somewhat paralleling the history of pronatalist policies, more recent formulations of the rationale of government-sponsored family planning programs tend not to emphasize the goal of aggregate fertility reduction but to justify the programs as a social service catering to individual needs.

Socioeconomic, cultural, and political-programmatic changes of the sort outlined above form a complex that generated the rapid decline in fertility observed in much of the world during the period 1960–90. These underlying causes of change work through a number of direct mechanisms, known in demographic analysis as the proximate determinants of fertility. As was shown by Bongaarts (1978), numerically four of these proximate determinants are dominant: the proportions married, contraception, induced abortion, and lactational infecundity. Of these, contraception is statistically most closely associated with the change in fertility that took place between 1960 and 1990, especially in the less developed countries. In these countries, around 1960, the prevalence of current use of a contraceptive method among married women of childbearing age was estimated as approximately 10 percent. By 1988, according to the United Nations (1989), contraceptive use rose to 48 percent;

²⁰ For an estimate of the impact, see Bongaarts, Mauldin, and Phillips, 1990.

the figure probably exceeded 50 percent by the early 1990s. These estimates are subject to substantial margins of error; the average is also heavily influenced by the inclusion of China, where the rate of prevalence of contraception (as defined above) is about 70 percent²¹—roughly the level that characterizes the more developed countries as a whole. But the rapid upward trend in contraceptive practice since 1960 is unmistakable and in the accounting sense explains a large part of the fertility decline that had occurred in LDCs by 1990.

Prospects for Population Growth: 1990–2020

Human capacity for predicting future events is inherently limited, and prediction of demographic futures is no exception. Nevertheless, fertility and mortality trends possess a degree of inertia that renders forecasts of population size for the near and medium term—roughly the next 25 to 30 years—highly informative about likely future population trends.²²

Also, and alternatively, population projections can be thought of not as actual forecasts but hypothetical exercises that merely spell out the numerical implications of specified assumptions concerning future mortality and fertility trends, thus establishing reference scenarios for future population change. Such scenarios can then be challenged as too high or too low by challenging the underlying mortality and fertility assumptions. For example, a projected future population size can be considered too high only by asserting that future fertility will be lower than specified in the projection, or that future mortality will be higher. By calculating alternative projections based on changed mortality and fertility assumptions, the sensitivity of any projected population figure to alternative future mortality and fertility trends can be explored.

Tables 3.4 and 3.5 summarize the assumptions on mortality and fertility incorporated in the United Nations “medium” projections for the period 1990–2020. They indicate, in regional detail, changes in expectation of life at birth and in the total fertility rate during this 30-year span. These assumed changes may be characterized as largely surprise-free, plausible extrapolations of trends observed during the period 1960–90 (summarized in Tables 3.2 and 3.3). As to mortality, they specify further general gains in survivorship, albeit gains that in terms of expectation of life at birth are generally more modest than those registered in the previous three decades. Thus, for LDCs, the gain in e_0 from 1960 to 1990 was 15.8 years; from 1990 to 2020 the anticipated further gain is 9.0 years. The corresponding figures for MDCs are 5.1 and 4.2 years. This slowing-down in the assumed rate of progress reflects the increasing difficulty of further reducing death rates once mortality is fairly low. A corollary is that mortality differences between regions are expected to be further

²¹ Estimated contraceptive prevalence rates are about 17 percent in Africa, 30 percent in Asia excluding East Asia, and somewhat above 50 percent in Latin America.

²² For a discussion of the information content of population projections, see Keyfitz, 1981.

TABLE 3.4. *Projected mortality change, 1990–2020, world regions*

	Expectation of life at birth (e_0) (years)		Change in e_0 , 1990–2020	
			Years	Percent
	1990	2020		
Africa	52.4	64.6	12.2	23
Asia	63.9	72.9	9.0	14
Europe	74.8	78.8	4.0	5
Latin America	67.3	73.1	5.8	9
Northern America	75.7	79.6	3.9	5
Oceania	72.1	77.6	5.5	8
USSR (former)	69.8	75.2	5.4	8
LDCs	61.6	70.6	9.0	15
MDCs	74.2	78.4	4.2	6
World	64.0	72.0	8.0	13

Source: United Nations, 1993a ("medium" projection)

narrowed, although inequalities between regions would still persist in 2020. For example, the relative advantage of MDCs over LDCs as a whole was some 23 years in 1960 and 13 years in 1990; by 2020 this gap would be reduced to 8 years. Africa would remain the highest mortality region, but even there e_0 would exceed 64 years, that is, would reach roughly the same level experienced in the Asian region in 1990.

As to fertility change, the UN "medium" projections assume that by 2020 average total fertility rates will be very near to or below replacement level in all regions except in Africa. The amount of decline in fertility required to yield this result is substantial in Asia and Latin America, although still much less than the decline registered in these regions between 1960 and 1990. In contrast, fertility change is assumed to accelerate markedly in Africa. For that continent, the expected change from 1990 to 2020 is massive: roughly of the same magnitude as the one experienced in Asia between 1960 and 1990—a drop of 2.5 children per woman or a decline of about two-fifths. Such a change would still leave African fertility in 2020 at a level comparable to that of fertility in Asia or Latin America in the 1980s. In Europe, the projections anticipate a modest recovery from the very low fertility levels around 1990. The assumed level of fertility in 2020, however, would be still below replacement. In Northern America, assumed total fertility in 2020 would be about the same as in Europe, implying a small decline between 1960 and 2020. In Oceania and the former USSR some modest declines of fertility are also assumed, bringing total fertility rates in those regions to slightly below 2.2.

The implications of these stipulated mortality and fertility changes for change in total population from 1990 to 2020 are shown in Table 3.6. During that period, again with the exception of Africa, anticipated average regional rates of population growth will be markedly slower than was the case between 1960 and 1990 (summarized in

TABLE 3.5. *Projected fertility change, 1990–2020, world regions*

	Total fertility rate (TFR) (number of children per woman)		Change in TFR, 1990–2020	
	1990	2020	Number of children per woman	Percent
Africa	6.13	3.63	-2.50	-41
Asia	3.33	2.19	-1.14	-34
Europe	1.71	1.87	0.16	9
Latin America	3.23	2.20	-1.03	-32
Northern America	1.97	1.83	-0.14	-7
Oceania	2.52	2.17	-0.35	-14
USSR (former)	2.34	2.15	-0.19	-8
LDCs	3.77	2.50	-1.27	-34
MDCs	1.92	1.94	0.02	1
World	3.35	2.41	-0.94	-28

Source: United Nations, 1993a ("medium" projection)

TABLE 3.6. *Projected population growth, 1990–2020, world regions*

	Population size (millions)		Change in population size, 1990–2020		
	1990	2020	Absolute increase (millions)	Percent increase	
				Total	Annual average
Africa	280	643	363	130	2.8
Africa	643	1,421	778	121	2.6
Asia	3,118	4,698	1,571	50	1.4
Europe	509	542	33	6	0.2
Latin America	441	671	230	52	1.4
Northern America	227	352	75	27	0.8
Oceania	27	39	12	44	1.2
USSR (former)	281	336	55	20	0.6
LDCs	4,084	6,663	2,579	63	1.6
MDCs	1,211	1,387	176	15	0.5
World	5,295	8,050	2,755	52	1.4

Source: United Nations, 1993a ("medium" projection)

Table 3.1). In LDCs as a whole, the rate will be 1.6 percent, well below the 2.3 percent average rate experienced during the preceding 30 years. In MDCs, the corresponding figures are 0.5 (projected) and 0.8 percent, respectively. The average global rate of growth of 1.4 percent per year is still very rapid by historical standards, reflecting the sluggish response of the rate of population growth to the decline in fertility rates, caused by the large cohorts entering the childbearing years in LDCs—an inheritance of past high fertility. Because of the contribution of this “population momentum” to growth, global population increase between 1990 and 2020 will be nearly 2.8 billion, bringing world population size in 2020 to 8 billion. The net addition to the global total thus will exceed roughly by 500 million the absolute increase experienced between 1960 and 1990. Nearly 2.6 billion of that growth, or some 94 percent of the total, will take place in LDCs. In Africa alone, notwithstanding the assumed rapid decline of fertility, population increase during the period would approximate 800 million, or more than twice the amount of increase during the preceding 30 years.

Shifts in the age distribution implied by the projections will be substantial. For example, between 1990 and 2020, the population under age 15 will grow by 26 percent, while the population aged 15–64 and 65 and older will grow by 78 and 160 percent, respectively. Rapid aging of the population in the MDCs will be even more pronounced: in the three age groups 0–15, 15–64, and 65 and older, the projected growth will be 1 percent, 11 percent, and 60 percent, respectively. The shift among regions with respect to total population size will continue. For example, Africa’s share in the global total will rise from 12 percent in 1990 to nearly 18 percent; the share of MDCs will drop from 23 percent to 17 percent.

Different assumptions concerning mortality change than those shown in Table 3.4 would affect projected population numbers but, short of major retrogression in health conditions, would not change the overall character of regional population dynamics during the coming decades. More optimistic assumptions concerning improvement in survivorship would of course increase the population totals; their most noticeable effect, however, would be acceleration of the process of population aging, especially in the more developed world.

Faster or slower declines in fertility than those underlying the projected population numbers shown in Table 3.6 would make a difference in the size of the global population, but major population increase is inevitable under any plausible assumption concerning fertility change. Alternative projections predicated upon slower or faster fertility declines suggest the likely upper and lower limits of global population growth in the medium term. The United Nations “high” variant projection implies a global population of 8.5 billion by 2020. The corresponding figure for the “low” variant is 7.6 billion. The difference of 900 million is of course substantial—roughly equivalent to the entire population of the more developed world in 1960. But even the low projection implies a population growth of 2.3 billion between 1990 and 2020—or growth of the same magnitude as occurred between 1960 and 1990. The major difference between the two projections assuming a more and a less rapid decline of fertility lies in the implication of such trends for

population growth in the longer term. A more rapid decline of fertility in the near term could set the stage for a rapid deceleration of population growth later in the twenty-first century, and for the likely stabilization of the global population around, or not much above, the 10 billion mark. Slow decline of fertility in the near term would almost certainly imply an eventual global population at least several billions higher.

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Part II

Population and Physical Resources

4 Introduction

ANDRÉ BLANC-LAPIERRE

Concern with how human populations use and abuse physical resources was eloquently expressed by Pope John Paul II in his message commemorating the Day for World Peace (1 January 1990):

Today there is a more acute awareness of the threats to world peace, not only because of the weapons race or of the regional conflicts, or of the many forms of injustice that still exist among peoples and nations, but also because of the many infringements upon the laws of Nature and the denial of the respect due to it, of the indiscriminate exploitation of its resources, and of the gradual deterioration in the quality of life. . . . Facing a general deprivation of its environment, mankind has now become more aware of the fact that the world's wealth cannot continue to be used as it has been in the past.

Much of this wealth is not renewable. It must therefore be used with thrift, avoiding all waste. This principle, considered obvious for minerals and raw materials, has, since the oil crises, become so for energy as well. It is just as imperative for water. The never-ending water cycle is so ingrained in our minds that for many, water is perceived as a renewable resource. This view is erroneous, and all the more so for arid zones.

Being thrifty does not suffice, however. We must use resources more wisely, we must have recourse to substitutes, and we must advance technology. The ways that resources are put to use should not bring about an alteration of the environment (through pollution of land, air, and water, carbon dioxide, sulfur compounds). The concern with careful husbandry is all the more necessary since our resources are to be used by a growing population.

The types of resources considered here—energy, raw materials, water, and arable land—do not constitute independent domains. Processing of raw materials and cultivation of land require energy and water, which in turn are obviously inter-related.

The imperatives to avoid waste and assaults on the environment may seem, or perhaps even be, in contradiction to economic guidelines in the short term, especially for those seeking immediate and maximum profits. Yet the very future of mankind depends on careful husbandry. The fundamental and increasing gap between industrialized countries and developing countries adds to the challenge.

It is therefore increasingly urgent that a new solidarity be developed in the use of the Earth's resources. In this regard and as a conclusion, I again quote from the same message of the Holy Father:

The ecological crisis points to the urgent moral necessity of a new solidarity, particularly in

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the relations between developing countries and highly industrialized countries. Nation-states must show more and more solidarity and complementarity, so as to foster the development of a natural and social, of a peaceful and beneficial environment.

5 Energy Resources and Population

UMBERTO COLOMBO

Since the discovery of fire, energy has been a major factor in development. Each of the great transformations of civilization has been accompanied by new ways to produce and utilize energy. Conversely, each new source of energy has made possible, or has necessitated, transformations in social organization. Fire, by permitting the conservation of food and protection from cold, brought about a more stable and complex prehistoric society; draught animal energy was a major component in the advent of agriculture; the use of the wind in sea transport and for mills had a profound influence on the Renaissance and contributed to the expansion of cultural and commercial horizons. Coal was at the base of the industrial revolution, which developed in countries having large reserves of this fuel (such as Great Britain and Germany). Electricity stimulated new forms of industry and changed the urban environment, while oil has fueled the great transformation of industrial society, especially after World War II.

Energy and Population

In the past, energy was essentially a matter of local concern. It was difficult and costly to transport fuels over long distances and populations had to rely on what was on hand. In this century, fossil fuels have been increasingly traded in the international market. This was initially due to the diffusion of the use of oil as an energy source, a fuel easy to transport by sea, pipeline, and road; but now a progressively greater contribution is also coming from trade in natural gas, coal, and even electricity. The importance of energy for development is well recognized today. Some 25 to 30 percent of all financial resources allocated to aid-to-development programs is targeted to energy projects.

The environmental consequences of energy production and use are also becoming a global phenomenon. Air pollution and acid rain know no frontiers; and the explosion in 1986 of the Chernobyl nuclear power plant in the former Soviet Union, with its toll of mortality, morbidity, and environmental damage, has demonstrated that nuclear energy can no longer be considered merely a matter of national concern. Threats to the stability of the Earth's climate deriving from accumulation of carbon dioxide in the atmosphere have their main origin in the use of fossil fuels; action to prevent possibly irreversible changes in climate will require negotiations and agreements involving most countries of the world, as called for by the UNCED

Conference held in Rio de Janeiro in June 1992. Even deforestation and desertification, which derive at least partly from an unsustainable demand for firewood, have effects that extend far beyond the local level. In short, energy has become a global issue.

Contrary to the fears of the 1970s, it is now clear, however, that the world is not running out of energy resources, at least in the short to medium term. Rather, and especially in the third world, the major issue is uncertainty of energy prices and, at times, fear over the security of supply. In addition, the use of fossil fuels, in particular coal, presents a number of environmental problems. Difficulties in increasing the use of natural gas arise from the lack of adequate infrastructure. Greater diffusion of nuclear energy, a potentially important energy source, is hampered by adverse public opinion, political concern and economic constraints. The fuelwood resources that are a vital energy source for a large part of the rural population in the less developed world are being rapidly depleted. Large-scale hydropower schemes meet with environmental problems, as well as with lack of capital.

The situation is difficult for all countries, but the more so for less developed ones where human and financial resources are scarce. Yet, the future increase in energy demand will be concentrated overwhelmingly in the developing countries. This is the natural consequence of the fact that the expected increase in population is concentrated in the third world. Moreover, on average, the current level of per capita use of energy in developing countries is only about one-tenth of that in industrial countries, and any hypothesis of development must contemplate a great narrowing, even eventual closing, of this gap. Thus, while developing countries account today for only about one-fourth of worldwide energy consumption, their share is expected to rise to nearly one-half by the middle of the next century. Global energy consumption is now increasing at an annual rate (2.3 percent) exceeding that of population growth.

At the world level, changes in the shares of the various energy sources have been relatively slow hitherto (see Fig. 5.1), and it is conceivable that this trend will continue in the near future.

A review of Energy Sources

Let us now consider the present situation for the different sources of energy, fossil and nonfossil.

Fossil fuels

In the early 1990s, oil is still the main energy source, accounting for about 38 percent of world supply. Oil production increased steadily until 1979, with a minor setback following the first oil crisis of 1973. After suffering the consequences of the sudden price increase of the second oil crisis (1979–80), production resumed an

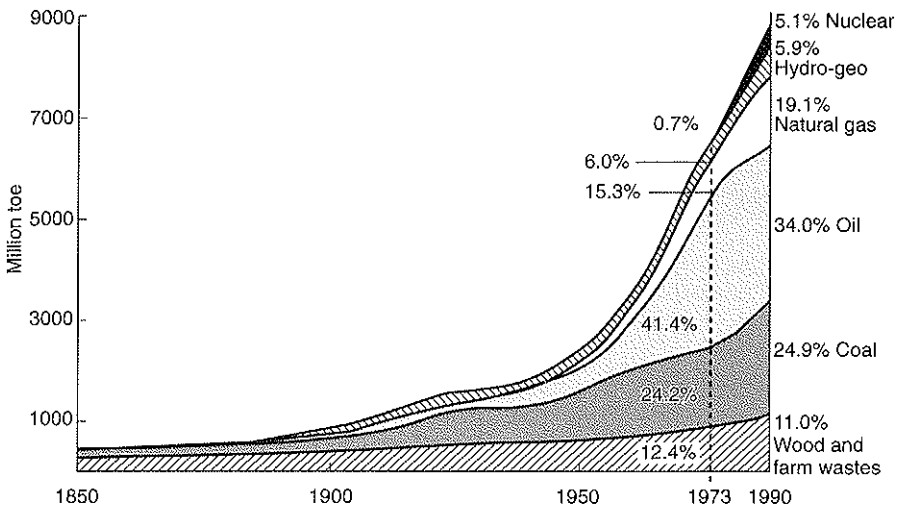


FIG. 5.1. World energy consumption by primary sources, 1850-1990 (millions of tons of oil equivalent (toe))

Note: Percentage figures for 1973 and 1990 indicate composition of consumption in those years.

Source: Elaboration by ENEA

upward trend that has continued despite the Gulf War (with its temporary impact on production by Kuwait and Iraq) and the decline in output in the former Soviet Union. Proven oil reserves, as shown in Fig. 5.2 for the main geographic areas, have never been so abundant. In 1989 the ratio between proven reserves and annual consumption was at an all-time high of 44 : 1. In other words, at the present level of consumption, we have 44 more years before we run out of oil, even if no other oil deposit is discovered in the meantime. In fact, in the last 15 years the increase in reserves has outstripped the consumption of oil. (Increases in proven reserves do not, of course, refer necessarily to new discoveries of oil. Modern geophysical methods now permit substantial re-evaluation of existing reserves, boosting figures for those that can be considered "proven.")

Natural gas appears to be the most acceptable energy source from the point of view of the environment. The greatest obstacles to its diffusion are the costly transportation, storage, and distribution infrastructures that are required. This explains why many known gas fields have not yet been exploited, especially when the distance from potential markets is great. Natural gas present in many oil fields is currently reinjected, and in a few cases, still flared without utilization. Current production data indicate that former Communist countries and North America account for more than 70 percent of world gas output. Proven reserves are about 59 times higher than annual production levels. (The former Soviet Union and the Middle East, especially Iran, are the most important geopolitical areas where major

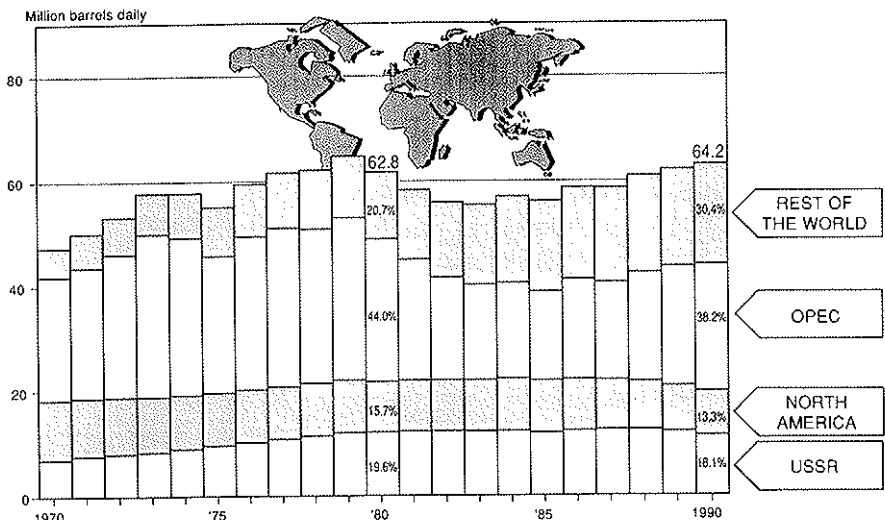


FIG. 5.2. *World oil production, by geographical origin, 1970-1990*

Note: Percentage figures for 1980 and 1990 indicate shares of total production for those years.

Source: BP Statistical Review of World Energy (June 1991)

gas fields are expected to be exploited in the future.) Known gas reserves have grown even more rapidly than oil reserves, and the two are now of the same order of magnitude in terms of energy content. Currently, only a small percentage of gas produced is traded on the international market. With expansion of capacity and investment in new infrastructure, this share is rising.

As for coal, the outlook could be even more optimistic: reserves are concentrated in the United States, the former Soviet Union and China (which together account for more than 62 percent of the total), and exceed one thousand billion tons. If not for the adverse effects of coal combustion on the environment, coal could guarantee about 230 years of energy supply at present levels of consumption. As with gas, coal constitutes mostly a domestic energy source, with a smaller fraction of coal production traded in the international market.

In fact, as Fig. 5.3 shows, the international energy market has in essence hitherto been dominated by oil. Only now are the quantities of coal and natural gas traded beginning to appear significant in the overall total. The amount of electricity crossing international borders, though increasing, is still small compared to the size of world trade in primary energy.

Nonfossil energy sources

Renewable energy sources play a central role as candidates for future energy systems, especially with respect to decentralized production. Developing countries

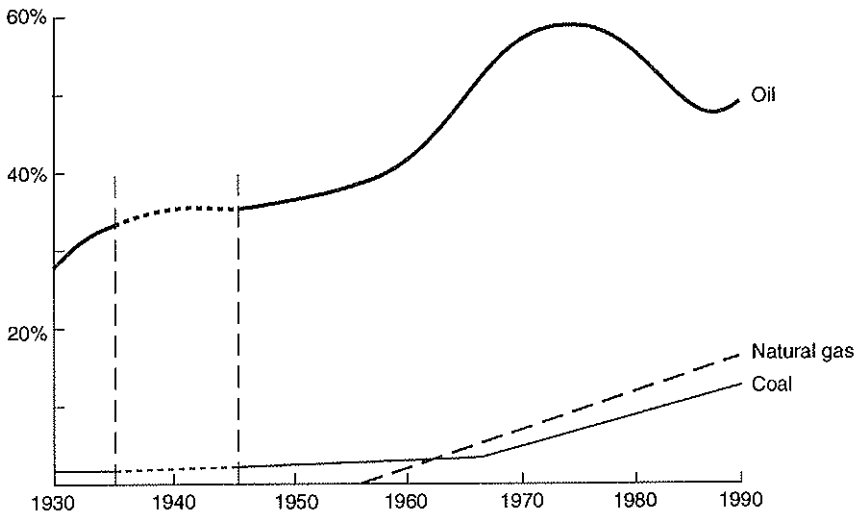


FIG. 5.3. *International trade shares of oil, coal, and natural gas, by percent of the total consumption of each of these energy sources, 1930–1990*

Source: ENEA processing of OIL & GAS Journal, Petroleum Economist, CEDIGAZ data

that lack sufficient energy infrastructure for the transportation and distribution of electricity and gas could profit from passing directly to decentralized energy systems based largely on renewables, “leap-frogging” the capital-intensive energy systems universal in the industrialized North.

Hydropower, which contributes about 6 percent to the total world commercial energy supply, is the most exploited renewable energy source in industrial countries. For large plants, the number of appropriate sites still available in Western industrial countries is limited, but large, untapped resources remain in many developing countries, as well as in the former Soviet Union. Prospects for new hydropower plants will improve if technologies (for instance, high-temperature superconductivity) for long-distance transportation of electricity without excessive loss become available. However, increased attention needs to be devoted to environmental impacts and to better integration of hydroelectric power schemes with other water uses.

Biomass energy can be derived from agricultural residues or as a byproduct of food production or other activities, or else it can be cultivated ad hoc in the form of energy crops. At present, biomass is one of the main energy sources in less developed countries, where it is used in a nonsustainable way. The need is to produce and use biomass as a truly renewable source of energy. A wide range of technologies exists for the transformation and use of biomass, from such well-established technologies as direct combustion to others still at the research stage (e.g., enzymatic hydrolysis of cellulosic materials followed by fermentation to

produce ethanol; or biomass gasifiers coupled to high-efficiency combustion turbines to produce electricity). All of these technologies have been improved in recent years, and the accumulated experience is much greater than it was only ten years ago.

Photovoltaic (PV) direct conversion of solar energy into electricity is a promising technology for several reasons: it has the potential for substantial cost reduction; it is modular, which makes even small plants economically viable; it requires little if any supervision or maintenance, making it ideal for isolated sites; and it has an intermediate market. Even if the cost of photovoltaic conversion is still much higher than conventional sources for bulk electricity production, there is a growing number of high-value applications for which it is already competitive, and the size of this market is increasing rapidly as the price of conversion systems decreases.

Other new and renewable sources can be important under particularly favorable conditions: for example, wind, geothermal energy, and, at least in prospect, energy from the oceans (tides, waves, thermal gradients).

Nuclear energy has attained a share of about 5 percent of global energy consumption. It is the best option currently available for the generation of baseload electricity without the emission of carbon dioxide. But nuclear energy is facing a quasi-stalemate in many countries (including most of Europe and the United States) because of problems with social acceptability. Worldwide, nearly as many nuclear plants are likely to be shut down over the next decade as new plants commissioned. Only in a handful of countries, notably in France and Japan, has construction of new nuclear power plants not suffered setbacks following the Chernobyl accident in 1986.

A new wave of nuclear power plant construction worldwide could be expected if the technological and economic feasibility of innovative concepts of intrinsically or passively safe reactors can be demonstrated. Such new-concept reactors would greatly reduce the probability of accidents arising from human error. By improving containment at all levels (from the fuel cycle all the way to the reactor building), it should be possible to ensure that no accident, however improbable, requiring evacuation would have appreciable consequences outside the plant. This would go far to restore public confidence in nuclear power as an energy source.

The main environmental problems with the nuclear fuel cycle are associated with radioactive waste, especially with long-life alpha emitters. Technologically acceptable solutions to cope with this problem have been devised and are actively being pursued. A crucial issue here is, again, educating the public. In addition, the discovery in 1991 of a clandestine nuclear bomb program in Iraq, and more recently in North Korea, has evidenced the need for more reliable international surveillance and arms control to prevent the proliferation of nuclear weapons. Such a regime must include provision for international intervention, should secret weapons programs be uncovered. All in all, for strategic and financial reasons, it is unlikely that nuclear energy can play a significant role in responding to the increasing energy needs of the third world for the foreseeable future.

I could not end this brief overview without mentioning an energy source that is

presently under study but is not likely to become commercially available for at least 50 years. This is nuclear fusion, which took a further step forward in November 1991, with the successful plasma experiment at the European Community's JET device in Culham, near Oxford. Because of the extreme complexity of the technology involved, and the need to experiment in very costly machines, nuclear fusion clearly requires considerable cooperation in research and development, at the world level. The European Community, with its long tradition of cooperative research, is thus joining forces with the United States, Japan, and Russia in the design and construction of the next-generation large magnetic confinement device, ITER.

Nuclear fusion is a very long-term option that will be realistically available only to industrial countries that have the capacity to master its complex technology and the need for large electricity-generating production units. Nevertheless, commercialization of fusion could, in due course, ease the overall situation in the energy market and in this way assist developing countries too.

Energy, Development, and Industrialization

In dealing with the world's future energy needs, it is not sufficient to consider the supply side—that is, how to generate the ever-increasing amount of energy that will be needed. It is equally important, now perhaps more so, also to deal with the demand side. Energy demand is not an independent variable, even assuming a certain rate of economic development. The amount of energy that is actually required for a given purpose depends on the efficiency of its use, which varies greatly from one situation to another.

If we look at the evolution of the gross domestic product (GDP) for selected countries, some interesting observations about the energy intensity of GDP can be made. In advanced industrialized countries, the energy content of each additional unit of GDP is gradually decreasing, as a consequence of "dematerialization," a process described in detail by Ugo Farinelli in this volume. Dematerialization applies to energy as well as to materials themselves. Fig. 5.4 shows the decrease of energy intensity of GDP during the 1970s and 1980s in a number of industrial countries.

Let us now discuss the importance of dematerialization in the context of development. In any country undergoing economic development up to and beyond the stage of industrialization, the energy intensity of GDP evolves over time (hence, with the growth of GDP itself), following the type of path depicted in Fig. 5.5. In an early stage of economic development, the energy intensity of GDP rises because a country needs to build its basic infrastructure, which requires a large amount of material goods, and also because of the shift in agricultural practices toward energy-intensive inputs and technologies. Once the need for basic goods and infrastructure is saturated, demand can be expected to shift toward goods with less material content and toward services.

If a given country undergoes industrialization at a later stage than others, it

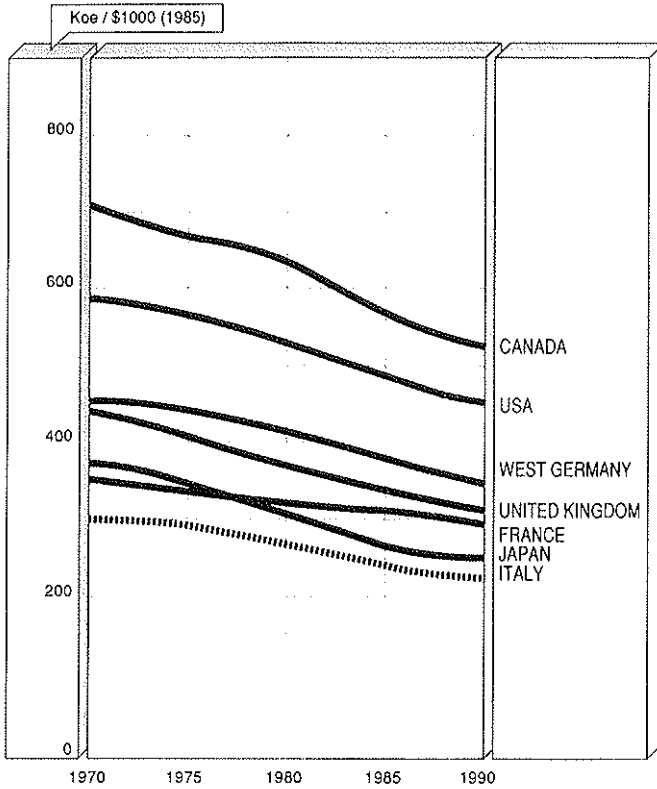


FIG. 5.4. *Energy intensity of GDP in selected countries, 1970–1990 (kilograms of oil equivalent (koe) per 1,000 US 1985 dollars)*

Source: Elaboration by ENEA

can expect to have at its disposal better technologies—reflecting progress in the efficiency of use of materials and energy—and thus will exhibit a lower peak on the curve, as represented by “country B” in Fig. 5.6. This is confirmed by looking at the curves representing the real situation in selected countries, starting in the early nineteenth century (see Fig. 5.7). Great Britain, the first country to industrialize, exhibits the highest value at its peak in the curve representing the energy intensity of GDP over time. Then come the United States, Germany, France, Japan, and Italy. All curves, obtained from actual statistics, are in remarkable agreement with expected performance.

If we now consider, in Fig. 5.7, the evolution of energy intensity of GDP in the former Soviet Union and other centrally planned economies of Eastern Europe, we note that this curve peaks only in the 1980s. However, the value of energy intensity of GDP at the peak corresponds to a situation that would have been normal in the West with the technologies available in the 1920s or 1930s. In other words, there is

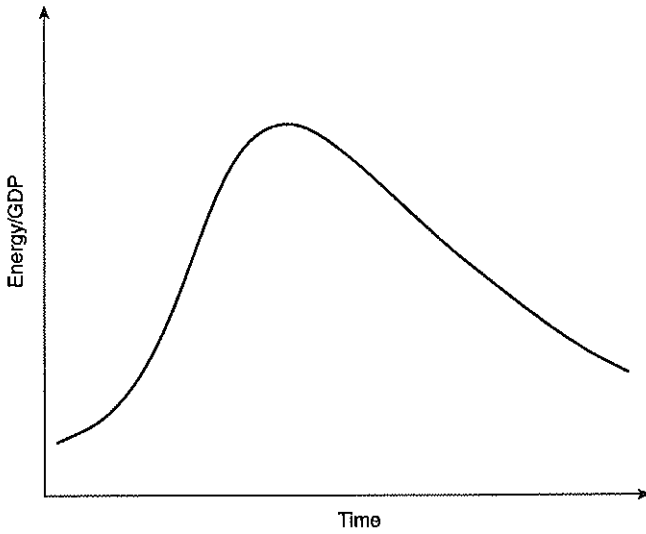


FIG. 5.5. Stylized representation of the evolution of energy intensity of GDP during the process of economic development
Source: Elaboration by ENEA

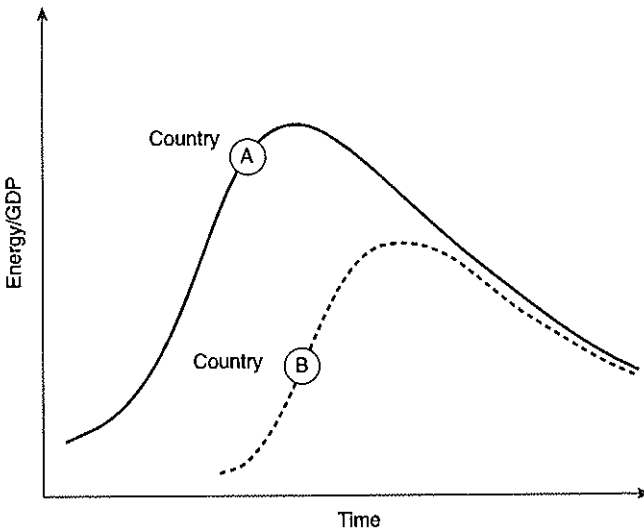


FIG. 5.6. Comparison of the evolution of energy intensity of GDP in two countries
Note: Country (A) industrializes earlier; country (B) industrializes later, when more efficient technologies have become available.
Source: Elaboration by ENEA

no sign in this curve of the use of energy-efficient technologies that would have resulted in a lower peak. The Soviet Union and its Eastern European satellites were not open economies, exposed to market forces and competition. The economic system did not favor innovation. The artificial, top-down nature of the pricing structure and the fact that the energy sector was highly subsidized also go some way to explain the exceptionally high values of the peaks in the energy content of GDP in that region.

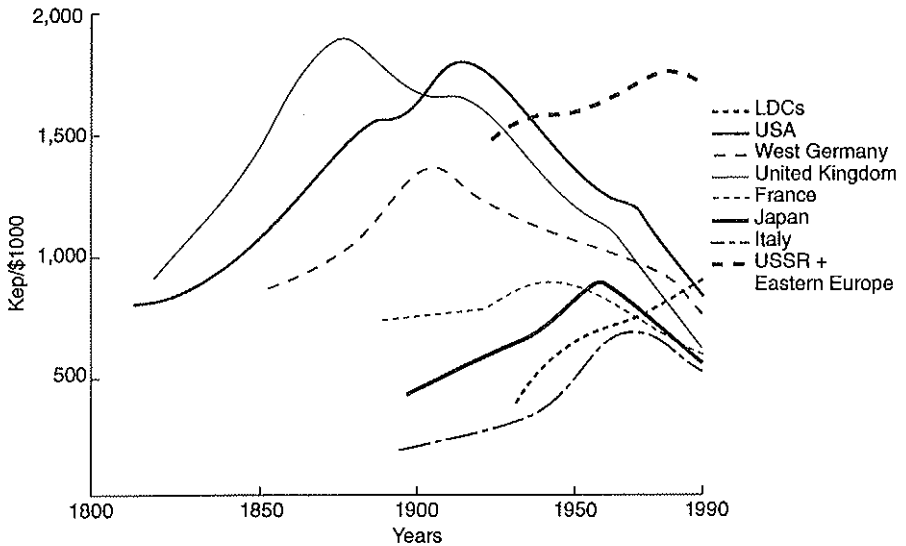


FIG. 5.7. *Historical trends in the energy intensity of GNP in selected countries and groups of countries, 1800–1990 (kilograms of oil equivalent per 1,000 US dollars)*

Source: Elaboration by ENEA

Other important conclusions derive from the observation of the curve, pictured in Fig. 5.7, representing the energy intensity of GDP in developing countries (data for this curve are available for a few decades only). As one would expect, the curve is still rising steeply, indicating that these countries, taken as a whole, are still at the early stage of industrialization. What is of concern is that the energy intensity of GDP has already reached values higher than the peak in the curves for Japan and Italy, that is to say, for those OECD countries that reached full industrialization most recently. This indicates that modern, high-energy-efficiency technologies are not generally available in developing countries. This in turn is due to the lack of capital to acquire these technologies, to the insufficient technical background, to inadequate education and training, to different priorities set by governments and, often, to energy prices that are artificially kept low. There is also the fact that aid programs funded by the North have given higher priority to the transfer of conventional plants

and technologies than to the development of energy technologies specifically appropriate to the needs of developing countries.

Final Remarks

The availability of energy sources in general, and the depletion of fossil-fuel reserves in particular, are not by themselves limiting factors in sustaining a still rapidly increasing world population on its way to development. The limits are rather in the way these resources are used, in the way technologies for their use are made available, and in how developing countries can be enabled to acquire, adapt, develop, and diffuse advanced energy technologies. Unless positive action is taken on a large scale by governments and by international aid agencies, the energy situation in many developing countries is likely to deteriorate rapidly. This will impede improvements in the quality of life, exert negative consequences on the environment and climate, and possibly generate conflicts within and between states. Market forces, on which so much reliance is rightly placed for optimizing the allocation of economic resources, cannot satisfactorily address the problems of energy resources, as market forces inherently tend to neglect problems that are distant in space and time. The role of government is to correct this perspective, by creating appropriate conditions so that market forces can orient themselves in the right direction.

The highest priority is to increase the efficiency of energy use. This is particularly important where efficiency is now lowest, namely in Eastern Europe and in the majority of developing countries. Countries needing assistance must assess their needs and opportunities for the introduction of advanced technologies and must create favorable conditions for their adaptation and use. For the countries in the North, successful technology transfer means making the most appropriate and advanced technologies readily available, while respecting the intellectual property rights of inventors and investors. It means encouraging technological cooperation with developing countries, and supporting research and development where needed. International organizations should consider innovative schemes for financing technology transfer and adaptation. Finally, it is important to recall that the industrial democracies, although using energy more efficiently, have per capita levels of energy consumption that are much higher than in the rest of the world. They should therefore take every opportunity to introduce energy saving and renewable energies. This is particularly important as they seek to convince developing countries of the desirability, indeed necessity, of adopting a pattern of development inspired by the concept of sustainability. In short, members of industrialized societies must accept the notion that sustainable development implies a radical change in their own culture and lifestyle.

6 Materials and Mineral Resources

UGO FARINELLI

Our views on the problem of raw materials and mineral resources are qualitatively very different today from what they were 40 or even 20 years ago; actually, it may seem that we speak of quite different subjects.

The "classical" vision that prevailed some 40 years ago did not take into account the limited nature of material resources. The Earth's crust, it was thought, contained enough of each mineral and material to satisfy any conceivable need of its inhabitants. The challenge was rather how to extract and process these resources. The problem was one of capital investments, of manpower, and to some extent of technologies.

Many minerals were available in large amounts in certain poor countries. Since these countries generally also had abundant and cheap manpower, the countries further along the path to industrialization could invest some capital and supply the technologies needed to extract and process the required materials. A country in which these resources were located would benefit in state revenue, in employment creation, and sometimes through participation in what today we would call a "joint venture." Raw materials were considered one of the basic assets of such countries. The export of these materials supplied the initial capital necessary for a transition from a subsistence economy based on primitive agriculture to the beginnings of industrialization. At a later stage, a country thus endowed would supply the first processing of these raw materials (and countries possessing indigenous low-cost energy resources, such as hydropower or coal, were in a particularly good position for this second step) and eventually move downstream in the process, until it reached full development.

The notion of unlimited natural resources came to a sudden end in the early 1970s. It is convenient to identify this change of attitude with the publication in 1972 of the MIT report on *The Limits to Growth* commissioned by the Club of Rome (Meadows, 1972), although a number of warnings on the possible exhaustion of resources had been voiced earlier. In the presence of a world population that grew faster than exponentially, and of consumption of goods, energy, and raw materials that increased at least at the same rate, the question "How long can all this last?" was well justified and perhaps overdue.

The MIT report listed a number of nonrenewable resources, giving for each the known global reserves, the rate at which its consumption was growing, and the time when the resources would be exhausted under various scenarios. According to these projections, a number of resources should have been exhausted (or nearly exhausted)

by 1990: among them, aluminum, copper, gold, lead, mercury, silver, and zinc. Petroleum and natural gas should also have run out by 1990. Even accounting for a fivefold increase in discovered reserves, these materials would not last for more than 50 years: such is the power of exponential growth.

The energy crisis of 1973, following shortly upon the publication of the MIT report, seemed to give a dramatic confirmation of its predictions; the sudden increase of oil prices was attributed by the media to the impending scarcity of oil reserves. We now know that this was not the case, and that the causes of the crisis were quite different; but the combined effect of the realization of the limits to growth and the first worldwide shortage of a basic resource had important consequences.

In the field of materials and mineral resources, emphasis in the advanced industrialized countries was placed on the identification of "strategic materials"—those materials considered to be essential for economic growth and for defense purposes that were not available domestically and whose supply could be endangered by political and social events. A report by the Office of Technology Assessment of the US Congress (OTA, 1985) observed, for instance, that "only three nations (South Africa, Zaïre and the USSR) account for over half of the world's production of chromium, cobalt, manganese and platinum group metals. These metals are essential in the production of high-temperature alloys, steel and stainless steel, industrial and automotive catalysts, electronics and other applications that are critical to the U.S. economy and the national defense."

The concept of strategic materials called for the setting-up of stockpiles (causing a temporary further increase of market uncertainty and a rise of international prices); and it contributed to international tensions, if not open conflicts, over the control of resources situated in certain developing countries. Eventually, it also gave rise, on the positive side, to technological efforts aimed at replacing materials that were considered to be running short, or of uncertain assurance of supply, with others that were more abundant, domestically available, or easier to procure.

This last line fortunately met with success in most cases. A new set of technologies had to be developed—the new materials technologies—that together with informatics and biotechnology constitute the basis of the new industrial (or post-industrial) revolution. As early as 1964 United Nations Secretary General U Thant had anticipated this development with surprising clarity and foresight: "The central stupendous truth about developed economies today is that they can have—in anything but the shortest run—the kind and scale of resources they decide to have. . . . It is no longer resources that limit decisions. It is the decision that makes the resources. This is the fundamental revolutionary change—perhaps the most revolutionary man has ever known" (quoted in Cox, 1965: 184).

The Process of Dematerialization

The substitution of new materials for traditional ones is only one aspect of dematerialization, a general process by which advanced industrial societies need less

energy and fewer raw materials to generate increasing wealth. This trend is the result of a number of concurrent causes. One is that once the process of industrialization is completed, heavy infrastructures are in place; they include roads, railways, buildings, pipelines, and basic installations for heavy industry, all of which have involved large investments in materials (steel, nonferrous metals, concrete, glass, plastics, etc.). The basic needs of the population for durable goods are also satisfied, and the production of materials-intensive goods is motivated by replacement and maintenance rather than by an expanding market. The market shifts toward more "immaterial" goods and services, toward "software" rather than "hardware," toward quality rather than quantity. The increasing incorporation of aesthetic values, taste, and personalization into industrial design confers greater value added per unit weight.

A second component of dematerialization is the substitution of technology for materials. By adopting more sophisticated design methods, more appropriate materials, and new materials-processing technologies, producers can obtain the same product (or a product accomplishing the same functions) with a much smaller quantity of materials. The weight of the average automobile in the United States decreased by some 15 percent from 1976 to 1987 (Arnold et al., 1989), at the same time that its performance and its safety have improved; even larger weight reductions are observed in European and Japanese automobiles. On a longer time scale, the weight-to-power ratio of a locomotive decreased by a factor of about 100 from 1850 to 1990 (Williams, Larson, and Ross, 1987). In some cases, technological advance has brought a completely new approach to a given problem. Optical fibers replace copper wires to transmit signals, employing a far smaller quantity of material to convey much greater quantities of information. The use of satellites in telecommunications avoids the use of long and heavy cables.

The new materials technology has a number of distinctive features. First, it is widely based on fundamental science, on the understanding of the interactions of single atoms in a lattice and on their effects on macroscopic properties, more than it is based on empirical findings. As is the case with other emerging technologies, its connections with basic research are much closer than was the case with past technology. Second, this approach has created a tremendous amount of new materials, and for each particular application the designer has a very wide choice. Even if economic considerations point to a certain solution, small changes in boundary conditions may shift the preference to a different material. Availability of a material is no longer a critical issue, since many alternatives are often economically quasi-neutral. Third, in many instances the distinction between the material and the production of an object made of that material is vanishing: the material is "designed" for that particular application together with the object that must be produced, in a combined process of optimization.

Examples of new materials and their applications are too numerous to be cited or even meaningfully sampled. Two classes of materials that will be mentioned here are fiber-reinforced composites and advanced ceramics (OTA, 1986). Composite materials are obtained by embedding carbon or glass (or other) fibers of different

geometries in a matrix such as a polymeric resin (metallic matrices are also used). Such materials can replace ordinary steel or several special steels in a large number of applications; the main market today is in aerospace, but the automobile industry could rapidly become the largest consumer (Amendola, 1990). The initial advantage of reducing weight (a particular premium for airplanes and space vehicles) will increasingly be accompanied by economic advantages. The reduction of weight implies increased fuel economy. In the future, composite materials should penetrate the construction sector, with revolutionary effects on the ways in which buildings are designed and built. Because composites are designed materials, their properties can be altered to meet widely varying specifications. The very definition of their properties is quite different from that of traditional materials. Concepts like toughness, shear, and compression are poorly defined; the design optimizes the behavior of the material in the particular application and product considered (e.g., by appropriately orienting the fibers).

Ceramic materials, which are typically brittle, can be made resistant and resilient by such techniques as reinforcement by fibers or by chemical bonding. The first market for advanced ceramics has been in heat- and wear-resistant applications (some engine parts, cutting tools, and coatings); high-temperature ceramic diesel engines are already being tested. With time, the diffusion of low-cost, flexible fabrication methods for ceramics could allow them to displace metals and plastics in a wide variety of applications. The basic components of ceramics are very common, widely distributed, and cheap materials such as silica and alumina.

The fact that technologies displace materials in advanced societies is amply illustrated by the fact that the concept of "strategic materials" has been replaced by that of "strategic technologies"; now the availability of certain technologies, rather than of certain raw materials, is considered essential for independence, economic development, and defense. The surveys of strategic materials in the late 1970s and early 1980s have been replaced by surveys of strategic technologies. A study on this subject prepared for the US Administration by a specially appointed Panel on Critical Technologies (Phillips, 1991) devotes an important share of its content to new materials technologies.

If dematerialization and new materials decrease the demand for materials, two other trends help reduce the need for minerals and raw materials. The first is the increasing role of recycling: a substantial share of the production of steel, aluminum, and glass today is based on the use of scraps rather than minerals. The second is the increased life of many materials; for instance, protection against corrosion (deriving from surface treatments and coatings, from improved materials, and from a better understanding of corrosion mechanisms) extends the life of many steel and other manufactures by a factor of two or more, decreasing proportionately the need for replacement. This is particularly important in economies (such as those of advanced countries) where material-intensive production is aimed at replacement of an existing stock rather than at an expanding market.

The Situation of Developing Countries

Having seen that the demand for raw materials and minerals is (or will eventually be) decreasing and shifting toward a variety of widely available materials, should we conclude that available materials will be sufficient to meet the demand of a rapidly increasing world population? Certainly not. The fact that technical solutions exist and are being applied in advanced industrialized countries does not imply that they will diffuse to the rest of the world or that they will be implemented rapidly enough to prevent the scarcity of materials from negatively affecting the process of development.

In fact, the ongoing process of dematerialization in advanced countries has negative effects on developing countries. The revenue that developing countries derive from the export of minerals and raw materials is steadily decreasing, both because demand is stagnant or declining and because international prices (in real terms) are also generally decreasing, as a consequence both of the relaxation in demand and of the competition from alternative solutions (the new materials).

The value added of materials is shifted downstream, because the technological content of materials processing has greatly increased. At the same time, this technological content is, as we have seen, increasingly based on advanced scientific knowledge and technologies that are not available in developing countries. This has largely blocked the traditional process of gradually extending downstream the contribution of the developing country that owns the mineral resources. When (as in the extreme case) the material is designed as part of the product design procedure, its processing is necessarily embodied in the manufacturing stage.

Facing decreasing revenues from the export of their traditional products, developing countries need increasing quantities of traditional materials for building their heavy infrastructures and supplying basic material goods to their fast-growing populations. They cannot use advanced materials (except in particular circumstances) because these are strictly connected to advanced technologies that they do not possess. Even the transfer of these advanced technologies from industrialized countries meets with difficulties: on the side of the donor country, because it often wants to protect its own industry and tends to supply obsolescent technologies instead of the most efficient ones; on the side of the receiving country, because it does not possess the level of scientific and technical knowledge, nor the infrastructures, necessary for a successful implementation of advanced technologies.

Remedial Actions

The situation is highly negative for the developing countries: the decreasing revenue from export of raw materials, the increasing need for traditional materials, and the insufficient access to advanced technologies make the transition to development increasingly difficult. The consequences are negative also for other countries, in terms of stability and peace (which would undoubtedly be menaced by a widening

gap between rich and poor countries), in terms of economics (since advanced countries would benefit from an expansion of the market), and, perhaps most of all, in terms of the environment and the global climate because of the extra burden placed on the atmosphere by an inefficient use of primary resources and of energy-intensive materials.

This situation calls for rapid and energetic action in both industrialized and developing countries. Advanced countries should accelerate the trend toward dematerialization and demonstrate the possibility of sustainable growth, also in terms of material resources (Young, 1991). This involves speeding up the introduction of new materials and new materials technologies, resorting as much as possible to the recycling of materials and to extensive consideration of the "life cycle approach." This approach seeks to design materials and products having in mind from the beginning the possibility of reusing the product, or parts of it, or recycling the material from which it is made, once the product has accomplished its primary function; the way in which what is not usable should be disposed of must also be considered from the start.

Advanced countries should also make an extraordinary effort to make materials-effective technologies available to developing countries. Even if this may seem in some cases to be counter-productive for the donor country, it may be so only in the short term: it is bound to have positive effects for all in the long term. The transfer of such advanced technologies must be carried out in appropriate ways, by making the receiving country responsible for the choice of the technology, for its adaptation to local conditions, and for its applications. Joint ventures are often the most appropriate mechanism for meeting these requirements.

It may be possible for developing countries to avoid repeating the same route to development and industrialization followed by the present advanced countries, and to "leap-frog" the most materials- and energy-intensive steps by adopting directly some solutions that are only now being introduced in the most advanced countries. This obviously requires a concentrated and large-scale effort in education, research, training, and administration that could hardly be faced without substantial help from more advanced countries.

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7 Approaching the Ultimate Constraint: Water Shortage in the Third World

MALIN FALKENMARK

This chapter addresses the relationships between natural resources and population from the perspective of water as fundamental to life. I start with the premise that a large number of the lowest-income countries suffer from water shortages. Since water—in spite of its renewable character—is a finite resource, I argue that population growth will exacerbate the problems of water deficiency.

Water—The Lifeblood of the Planet

The presence of the water cycle constitutes a fundamental difference between Earth and other planets in the solar system. Life is made possible by the solar-driven circulation of water between three main spheres: the atmosphere, the lithosphere/continents, and the oceans. The ecosystems are the results of complex biological interactions in the presence of solar energy, circulating water, and biogeochemical substances circulated by air and water. Because evaporative demand and therefore rainfall efficiency vary with air temperature, the same annual rainfall produces totally different ecosystems in different climatic zones. Rainfall seasonality also contributes to such differences.

The dominating importance of water for life derives from its many remarkable physical and chemical characteristics: unique solvent, carrying nutrients to the cells and evacuating their waste products; its capillarity and surface tension, which leave percolating water hanging between the mineral particles in the soil, thus keeping it accessible to the plant roots; its high heat capacity, reflected in its influence on climate and its function as a cooling agent for plants and animals; and its chemical activeness and underground mobility, making water a carrier of nutrients and minerals from land to water bodies.

The crucial importance of water to livelihood has been well known since early civilizations, which settled alongside rivers to benefit from the passing water brought from remote areas, better endowed with rains. This basic appreciation of water dependency was lost during the era of industrialization, however, when water

This chapter summarizes a number of earlier papers by the author on water scarcity as the ultimate constraint in the development of the dry-climate tropics and subtropics (Falkenmark 1988a, 1988b, 1989; Falkenmark et al., 1987; Falkenmark, Lundqvist, and Widstrand, 1989).

was supplied first from pumps in streets, then from faucets in individual homes. The result of its ready accessibility is a distorted and highly simplistic view of water as a resource among world leaders. We may in fact speak of a widespread "water blindness"—even among Northern scientists and professionals. Engineers tend to see the technical aspects, ecologists to see water as wetlands or aquatic habitats, neither group recognizing its finite nature and its multiple functions.

The oversimplification and distortion are illustrated by the message broadcast in the report of the Brundtland Commission (World Commission on Environment and Development, 1988): water is like air—it is everywhere, and the problem is to keep it clean. This chapter offers a very different message: an increasingly serious problem in the third world is water scarcity, which is now spreading dangerously as a result of population growth in dry-climate countries.

As shown in Fig. 7.1a, the lowest-income countries as expressed by per capita income are located in Africa, South and East Asia, and western South America. In Fig. 7.1b the 44 countries that have a low "human capability index" (Simonis, 1990)—an index integrating life expectancy at birth, literacy, and purchasing power among the poor—tend to fall within the same regions. The hydroclimatic map in Fig. 7.1c shows that the regions where these countries are concentrated must cope with several parallel characteristics of water scarcity: part of the year is arid and/or there is a large or moderate risk of recurrent drought years (Falkenmark and Chapman, 1989; FAO 1987); and the evaporative demand of the atmosphere is particularly high (more than 1500 mm/yr), reducing the efficiency of rainfall as compared to conditions in Europe, where the typical level is only 500 to 1000 mm/yr (Falkenmark and Chapman, 1989).

The Poorest Countries: Living on the Hydrological Margin

Fig. 7.2 illustrates the congruence between the "hunger crescent" struck by severe famine during the 1984–85 drought (Fig. 7.2b), on the one hand, and the zones where there is lack of water both for plant growth (short growing period) (Fig. 7.2a) and for recharge of the water courses (Fig. 7.2c) (Falkenmark, 1988a). The zone of water

FIG. 7.1. *Geographical location of the lowest income countries and countries with low human capability index, in relation to dry (arid, semi-arid, dry subhumid) climate zone*

Note: Isolines indicate evaporative demand or "thirstyness" of the atmosphere, which is a fundamental determinant of living conditions.

(a) *Geographical location of the lowest income countries*

Source: Based on GNP-data from late 1980s

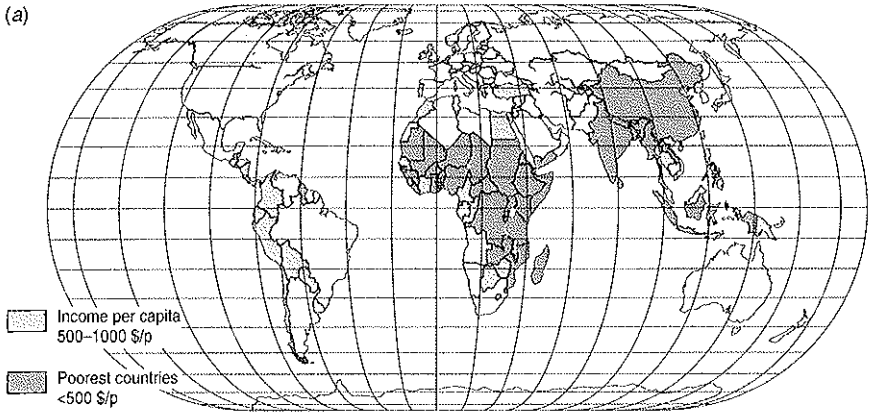
(b) *Countries with low human capability index*

Source: U. Simonis, 1990

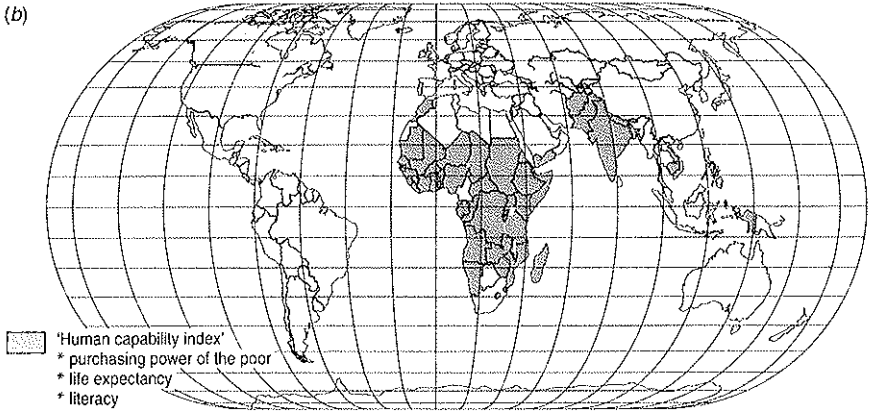
(c) *Dry (arid, semi-arid, dry subhumid) climate zone*

Source: Falkenmark and Chapman, 1989

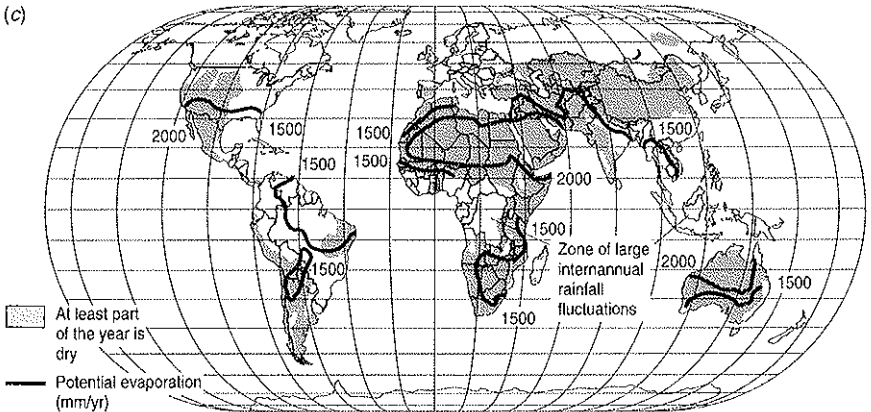
(a)

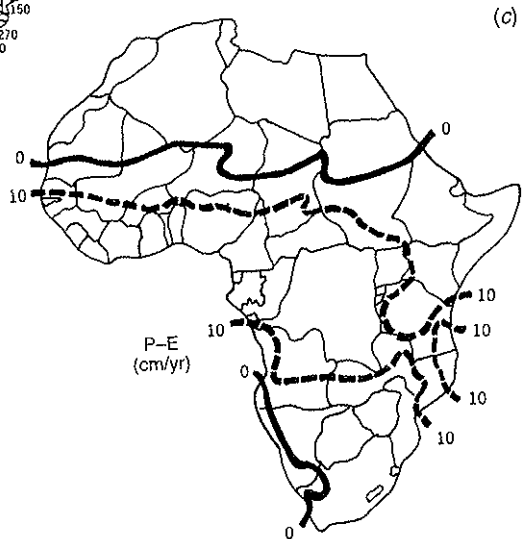
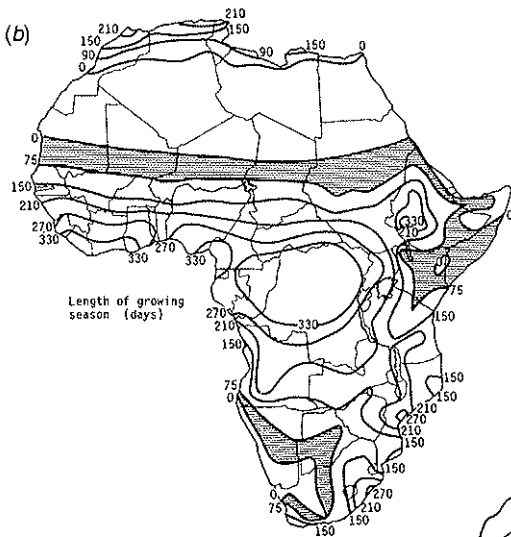
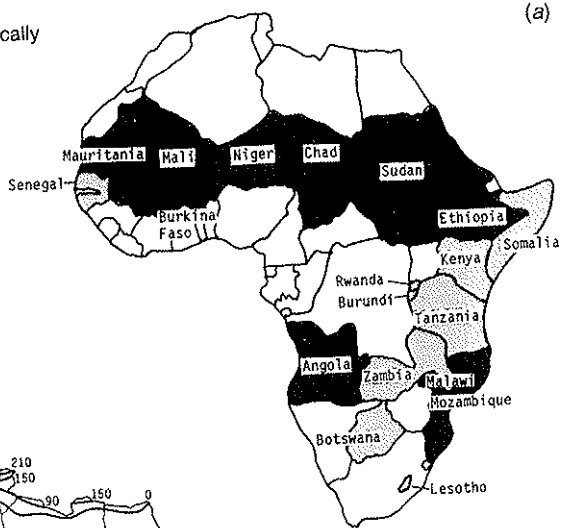


(b)



(c)





scarcity both for food production and for societal use is characterized by a high degree of vulnerability. The growing season is short and the rainfall has not only high intensity but also low reliability due to the erratic character of the rains. The result is a high degree of multidimensional environmental vulnerability: (1) to land impermeableness when a protective plant cover is cleared by overgrazing or fuel-wood harvesting (reflected in rapid, highly erosive and flash-flood-producing overland flows, and minimal groundwater recharge); (2) to drought years due to a short growing season and large interannual rainfall fluctuations; and (3) to water scarcity for societal use due to the limited recharge of local aquifers and rivers since most rain returns to the atmosphere.

In analyzing the predicament of poor countries located in the dry-climate tropics and subtropics, it is helpful to distinguish genuine water scarcity from man-induced water scarcity (Falkenmark et al., 1989). The former is related to the hydroclimate and has therefore to be adapted to and compensated for, whereas the latter is exacerbated by human behavior. It can thus be minimized and controlled.

Genuine water scarcity

Two modes of genuine—that is, hydroclimatically defined—water scarcity can be distinguished. Type *A* is characterized by climate dryness in general, defined by the combination of limited, highly seasonal rainfall and very high evaporative demand, reducing the efficiency of rainfall. The result is a short growing season. Type *B* is characterized by large interannual fluctuations in the limited rainfall, due to variations in the atmospheric water vapor flux system. These fluctuations may be coupled with phenomena in other regions, primarily El Niño in the South Pacific. The rainfall fluctuations take the form of recurrent droughts, which are particularly hazardous in areas suffering also from water scarcity type *A*. They imply that intermittent drought years are part of the climate (FAO, 1987).

Both modes of water scarcity call for drought-resilient crops and for storage facilities so that the surplus crops from the wet years can be used as a food base during the dry years. Wherever additional water is brought to an area in international rivers or aquifers, irrigation is a possibility. Certain dry-climate regions have been buying time by relying on fossil groundwater as a base for irrigation. This postpones the need to adapt to the climate until these aquifers are depleted.

←
 FIG. 7.2. Water inadequacy in the "hunger crescent" of Africa
 (a) Countries critically affected by drought during 1984–1985

Source: Glantz and Katz, 1985

(b) Lack of water for societal protection, showing length of growing season in days

Source: UN, 1987

(c) Lack of water for societal protection, showing the recharge of aquifers and rivers (cm/yr)

Source: Falkenmark, 1986

Man-induced water scarcity

Man-induced water scarcity may also be of two types. Type C is characterized by desiccation of the landscape from reduced land permeability due to mechanical or chemical crusta-formation processes at the ground surface. Active in reducing soil permeability are overgrazing and clear cutting, which expose the soil surface to high-intensity raindrops. The result is that most of the rain leaves the area as overland flow, causing major erosion upstream and sedimentation and flooding downstream. Practically no water infiltrates; the root zone runs out of water; nothing can grow and there is no groundwater recharge. The water table in local wells decreases, and the local populations experience what they perceive as drought. This phenomenon is in fact widespread: not only in the dry-climate regions, where it is referred to as dryland degradation or, in a more outdated manner, as desertification (Nelson, 1988), but also in well-endowed areas like the Ethiopian highlands and even the Himalayan slopes, where the inhabitants complain about droughts in spite of several meters of annual rainfall (highland degradation).

Type D is water scarcity experienced on a per capita basis, emerging because, on the one hand, rainwater surplus for recharging aquifers and rivers is highly limited with most of the rainwater returning to the atmosphere and, on the other, because the population is growing rapidly (Falkenmark, 1989). When the population pressure on water increases, it becomes increasingly difficult to find enough water for socioeconomic development.

In countries lacking both trained manpower and the financial base needed to develop water storage and distribution facilities, water stress develops and may become chronic. Traditional water-dependent development becomes impossible in areas where the climatically determined lack of water cannot easily be compensated through water transfer, desalination, or pumping of fossil aquifers.

Rural-urban differences in water needs

According to Leonard et al. (1990), the majority of the rural poor are spread over a limited set of environments: degrading rainfed croplands, eroding hillsides, drylands, and tropical forests. Some one billion rural residents live in a state of "absolute poverty." Close to a billion more live "along a subsistence margin that, while not life-threatening, precludes attainment of much beyond the minimal necessities" (citation from the World Bank in Leonard et al., 1990). At least 80 percent are said to live in areas where they overwhelmingly depend on agricultural activities for their daily subsistence.

What is called for in these environments is the simultaneous alleviation of poverty and of environmental destruction. Livelihood security for the rural poor based on local self-reliance in food production can only be achieved through "bottom-up" solutions such that further water-related deterioration of soil fertility is stopped. In the undulating uplands where many of these poor live, catchment-based co-operatives may be a realistic solution. Soil conservation on eroding hillslopes is

necessary not only to provide livelihood for the local inhabitants but also to protect the soils in the fertile valleys from further deterioration from flooding and silt flows.

At the same time we are now witnessing a general shift away from support of rural development in favor of urban development (Falkenmark and Lundqvist, 1992). This is due to massive urban growth, driven both by the attraction of urban areas for poor rural inhabitants and repulsion from rural lands that cannot feed the local population. From a policy perspective urban areas are seen as centers of industrialization and development. If the municipal authorities cannot keep pace with the growing population in terms of supplying safe water and waste-handling facilities, we may see an enormous rise in urban poverty and morbidity.

The task of supplying the urban population with safe water is daunting. During the 1980s, despite the massive effort of the UN-designated International Drinking Water Supply and Sanitation Decade, no more than 380 million people in urban areas were supplied with safe drinking water. This is a huge number of people in an absolute sense, but not in comparison to the task that lies ahead. During the 1990s alone there will be another 900 million people to supply, and during the period 2000–25 a further 1.9 billion will have to be provided with safe drinking water and sanitation. Failure to achieve adequate hygienic levels through access to clean water will result in increased urban morbidity and mortality.

Implications of Population Growth

Under rapid population growth, the four water-scarcity types noted above will be superimposed on one another. When combined, these risks tend to reinforce one another, readily producing collapses of crop yields during recurrent droughts.

The total amount of renewable freshwater passing through a country's aquifers and rivers and available to support societal water needs is finite. It is defined by the position of a country in the global water cycle and is composed of two complementary components: the amount of rainfall feeding local aquifers and watercourses (an endogenous component) and the water flow entering the area in regional aquifers and international rivers (an exogenous component).

The relation between the finite water availability and a growing population can be expressed either in terms of population pressure on water—that is, as the number of individuals per flow unit of water—or, inversely, as per capita water availability. The latter is equivalent to the ceiling in terms of maximum average water demand that can be allowed, provided that every flow unit of water in aquifers and rivers can be used. This corresponds to what we may term a mobilization level of 100 percent of overall water availability. Mobilization of all of the potentially available water is achievable only where all the water surplus during wet seasons and wet years can be stored and put to use during dry seasons and dry years. There are a number of constraints to reaching such a high use level: topography (the possibility of locating reservoirs); climate (water losses from reservoirs); geology (possibility to store water underground). In hot poor countries, the mobilizable fraction may be limited

to 20–30 percent, whereas in advanced countries with favorable geology the water can be stored underground, the losses minimized, and 100 percent of the availability can be mobilized for use.

Per capita water availability can be related to per capita demand in a number of countries, based on statistics from the late 1980s. Demand is given as a multiple of an assumed household demand in water-scarce regions, H , equivalent to 100 liters per person per day (or 36 cubic meters per person per year). The favored countries do not need to mobilize even 5 percent of the potential availability: Sweden, for instance, mobilizes just under 3 percent to satisfy a demand of $17H$. Many developing countries also have low water demands (below $5H$), and their water availability potential may allow much higher demands; how high depends on the per capita availability. In effect, these countries remain in a state of underuse with high potential for water-resource development. How much higher demand they would be able to satisfy in order to facilitate socioeconomic development depends on future levels of population growth.

At the other extreme, a number of countries are overusing their available water in the sense that their water demand is higher than the renewable resource. Libya is one example, where reliance is on fossil groundwater aquifers in the south. The Lower Colorado and Rio Grande basins in the United States are other examples of over-exploitation of groundwater aquifers.

A number of countries in North Africa and the Middle East find that their population growth is rapidly pushing them toward chronic water scarcity. In 1990, around 300 million people lived in countries whose water availability may be characterized as less than 1,700 cubic meters per person per year. By 2025, under the UN medium population projection, this number would rise tenfold to over 3 billion, mainly in Africa and Asia.

A country's predicament is also related to how large a fraction of the gross availability of water can be mobilized for use. Increasing demand means mobilizing a larger fraction of water through reservoir storage, canal and pipeline redistribution, and the like—in other words, through efforts depending on technology and economy as well as on topography and climate.

What does this mean in terms of the water demand that can be afforded in water-scarce countries with rapid population growth? In a time perspective of a few decades it is often not realistic to expect that such societies can mobilize more than 20 percent of the available water for use, given their lack of economic resources and professional manpower. In such countries a mobilization level of 20 percent would allow an average water demand of the order of only $5H$, or 500 liters per person per day. This is in fact one order of magnitude below the typical water demand in irrigated developing countries, which is closer to $50H$ or 5,000 liters per person per day (Falkenmark, 1989).

The fact that the possible demand ceiling moves downward in response to population increase represents one of the opportunities forgone owing to population growth. As the number of individuals increases, less and less water will be available to satisfy the demand from each of them. A consequence of population growth is

therefore to reduce potential for water-dependent socioeconomic development. This will have evident implications for a country's industrial development and for food self-reliance through increased agricultural production.

The growing population pressure on a finite water availability is exacerbated by the fact many third world countries need to increase their agricultural yields considerably, simply to provide food for their undernourished populations. Already by 1975 almost half of Africa's land was unable to support its population with the low-yielding agriculture generally practiced. Indeed, 22 of the continent's 51 countries, with half the total population, could not support their populations (FAO, 1984). It is probable that genuine water scarcity adds to the incidence of low yields and intermittent crop failures. Making agricultural production drought-proof is therefore a crucial measure, but one that is limited by the ceiling in terms of the water demand that can be met.

I have made a back-of-the-envelope calculation of the amount of extra water needed to increase the crop yields in traditional agriculture from the present 1 ton/ha to 4 tons/ha (Falkenmark, 1990). With a consumption of 1,000 cubic meters of water per ton of biomass and with 4 persons being fed from each hectare of cropland, the extra water demand would be 20H. This is considerably more than the 5H that has been suggested as a realistic ceiling in a medium-term perspective in many water-scarce African countries. The calculation raises the question whether there is enough water to support self-reliance in food production in the water-stressed countries of Africa and Asia.

The Fatal Crossroad

The implications of increasing population pressure on the finite water availability can be represented in terms of a multidimensional risk pattern. There are at least four types of risks.

The first type is the water-quantity risk that results when rising expectations cannot be met. The outcome may be disputes over access to water between different segments in society, different user categories, different regions in a country, and different countries along a shared river basin.

The second risk is one of water quality. An increasing population will produce more waste, but the river flow in which that waste is diluted remains finite. As a result, water pollution will increase as will, concomitantly, the risk of water-related hazards due to bacterial diseases and to toxic pollutants from industry. The population segments primarily affected will be the poor, especially the urban poor since urban areas have a particularly high intensity of polluting activities.

Third is the risk related to failures in food security. Dry years will lead to collapsing crop yields; in the absence of organized contingency planning for food distribution, large-scale famine can easily follow.

Finally, the exacerbated risk of land degradation is related to environmental vulnerability in dry tropical areas. When population pressure increases, the manipu-

lation of the landscape intensifies in the effort to support a growing number of individuals with food, fodder, fiber, fuelwood, and timber. The result is aggravated desiccation of the landscape, locally experienced as "droughts," and intensified erosion, silt loads, and downstream sedimentation and flooding.

The lowest-income countries with rapid population growth stand at a fatal crossroad between the possibility of achieving livelihood security through careful soil and water management and a situation of exacerbated poverty, famine, and conflict. Population growth is equivalent to future opportunities forgone in terms of water-dependent societal activities and potential. If developing societies can reduce their ultimate population size by rapidly reducing the number of children per woman, more of them will be better situated to meet the tremendous challenges of providing safe water supply and waste-handling facilities in urban areas, stimulating water-saving and low-waste alternatives in industry, increasing yields in dryland agriculture, and stimulating rural development and self-sufficiency in order to reduce the rural push factor in urban growth. A crucial strategy component is integrated land use and water conservation and management so as to minimize the losses and maximize the productivity of available rainfall.

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Part III

Population and Biological Resources

8 Introduction

LESLIE FOWDEN

There is agreement that, given the finite nature of many resources, agricultural production and derived food supplies must ultimately regulate the world population. There is less agreement concerning the population that global agriculture could support. Reasonable confidence exists that the 9–10 billion individuals projected to be alive in 2030 could be fed: it is less easy to foresee how agriculture could provide in sufficient amount the food, fiber, and fuelwood needed by some 15 billion people forecast by demographers as the possible plateau of world population by the year 2100.

In 1847, the first Director of Rothamsted Experimental Station, an institute with which I am affiliated, defined agriculture. He wrote, “Practical agriculture consists in the artificial accumulation of certain constituents to be employed either as food for man or other animals, upon a space of ground incapable of supporting them in its natural state.” This still holds good, except that now we would add that no harm should ensue affecting the long-term sustainability of production or of the environment. Clearly land is a primary resource for agriculture and food production. The future holds the possibility of bringing additional land into cultivation, albeit at considerable cost, but its availability is very limited in many regions; for example, in the rice-growing regions of Asia and the Pacific, where populations are expected to increase by 65 percent by 2030, foreseeable additional land for rice cultivation is a mere 5 percent of that now used. Therefore future agricultural practices must ensure continued, indeed better, maintenance of the soil’s physical structure and fertility by replenishing nutrients removed by crops, and regulation of soil depth, acidity, and organic-matter content, all achieved with minimal off-farm contamination.

Water is a second vital resource for agriculture, since irrigation accounts for more than 60 percent of consumption, with one-third of global harvests coming from about 17 percent of the world’s irrigated cropland. It is imperative that future water use in agriculture be increasingly efficient: collection, storage, and use should minimize evaporation, for example from open surfaces and during spraying; and the problems of soil salinity should be avoided by adoption of appropriate irrigation regimes.

Chemical inputs are another important resource for optimizing agricultural production on a long-term basis—especially fertilizers (organic or mineral) to maintain and increase the fertility and production potential of soils, and pesticides to control weeds, diseases, and insect pests. Yet agrochemicals are expensive items for peasant farmers, and their effective and safe use requires considerable technical know-how.

Therefore an increased future contribution from biological fertilizers (symbiotic and free-living nitrogen fixers, and mycorrhizal associations) and of biological pest control agents must be sought in integrated farming systems. To facilitate this, conservation strategies are needed for the world's genetic resources, that is for the biodiversity found among the world's plant and animal species, which in turn will assure the gene pool so vital to molecular biologists and plant breeders in their quest for high-performance crops and cultivars adapted to particular needs and environments. Future increased population pressure on food supplies suggests that greater attention should be given to the improvement of underutilized crops, for instance selected grain legumes including *Lathyrus* spp. and other grams, and of sorghum, millet, and other staples that are genetically adapted to hot, semi-arid climates.

Mechanized, high-input agriculture has become increasingly dependent on subsidized energy, such that the overall energy balance of food production (fossil fuel energy use compared with food energy available) is adverse in many situations: labor-intensive, low-input peasant farming is more energy efficient, but considerably less productive. There is a need for appropriate technologies allowing a move away from the use of nonrenewable resources and subsidized energy and toward the greater use of renewable local resources and increasing photosynthetic efficiency.

National economic development leading to higher standards of living often alters the food choices of people—wheaten bread replacing traditional cereal staples, and meat and other animal products contributing higher proportions of an individual's protein intake. In consequence long-term pressure builds up on both local and global agricultural resources, particularly because the production of animal protein indirectly requires more land than the equivalent amount of plant protein.

Human resources acting through political, social, and educational channels have a dominant influence on agricultural and food production. Often national infrastructures governing agricultural inputs, storage of commodities, and marketing, processing, and export of produce are insufficiently developed, with the end result that production is reduced, losses during storage of harvested crops are excessive, and quality is below that required for international markets. Often, in addition, food preparation locally by women is extremely laborious and time-consuming, adding to their burden of agricultural field work (women in Africa undertake about 70 percent of farm work). Help through education and training is essential at many levels: for building strong national institutions involved with agricultural policy and production, and to train those who then might train others in the better and more intelligent use of available resources, including time.

There is a maxim that increased agricultural productivity flows from, rather than creates, national economic development. Certainly, in many northern nations agricultural revolutions have been triggered by earlier industrial development, and have relied on subsidies of various kinds. Now many southern nations realize that they need to raise farm commodity prices to benefit rural communities and thereby motivate them to follow sound long-term investment and conservation practices,

even at the expense of urban populations. Their governments would gain encouragement for such policies if overseas markets for surplus agricultural produce were made fairer by removal of barriers to trade created by the subsidized agricultures of industrialized nations. It is only too clear that the provision of incentives stimulates agricultural production, while economic reforms quickly stimulate the exploitation of a host of unexploited technologies.

9 Population and Agricultural Resources in the Developing Countries

AMIR MUHAMMED

Food is the basic human requirement without which no life is possible. It is therefore not surprising that providing sufficient food for the national population has been a priority of governments from time immemorial. Many wars have been fought throughout history by nations seeking to secure adequate food supplies for their people.

Although the essential body requirements for energy and nutrients can be fulfilled by eating sufficient quantities of most basic food materials, human populations in different parts of the world have developed culinary preferences for special food items. The need for balanced food intake to suit the life- and work styles of people living under different climatic conditions has also been met in various ways, and many raw and semi-processed foods are available in the economically developed countries to suit different tastes and nutritional requirements. Whereas a sizable part of the population in the developing countries is undernourished due to inadequate access to food, the developed countries are concerned with the problem of overeating and diseases resulting from excessive intake of rich foods.

Fuelwood is another basic necessity of human populations, especially of the rural population of developing countries. Over two-thirds of all people in the developing world rely on wood for cooking and heating. According to the Worldwatch Institute, rural populations in Nepal and Burkina Faso meet roughly 95 percent of their energy needs from wood. While food shortages attract attention worldwide due to famine and the resulting large-scale loss of life, the fuelwood shortage that is chronic in many parts of the developing world often goes unnoticed. Since food and fuelwood are produced from the same soil, there is often a competition between land for food production and land for growing fuelwood. Only recently has high priority been accorded to fuelwood production through development of agro-forestry programs, at both national and international levels.

Not only is agriculture the main source of food and other basic requirements for human populations, it is also the main source of livelihood for large numbers, especially in the rural areas of developing countries. The widespread poverty in many countries is mainly due to the small size of farm holdings and low productivity. Rapid population growth, especially in rural areas, can aggravate the situation, causing further reductions in the size of holdings along with large-scale unemployment and underemployment.

World Population Increase

The human population has increased rapidly during the last century—from 1.6 billion in 1900 to 2.5 billion in 1950 and 5.3 billion in 1990; it is projected to increase to 8.5 billion by 2025, a more than fivefold increase in 125 years (World Resources Institute, 1990: 1).

The situation in the developing countries is particularly alarming. The United Nations medium variant projection estimates that the LDC population will increase from 3.6 billion in 1985 to 5.8 billion in 2010 and 7.0 billion in 2025 (TAC, 1992: 36). This means that the proportion of the world's population residing in the developing countries, of the order of 75 percent in 1985, will increase to 79 percent in 2000, and 83 percent in 2025. The highest growth rates will be in sub-Saharan Africa, where the population is expected to increase threefold by 2025. Asia will have the highest population increase in absolute numbers of any world region; its population will increase from 2.8 billion in 1985 to 4.9 billion in 2025.

Malthusian Predictions

Growth in world population has been a source of grave concern especially during the last two centuries. Malthus, in his *Essay on the Principle of Population* (1798), argued that human populations, which tend to increase exponentially, would overtake the world's capability to produce food, which tends to increase linearly, resulting in large-scale hunger and malnutrition. Similar concerns were expressed by Sir William Crookes in his presidential address to the British Association for the Advancement of Science at the turn of the twentieth century (quoted in Wortman and Cummings, 1978). Crookes predicted a bleak future for American agriculture (which now accounts for 40–50 percent of world wheat exports):

[T]here remains no uncultivated prairie land in the United States suitable for wheat growing. The virgin land has been rapidly absorbed, until at present there is no land left for wheat without reducing the area for maize, hay and other necessary crops. It is almost certain that within a generation the ever increasing population of the U.S. will consume all the wheat grown within its borders, and will be driven to import and scramble for a lion's share of the wheat crop of the world. (p. 84)

Although the predictions of Malthus and Crookes have not materialized, massive famines at different times and places in history have taken a heavy toll on human life. Food production is so dependent on weather conditions that any major change in climate could immediately induce severe food shortages and famines in large areas of the globe. The 1988 drought illustrates how the world food grain situation could be seriously threatened within a matter of months (Brown, 1988): world carry-over food-grain stocks (wheat, coarse grains, and milled rice), which were 465 million tons in 1986–87, sufficient for 101 days of global consumption, dwindled to 315 million tons in 1988–89, sufficient for only 68 days of consumption (see Table 9.1). A further reduction in these stocks to 311 million tons was projected for

TABLE 9.1. *World grain production, consumption and ending stock (million metric tons), 1978-1994*

Year	Production	Consumption	Ending stock	Days of consumption
1978-79	1,446	1,396	327	84
1979-80	1,411	1,423	315	80
1980-81	1,427	1,456	288	71
1981-82	1,481	1,461	309	76
1982-83	1,532	1,483	357	86
1983-84	1,467	1,519	304	72
1984-85	1,632	1,570	366	84
1985-86	1,646	1,577	434	98
1986-87	1,663	1,632	465	101
1987-88	1,594	1,651	407	89
1988-89	1,546	1,638	315	68
1989-90	1,666	1,680	300	63
1990-91	1,758	1,716	342	71
1991-92	1,690	1,719	313	64
1992-93	1,763	1,732	343	---
1993-94	1,709	1,737	311	---

Source: US Department of Agriculture (USDA), 1993

1993-94, sufficient for only 62 days consumption (USDA, 1993). In the United States food grain production dropped from 315 million tons in 1986 to 204 million tons in 1988 (a 35 percent decrease); as a result national grain production fell below consumption requirements for the first time ever (see Table 9.2).

TABLE 9.2. *United States grain production, consumption, and ending stock (million metric tons), 1985-1994*

Year	Production	Consumption	Ending stock
1985-86	346	201	180
1986-87	315	215	204
1987-88	280	216	170
1988-89	204	186	86
1989-90	284	203	61
1990-91	312	218	72
1991-92	279	218	48
1992-93	352	231	78
1993-94	322	236	81

Source: US Department of Agriculture (USDA), 1993

Resources for Agricultural Production

The primary physical requirements for agricultural production are land and water. In addition, most crops require specific weather conditions, especially with respect to temperature, for growth.

Soil conditions and agro-ecological zoning

Soil conditions have a great influence on potential crop production even under favorable climatic conditions. In many areas, serious soil limitations such as shallow depth, poor drainage, or salinity render the earth unfit for agriculture or at best fit for use as poor pasture land. Only about 21 percent of the world's land mass has soils with no inherent fertility limitations. In Southwest Asia less than 8 percent of the total area has soils with no inherent limitation to fertility, while in Africa suitable land is 19 percent of the total area, with coarse-textured soils and deserts covering 36 percent of the area. Southeast Asia and Central America have the most favorable soil endowments. In the former region 36 percent of the area has no inherent fertility problems, while about 25 percent has severe fertility limitations. Central America has the highest proportion of land with no inherent fertility problems (44 percent); the major constraint in about 22 percent of the remaining area is shallow soils.

With rapidly increasing population comes increasing pressure on cropland with good production potential to produce more per unit area to meet the rising demand. Cropland area per person has been falling steadily since the 1950s. The current world average of 0.28 hectares (0.69 acres) is expected to decline to 0.17 hectares (0.42 acres) by the year 2025 based on current projections of population increase and cropland use. Already about 580 million people live in absolute poverty on marginal or fragile land. These numbers are likely to increase sharply in the coming decades if the present trends of population increase and loss of fertile land to agriculture continue.

Nonagricultural use of land for housing, transport, industry, mining, recreation, and the like consumed 98 million hectares or 1.5 percent of the world's total land area in 1975. This is projected to increase to 180 million hectares or 2.8 percent of the total area by 2000. In Southeast Asia, nonagricultural use of land is likely to consume 11 percent of the land area, greatly aggravating land shortages.

A much more serious potential threat to the land base for food production arises from soil degradation, which can result from erosion from wind and water, salinity and waterlogging, depletion of plant nutrients and organic matter, deterioration of soil structure, and pollution. An estimated 30 percent of rainfed cropland in Central America, 17 percent in Africa, 20 percent in Southwest Asia, and 36 percent in Southeast Asia is currently subject to degradation from one or more of the above phenomena. Soil losses due to erosion can be staggering: the Yellow River Conservancy Commission in China reported in 1983 that the river was depositing 1.2 billion tons of soil into the ocean every year. Similarly, the loss of topsoil from the Ethiopian highlands was estimated in 1978 at 1 billion tons per year by the US

embassy in Addis Ababa. Soil erosion in developing countries, if unchecked, may result in a 20 percent loss of potential food production by the end of the century.

Water availability

After land, availability of adequate amounts of good-quality water is the other major limiting factor for agricultural production. Vast tracts of otherwise suitable land cannot be used for agricultural production because of insufficient rainfall and non-availability of irrigation water.

Development of irrigation in arid and semi-arid areas has been given high priority at national and international levels during the last 40 years. By 1950, the total irrigated area worldwide was 94 million hectares; during the next three decades this was rapidly increased through major irrigation projects to 249 million hectares, actually raising the average irrigated area per person in the world. However, the 1980s is the first decade in which both cropland area per person and irrigated area per person have declined. Irrigated area per person has shrunk by almost 8 percent between 1980 and 1990.

Not only is the irrigated area per person decreasing due to the faster pace of population growth vis-à-vis irrigation development, but large tracts of land in the irrigated river basins of the arid and semi-arid countries are prone to salinity and waterlogging, which greatly reduce their productivity and in many cases render the land totally unsuitable for agriculture. This is the inevitable consequence of large irrigation schemes if adequate drainage facilities are not provided along with the network of irrigation canals.

Population-supporting Capacity of World Regions

The population-supporting capacity of various regions of the third world has been calculated on the basis of resource endowments (FAO, 1984). Accordingly, 37 percent of the world's total land area has suitable climate for crop production while the remaining area is too dry or too cold. Climatic conditions suitable for crop production exist in 85 percent and 84 percent of the land area of South America and Southeast Asia, respectively. In Central America 64 percent and in Africa 53 percent of the area have climatic conditions suitable for producing crops. Southwest Asia is largely arid—only 18 percent of the land area has suitable climatic conditions for crop production.

In addition to soil conditions, water availability, and climate, agricultural potential has been calculated assuming three levels of fertilizer input. The low level implies no added chemical fertilizer, the medium level about 80 kg of nutrient per hectare per crop, and the high level around 160 kg of nutrient per hectare. Based on these assumptions, the population-supporting capacity of the main regions of the developing world is given in Table 9.3.

According to this analysis in the year 2000 Southwest Asia will be able to support

TABLE 9.3. *Population-supporting capacities of less developed world regions (excluding China) expressed as a ratio of agricultural potential to actual and projected needs, calculated on three assumptions concerning level of fertilizer use*

Level of fertilizer use	Africa	South-west Asia	South America	Central America	Southeast Asia	Average (all less developed regions shown)
Year 1975 ratios						
Low	3.0	0.8	5.9	1.6	1.1	2.0
Medium	11.6	1.3	23.9	4.2	3.0	6.9
High	33.9	2.0	57.2	11.5	5.1	16.6
Year 2000 ratios						
Low	1.0	0.7	3.5	1.4	1.3	1.6
Medium	5.8	0.9	13.3	2.6	2.3	4.2
High	16.5	1.2	31.5	6.0	3.3	9.3

Note: Needs are calculated assuming a dietary standard of 3,000 Kcal/day/person.

Source: FAO, 1984: 16

only 70 percent of its projected population at low input levels. The corresponding figures for Southeast Asia, Central America, and Africa are 130, 140, and 100 percent. South America, on the other hand, will have the potential to support 3.5 times the projected population in the year 2000. The average population-supporting capacity at low input levels in all developing regions is expected to be 160 percent of the projected population. The situation will be much different at high levels of inputs and management of agricultural production. Under this scenario the developing regions will, on average, be able to support 9.3 times the projected population, although the corresponding figure for Southwest Asia will still be only 1.2. The calculations assume a low dietary standard.

Individual countries and subregions within countries will experience vastly differing situations. Already in 1975, 54 out of 117 countries studied were classified as critical—that is, they could not feed their existing population using low inputs. By 2000, the number of “critical” countries at low input use is projected to rise to 64.

Climate Change and Agriculture

Agricultural production, especially in the rainfed areas, is dependent on weather patterns. While farmers have learned to adjust to seasonal variations in weather, future global climate change could have major consequences for agricultural production. Considerable evidence suggests that the build-up of greenhouse gases in large quantities as a result of industrial development in the developed countries is raising temperatures in several parts of the globe. Indeed, the four warmest years of the past century occurred in the 1980s (Hansen, 1991).

Sophisticated global climate models predict that a doubling of the preindustrial level of atmospheric carbon dioxide would raise the global temperature by 1.5 to 4.5°C around 2030 if present trends of industrial production and emission of greenhouse gases continue. The increase in temperature would vary widely in different parts of the Earth, some areas experiencing twice the global average and others remaining largely unaffected. Higher temperatures would also reduce soil moisture because of increased evaporation and could thus result in lower grain yields.

As a consequence of global warming, many fertile areas could go out of production. On the other hand, some parts of the world that are presently unsuitable for agriculture may become suitable. Thus there may be relatively little effect of global warming on food production for the world as a whole, although the impact on the agricultural production of individual countries may be drastic. A positive effect of higher carbon dioxide concentration in the atmosphere will be enhanced photosynthetic activity in plants. This would result in increased crop yields at the same input and management levels and would partly offset the losses from increased evaporation and reduced crop pollination due to higher temperatures. The major adjustments in the irrigation and drainage systems that would be needed under global warming would place a major burden on the already strained economies of developing countries.

Chemical Inputs to Increase Crop Yields

A major breakthrough in efforts to increase food production was the advent of the green revolution in the 1960s, which resulted in substantial increases in yields of wheat, rice, and maize in many developing countries. The main ingredients of the green revolution were the dwarf, photoperiod-insensitive, fertilizer-responsive varieties of wheat and rice, increased use of chemical fertilizer, and increased availability of irrigation water. Fertilizer use especially resulted in large gains in crop yields. Governments in many developing countries invested heavily in fertilizer plants and took special measures to promote the use of adequate amounts of fertilizer. Initially the main emphasis was on the use of nitrogenous fertilizer, followed by other macro-nutrients (phosphate and potash). More recently the emphasis has been on balanced fertilization of crops in relation to crop rotation practices, which necessitates the use of micro-nutrients in some crop and soil situations. Per capita fertilizer use in the world increased from 5 kg per annum in 1950 to 27 kg in 1990 (see Table 9.4).

Fertilizer use has been accompanied in many developing countries by use of other technologies, especially crop protection and mechanization. However, the returns in terms of grain produced per kg of added fertilizer have gradually decreased. In Indonesia, for example, one kg of fertilizer nutrients led to a yield increase of approximately 10 kg of paddy in 1972; this ratio fell to about 1 : 5 during next 15 years (Brown, 1988). This could be because of limits on photosynthetic efficiency or other physical constraints when high crop yields are harvested. Agriculture relying on

Table 9.4. *World fertilizer use, 1950–1990*

Year	Total (million metric tons)	Per capita (Kg)
1950	14	5
1960	27	9
1970	63	17
1980	112	26
1985	130	26
1987	131	26
1988	135	26
1989	139	27
1990	143	27

Source: FAO Fertilizer Yearbooks and FAO, Current World Fertilizer Situation and Outlook

high energy inputs is not sustainable in many developing countries because of the steep costs of the mostly imported inputs. Organic fertilizer and integrated pest control methods are being introduced to reduce the use of chemicals in agriculture.

A Balance Sheet for the Future

There is no doubt that the world's population, especially in the poverty-stricken developing countries, will rise rapidly in the coming decades. Many developing countries will not be able to feed their expected populations at the projected levels of food production. A fuelwood crisis is also anticipated for many countries. Rapid degradation of land resources from nonsustainable agricultural and industrial development is further diminishing the resource base for food production. And global warming could have profound effects, largely negative, on the agricultural production capacity of most countries.

On the positive side, new and emerging technologies may radically improve agricultural yields by increasing productivity per unit of land and water several-fold. Improved preservation of food crops against damage during storage and processing would add substantially to the overall food stocks available for human consumption. Improved food and agricultural policies, especially in terms of favorable price policies for agricultural products, land reforms, and determined efforts at rural development, would also raise agricultural productivity.

Increased investment in research and development organized by the Consultative Group on International Agricultural Research (CGIAR) should likewise continue to generate new information and production technologies to improve agricultural productivity and increase food production in many developing countries.

Breakthroughs in biotechnology and genetic engineering promise to change the face of agriculture. Breeding of hybrid maize resulted in an impressive increase in yields of this crop compared to the synthetic varieties. Hybrids of wheat and rice have also been available for some time but these have not been widely adopted. Large-scale use of hybrids of these crops would result in a 20–25 percent increase in yields from the same land resources. Development of salt- and drought-tolerant varieties would enable production of crops on areas that now lie barren or have poor agricultural potential.

While there is wide scope for greater South–South collaboration in efforts to improve the food production capabilities of developing countries, the industrialized countries hold the key to the economic survival of the majority of the poor countries. The major obstacles include a heavy international debt burden, barriers to free international trade to the detriment of the developing countries, and restrictions on sharing new knowledge and on technology transfer imposed by most developed countries. Improvements in agricultural production depend largely on the increased use of chemical inputs and machinery, most of which are imported by the developing countries. Rationalization of the price structure of agricultural inputs, especially inputs for use in the food-deficient countries, will be a prerequisite to any significant improvement in the capabilities of these countries to increase their food production to meet the needs of their burgeoning populations.

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10 Nutritional Constraints on Human Resources

J. C. WATERLOW

As I understand it, the phrase "human resources" covers both the number of human beings that exist or could exist in the world and their capacity for leading a productive and healthy life. "Nutritional constraints" means the extent to which food supply limits the numbers of people and their quality of life. I shall concentrate on the second aspect—productivity and quality of life.

Our nutritional state depends on an adequate supply of energy and of many different nutrients, which can conveniently be divided into two groups. The first group consists of the vitamins and essential minerals, the second energy and protein. I do not emphasize the first group in what follows. Certainly, large numbers of people in the world suffer from deficiencies of vitamin A, iron, and iodine, and possibly of zinc and selenium. From time to time there are epidemic outbreaks of deficiency diseases; a recent example is pellagra in refugees from Mozambique. However, these deficiencies could in principle be eliminated or prevented. The constraint is not the total supply available in the world. The minerals are plentiful and cheap; the vitamins can be manufactured, though perhaps not so cheaply. The constraints are economic and in the operational costs of distribution. There are many successful programs around the world for combating these deficiencies, and I think that these programs could be extended to any size of population if the political will existed.

Energy: The Main Constraint

The position is quite different for energy and to a lesser extent for protein. It is generally supposed that the amount of food that people eat, assuming that it is available, is determined principally by their energy requirements. According to the current doctrine virtually all diets, even in less developed countries, supply adequate amounts of protein, provided that energy needs are met. This may not be so in some parts of the world for young children during the weaning period, but that question is still controversial. I believe that for weaning infants the protein intake may indeed become limiting with some diets, such as those based on maize or cassava.

Be that as it may, our first concern must be with energy, and here the constraint is quite simply the world's capacity for producing food, particularly grain. To examine how this constraint operates now, and will operate even more forcefully with an increasing population, we must have some estimate of human requirements

for energy. In general terms the requirement is defined as the amount needed to maintain health (which, of course, is undefinable); growth, where applicable, as in children and pregnant and lactating women; and physical activity. Nowadays physical activity is evaluated under two heads: the first, "occupational" activity, is that needed to support the life of the individual and his or her dependents. Physical work undoubtedly plays a larger part in the life of people in developing than in industrialized countries. The second component, termed "discretionary" activity, represents energy expenditure that is not essential but is important for the quality of life, such as improving the house, carrying a child to the clinic, playing games, and so on (FAO/WHO/UNU, 1985). In theory these discretionary activities are the ones most likely to be curtailed when food energy is in short supply. There is little objective evidence on the extent to which this actually happens, but for adults it would be reasonable to regard limitation of discretionary activity, hence impairment of the quality of life, as the first example of a nutritional constraint on human resources.

The same cannot be said for economic activity. Studies of seasonality in Africa have shown very clearly that in the preharvest season, when a shortage of food coincides with the need for extra work in the fields, both men and women increase their physical activity but lose weight, the loss being made good after the new harvest has come in (Ferro-Luzzi et al., 1988). Thus body tissues are sacrificed to maintain activity, but we do not know whether these people would have been even more active had there been no constraint on their food intake. I suspect that they would, but to my knowledge there are no data.

In a different context, under the rationing system that operated in Britain during World War II, it was accepted that workers in heavy industry, such as miners, had to be provided with extra energy if outputs were to be as high as possible. I am not a social scientist, but I think it is likely that with subsistence farmers the motivation will be somewhat different. Although it may be a good thing to produce extra food that can be sold in exchange for goods, the primary aim is probably simply to produce enough to maintain the individual and the family in a steady state.

There is some evidence that children react differently from adults to constraints on their energy supply. Many years ago a time and motion study in Uganda showed that young Ugandan children with a lower food intake spent less time than European children in running and vigorous play (Rutishauser and Whitehead, 1972). The conclusion that activity of the Ugandan children was limited by their energy intake has been criticized on the grounds that the study by its nature did not take account of the cultural differences between the two groups of children. However, there is some further evidence of the effect of energy intake on children's activity. In Guatemala a careful experimental study indicated that when a moderate reduction of energy intake was imposed on preschool children, they maintained a normal rate of growth but became less active, so that growth took precedence (Torun et al., 1983). In Mexico it was shown by an ingenious method of recording the number of times that a child's foot touched the floor that children increased their spontaneous activity when given a supplement of extra food (Chavez and Martinez, 1984). In Colombia,

children in a holiday camp were encouraged to participate in sports and games. Objective measurements of energy expenditure showed that those who were small for their age, described as "marginally undernourished," did not increase their activity as much as better nourished children, except for a short period after lunch (Spurr and Reina, 1988). During the depression of the 1930s, when farmers in Great Britain were unable to sell their milk, Boyd Orr, the founding father of the Food and Agriculture Organization, arranged for it to be distributed free in schools. This had only a small effect on the physical growth of the children, but they became more active and troublesome (Leighton and Clark, 1929). I have heard it suggested that politicians may find it convenient for the food intake of their people to be somewhat constrained, because it makes them easier to control.

On occasions when I have visited villages in poor parts of the third world, I have been struck by the apathy of young children sitting about in the yard doing nothing, rather than running about as I am accustomed to see children do. According to the conventional wisdom this inactivity may have serious effects on the child's social and behavioral development, which depends on exploration of the environment and of the people in it. From a practical rather than a psychological point of view, in any society where a child's progress through school depends on reaching a certain standard at each age, a slowing of development in the preschool years may result in the child's falling progressively further behind. I have treated this question of the activity of children at some length because I believe it may represent one of the most serious of all nutritional constraints on human resources.

What is the Acceptable Lower Limit of Body Weight?

Body weight is extremely important in the context of this discussion, because the energy expended on maintaining vital processes (the basal metabolic rate, or BMR) is, as one might expect, larger in big than in small people. Moreover, the cost of those physical activities that involve moving the body depends on body weight.

Weight is determined by two factors, a person's stature and his/her fatness or thinness at that stature. In an adult, stature (height) cannot be altered, so any consideration of adjustments to shortfalls in energy supply must concentrate on weight in relation to height. In children the situation is different, because nutrition and other environmental factors have an important effect on growth in height before puberty, and probably also on ultimate adult height.

Consider adults first. We need an expression that enables us to group together people of the same degree of fatness or thinness regardless of their height. The best way of doing this is by the ratio of weight to the square of height, an index introduced by the Belgian scientist Quetelet in the nineteenth century and often referred to nowadays as the body mass index (BMI). In Western societies the BMI of healthy nonobese adults ranges from about 20 to 25, with an average around 23. Table 10.1 shows in column A the estimated energy expenditure of a moderately active Western man of average height and BMI. Initially the energy intake is equal

TABLE 10.1 *Estimates of energy requirement (kilocalories per day) in relation to body size*

	A	B	C
Weight (kg)	70	56	51
Height (m)	1.75	1.75	1.6
BMI	23	18.3	20
	(Western average)	(Borderline risk)	(Acceptable)
Basal metabolic rate (BMR) (kcal/d)	1750	1540	1460
Total energy requirement ^a (kcal/d)	3000	2600	2400

^a Rounded to nearest 50 kcal.

Columns:

A Typical Western man

B Effect of reducing A's energy intake by 400 kcal/day

C Typical third world man.

Source: Estimates for males, calculated from FAO/WHO/UNU, 1985

to the expenditure, and a steady state is maintained. If intake were to fall by 400 kcal/day, or 13 percent of the initial requirements, body weight would fall, ultimately, by 20 percent and a new steady state would be reached at a BMI of 18.3, as shown in column B of the table. This process would in theory take about 200 days. There is a substantial economy of energy, but the question is whether there is any disadvantage in such a low BMI, and whether it could go any lower.

A recent attempt to grade BMIs is shown in Table 10.2, in which a level below 18.5 represents risk of undernutrition and below 16 frank undernutrition. Many population groups in less developed countries have an average BMI of about 20. In deprived populations, such as Rwanda in Fig. 10.1, the distribution is skewed to the left, and a proportion that is by no means negligible falls below the risk level. This

TABLE 10.2. *Grading of body mass index*
($BMI = Wt(kg)/Ht(m)^2$)

>30	Obese
30-25	Overweight
25-18.5	Acceptable
18.5-17	Risk of undernutrition
17-16	Moderate undernutrition
<16	Frank undernutrition
14	Anorexia nervosa
12	Starvation and ultimately death

Source: Modified from James, Ferro-Luzzi, and Waterlow, 1988

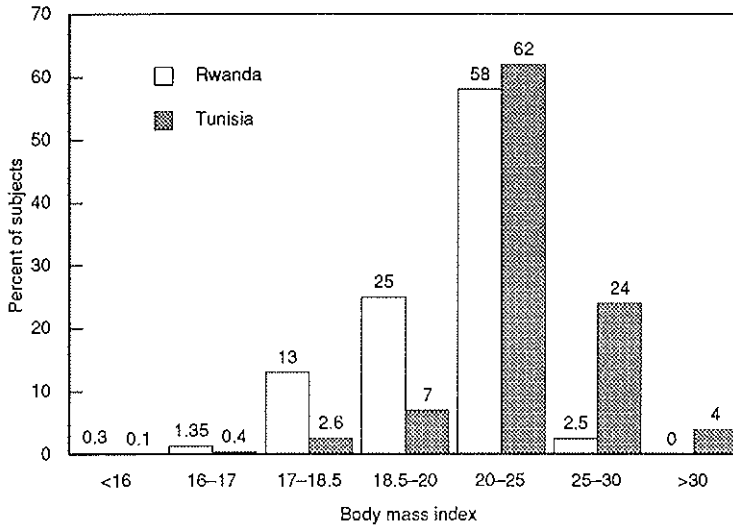


FIG. 10.1. *Distribution of body mass index of males in Rwanda and Tunisia*
 Source: P. François (FAO), personal communication

is hardly a satisfactory situation. Such populations could be regarded as “healthy,” in the sense that they exist and are maintaining themselves, perhaps even increasing. However, the mere fact of existence and maintenance does not mean that the adaptation of body weight to a low energy intake has no costs in terms of components of health, although these are not so easy to measure. For example, Fig. 10.2 shows an association between low BMI and days off work in laborers in Bangladesh; Fig. 10.3 shows a relation between BMI of mothers in India and the prevalence of low birthweight, which may not be a handicap for the mother but is certainly a handicap for the baby. I have already mentioned the hungry season. A study in Benin showed that in that season there was a significant reduction in basal metabolic rate in people with a BMI less than 17, but not in those with a higher BMI (Schultink, 1991). The basal metabolic rate represents the energy cost of the metabolic processes essential for life, and I doubt whether a reduction in the rate of these processes can be regarded as an acceptable adaptation.

These pieces of evidence suggest that a population in which a substantial number of individuals have a BMI below 17-18 may be able to maintain the status quo, but not without significant impairment of its resources.

Short stature

Another way of achieving a low body weight and hence economizing energy is simply to be short (Table 10.1, column C). A short person of normal weight for height has many advantages in terms of demands on natural resources. He/she needs



FIG. 10.2. *Body mass index and days of work lost by laborers in Bangladesh^a*

^a Excluding days lost due to accidents (n = 199).

Source: J. Pryor, personal communication

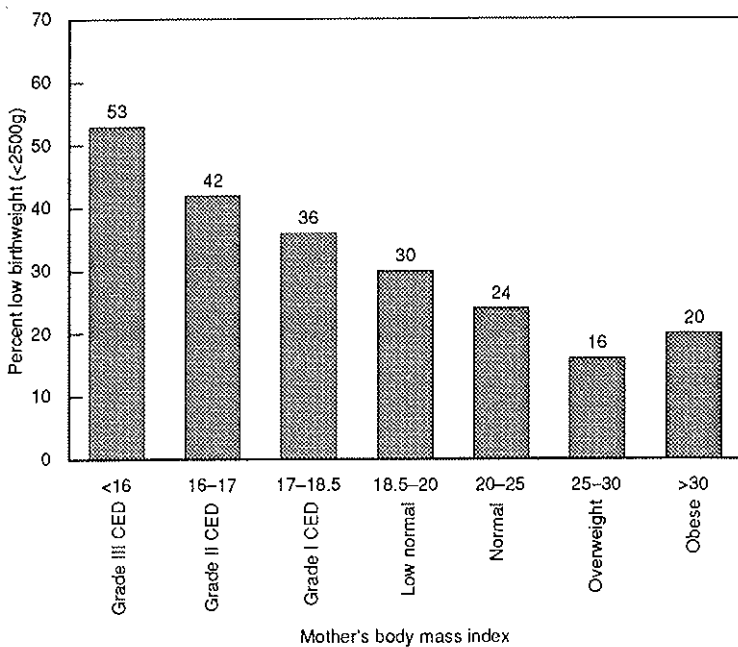


FIG. 10.3. *Body mass index and prevalence of low birthweight in Hyderabad, India*

Note: CED = Chronic energy deficiency.

Source: Nadumini Naidu, Neela, and Rao, 1991

less clothing and can fit into smaller houses and smaller motor cars. More important, as noted above, the small person has a lower basal energy expenditure and a lower cost for those numerous activities that involve moving the body, since the weight being moved is less. The only obvious physical disadvantage of being small is a reduced capacity for external work, such as lifting heavy objects or cutting down trees, where the force that can be deployed depends on the absolute muscle mass. In reality probably even this disadvantage can be overcome by practice and training. For example, the hill porters of Nepal, who are very short and light, can carry loads up to twice their body weight 1,000 meters in altitude in a day. For all these reasons, some years ago I tried to popularize the slogan "It's smart to be small," and I suggested that the secular increase in size that is occurring in many human populations is potentially as dangerous as the increase in their numbers, in terms of demands on natural resources.

That is a blind alley, however, for it would be impossible to advocate any policy for reducing the growth of children and their final adult size. Historical research in Europe and America, based largely on military recruits, has shown a clear correlation between fluctuations in average stature and in social conditions (Sandberg, 1989). For example, in Britain in the mid-nineteenth century, at the time of great industrial expansion, average heights fell, presumably owing to the appalling conditions for workers in the towns and to the agricultural depression that followed repeal of the Corn Laws. The remarkable secular increase in height that has occurred in Japan is well known, and in Britain the substantial social class differences in stature that existed in the 1930s have been largely reduced, although not entirely eliminated. People in what in Great Britain is referred to as social class V are a little shorter than those in more privileged positions and have higher rates of morbidity and mortality. Children of the unemployed in Great Britain were found to be about 1 cm shorter than the children of those in work (Cole et al., 1983). The following quotation from the *Dictionary of Statistics* of 100 years ago, to which my attention was drawn by Sir Leslie Fowden, illustrates social differences in an extreme form: "Fellows of the Royal Society on average are 3.9 inches taller (10 cm) and 21 pounds (9.5 kg) heavier than burglars and other convicts." It would be difficult, of course, to disentangle the causal nexus.

In the third world environmental effects on the linear growth of children are very clear. Certainly the height of individuals is to some extent genetically determined, being related to that of their parents; nor can one rule out small ethnic differences in growth potential. Nevertheless, as Fig. 10.4 makes clear, environmental factors associated with poverty override any possible ethnic differences. As Grantham-McGregor shows elsewhere in this volume, this stunting in physical growth is clearly associated with impairment of children's mental development. For that reason I cannot accept as the last word the view propounded by an economist that within limits stunting in growth represents a costless biological adaptation. It is true that, in the face of shortage of food, a smaller child may survive when a larger one would die, but there is a cost. It is true also that we do not understand the nature of the association between physical and mental retardation: presumably it is not a direct

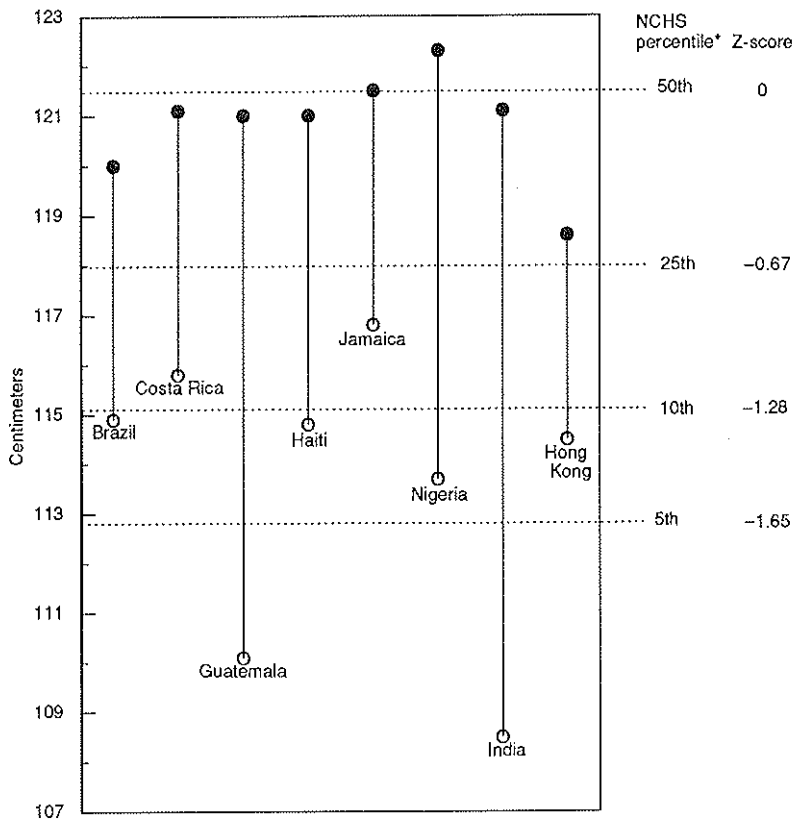


FIG. 10.4. *Heights of 7-year-old children from well-to-do and poor families in various populations*

* Reference data on child growth from the National Center for Health Statistics, USA.

Source: Martorell, 1985

causal one. All one can say is that both result from a deprived environment, one with inadequate food, frequent infections, and little psychosocial stimulation. The physical stunting is reversible, probably up to puberty; Grantham-McGregor's work suggests that the mental impairment is also reversible, at least in very young children.

To summarize to this point, I conclude that reduction of a child's growth below its genetic potential implies a constraint on human resources. How far this constraint is related to food is a matter of active debate. My view is that shortage of some nutrients, perhaps of good-quality protein and of minerals and micronutrients associated with protein in foods, plays an important part. Since this constraint on human resources has many causes, however, it will not be removed by improvements in diet alone.

Time

Time is another human resource. Time in the abstract may—or may not—be infinite and endlessly renewable, but the time at the disposal of each of us is limited. To work slowly, therefore, is an uneconomical use of this human resource. Walking, with or without a load, is the activity about which we know most. What is interesting is not so much the cost per minute of walking at different speeds, but the cost of covering a given distance at different rates. The lower curve in Fig. 10.5 shows that if, for example, one has to walk 4 km, there is an optimum speed, about 4 km/hour, at which the total energy expenditure incurred during the walk is at a minimum. However, if we consider a time period of say 3 hours, during which the subject walks 5 km and for the remainder of time rests at a basal rate of energy expenditure, a slightly different picture emerges (top curve in Fig. 10.5). The more slowly the subject walks and the less time that he has available for resting, the lower is his total energy expenditure over the three-hour period. Therefore there is a choice: if time is no object, walk slowly and economize energy; if there is no constraint on energy supply, walk fast and have time to do something else. Common observation suggests that people in third world countries tend to adopt the first solution, partly, perhaps,

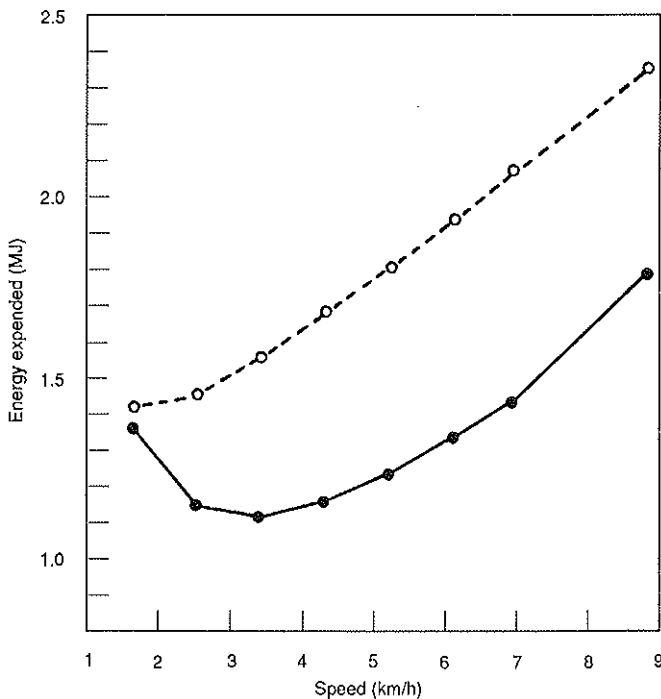


FIG. 10.5. Effect of the rate of walking on energy expenditure over a fixed time period (60 kg man carrying 20 kg load at zero grade)

Source: Waterlow, 1990

because the climate is often hot. There may be a sound physiological basis for preferring to move slowly when energy is in short supply, because the so-called slow muscles are much more efficient than the fast ones, that is, they can produce more mechanical work for a given input of food energy (Waterlow, 1990). Thus from the point of view of economizing energy, it is smart to be slow as well as smart to be small, but the other side of the coin is expenditure of that precious resource, time, which for each of us can never be renewed. As the Roman poet Catullus wrote nearly 2,000 years ago: "Nam nobis semel occidit brevis lux, Nox est perpetua una dormienda."

Fecundity

So far I have considered only nutritional constraints on health and activity. What about nutritional constraints on the numbers of people? Daily and Ehrlich (1990) have calculated the number of hunger-related deaths that may be expected to occur with different rates of increase in population and food production and different scenarios of climatic change. They start from the estimate that in the 20 years from 1969 to 1988, when there was no deficit in global grain production but only in distribution, 200 million hunger-related deaths occurred, that is, about 0.2 percent of the world's population per year. They further assume that there are 2 hunger-related deaths per tonne deficit in grain. The calculations suggest that at present rates of growth, 1.7 percent per year for population and 0.9 percent per year for grain production, the next 20 years would witness something like 1,000 million hunger-related deaths, with a population stabilizing at somewhat less than 6 billion. This calculation assumes that the increase in population is limited only by deaths from hunger. It is also necessary to consider the possibility that a certain level of hunger, short of causing death, may limit population growth by decreasing fecundity.

This is not a topic on which I am qualified to speak, and it will be dealt with by others in this volume. One or two remarks may, however, be in order. There seems to be no doubt that under famine conditions birth rates fall drastically: the siege of Leningrad is often quoted as an example. Perhaps more important, however, is what happens at levels of deprivation short of famine. One way of quantifying level of deprivation or intensity of nutritional constraint is by using the scale of body mass index that was shown in Table 10.2. Toward the bottom of the scale are women with anorexia nervosa, with a BMI of about 14. Such women almost invariably have amenorrhea and are infertile. However, this seems to be an extreme state. Moving up the scale to a BMI around 18, in countries such as India there are many millions of women at this level. Table 10.3 shows that in India the duration of lactational amenorrhea was inversely related to BMI. The effect of this should be to increase the birth interval and to decrease fertility in the most deprived women. This would represent a check on population increase in those who are least able to support an increase.

Furthermore, I believe that there is an important indirect effect of nutrition on the

TABLE 10.3. Relationship of BMI to duration of lactation and of lactational amenorrhea in Indian women

Duration (in months) of	BMI ^a				
	< 17.8	17.8–19.6	19.6–21.8	21.8–24	> 24
Unsupplemented lactation	9.2	8.9	8.6	8.4	7.6
Total lactation ^b	20.9	19.8	20.1	19.8	16.6
Amenorrhea	13.2	11.4	10.2	9.3	7.5

^a Calculated from weights on assumption that height = 1.5m.

^b Unsupplemented plus supplemented lactation

Source: Ramachandran, 1989

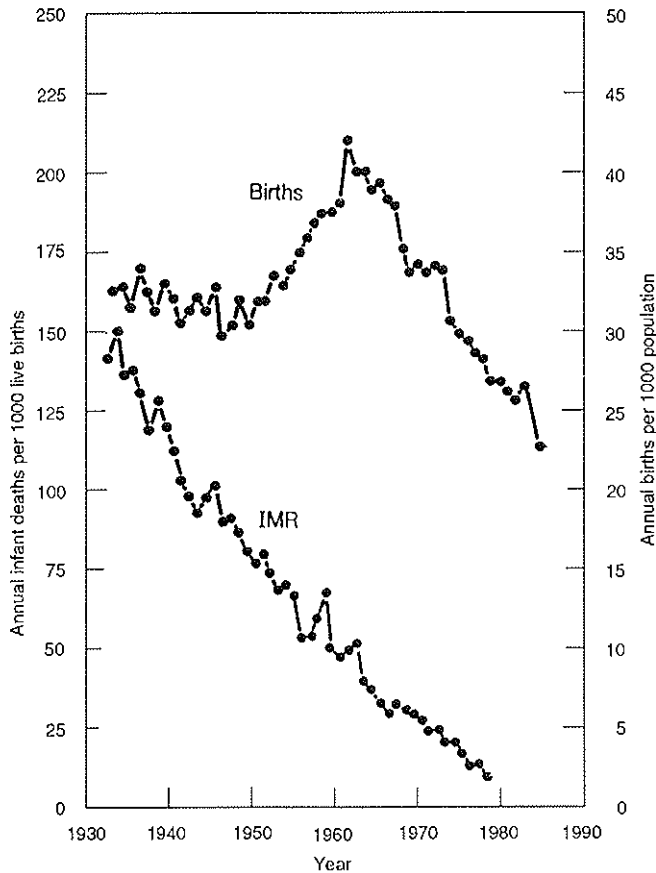


FIG. 10.6. Rates of infant mortality (IMR) and of births, Jamaica, 1930–1985
Source: Sinha, 1988.

birth rate. In the third world malnutrition is a major primary or associated cause of infant and child deaths. Reduction in child mortality, in part at least through improvement in nutrition, is frequently associated with a fall in the birth rate, although after a lag period that may be quite long. Fig. 10.6 gives one example. Many demographers deny that the association is one of cause and effect, whereas those of us working in public health and nutrition tend to believe that it is. The motivation is obvious for having smaller families if fewer children die, and there is a good deal of evidence from many parts of the world that the connecting link could be better education of women.

It might be thought that preserving the lives of more children would increase the rate of population growth. In fact, where birth rates are high the effect on population size of more children surviving may be compensated by a reduction in the birth rate (Table 10.4). If these two effects are really linked, then removing the nutritional constraints to child survival should be accorded high priority, quite apart from our natural humanitarian concern.

TABLE 10.4. *Relationship between reduced mortality under age 5 years and crude birth rate, 1950 and 1986*

	1950	1986	Percent change
Under-5 mortality per 1,000 births	286	110	-62
Crude birth rate per 1,000 population	45	30	-33
Number of children surviving to 5 years per 1,000 population	33	27	-8

Source: Data for Southeast Asia, from UNICEF, 1987

Conclusion

Nutrition is supposed to be a quantitative science, yet we are far from fully understanding the quantitative relationships between food intake, physical state, and functional capacity. I have tried to give a few examples, but it is clear that we need a great deal more information on many of the topics that I have raised, such as the effect of reduced energy intake on discretionary activity and on other aspects of the quality of life. Nevertheless, even with more information, two difficulties will always remain. The first is that it is hard to separate nutritional constraints from other components of an impoverished and deprived environment. One classical approach, although a very uncertain one, is through experimental trials on the effects of providing extra food. Even if the results are positive, however, many would feel

that to make available food alone, without attending to other aspects of the deprived environment, is not a realistic policy.

The second difficulty is to judge what constitutes an acceptable lower level of nutrition. More information will help, but judgments about what is "acceptable" can never be anything but subjective.

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Part IV

Population and Human Resources and Institutions

11 The Impact of Technological Changes on Resources for Growing Populations

NATHAN ROSENBERG

In addressing the question implicit in the title of this article, it is necessary first to look carefully at the content of technological change as a human activity. (1) What specifically does it consist of? (2) What are its possible consequences? (3) What are the social and economic factors that shape the ability to use and exploit superior technologies—not necessarily technologies that are new, but ones that have never been successfully exploited in a particular country?

Let me anticipate one of my main conclusions at the outset by stating that the third question is, in many respects, the most crucial of the three. For at present, the division of the world's population into rich and poor is closely, although not completely, congruent with its division into countries with high levels and countries with low levels of technological capability. The third question is an exceedingly difficult one that raises fundamental issues of human organization, social institutions, and economic incentives.

In some respects, at least, technological considerations seem to offer very promising prospects for the growing populations of poor countries. Technological change in the advanced industrial countries appears to be moving at a portentously rapid rate. One need only mention the realms of telecommunications, computers, electronics generally, metallurgy and new materials, and the vast new field of biotechnology. Although we do not have a single, reliable metric for quantifying the pace of technological change, such changes are playing a dominating role in shaping the performance of the industrial economies that have been generating these new technologies. As a result, the gap between the technologies employed by advanced industrial countries and by less developed countries is very large.

This gap surely suggests the existence of a powerful opportunity, not yet extensively exploited, for improving the standards of material well-being for the populations of the less developed world. Moreover, many of the technologies just referred to have the capability for being used in resource-augmenting ways. Precisely because such advanced technologies already exist, they need not be re-invented but only transferred and adapted to the needs of developing countries—a seemingly less demanding task.

The Content of Technological Change

In coming to grips with such opportunities it is necessary first to characterize the content of technological change. This is a rather elusive business. The first reason is that technological change is not one thing; it is, rather, many things, with huge variations among industries. The process through which new pharmaceutical products are introduced is vastly different from the development of a new design for a jet engine. The development of new forms of structural paneling in the construction industry—a highly resource-saving innovation—involved research procedures vastly different from the redesign of steam turbines intended to improve the efficiency with which steam power could be converted into electricity (Kline and Rosenberg, 1986).

A closely related point is that the actual content of technological change can be, and often is, literally invisible to everyone but an expert. It may include improvements in procedures such as materials handling, substituting cheaper for more expensive materials, redesigning production techniques for greater convenience, and reducing maintenance and repair costs through methods such as modular machinery. In metal-working, new and harder materials continue to be introduced in cutting edges, allowing a considerable acceleration in the pace of work. In electric power generation, the slow, cumulative improvements in the efficiency of centralized thermal power plants have generated enormous long-term increases in fuel economy. A series of minor plant improvements, including the steady rise in operating temperatures and pressures made possible by metallurgical improvements, new alloy steels, and the increasing sophistication of boiler design and resulting increased capacity, have sharply raised energy output per unit of input. In the United States, it required almost seven pounds of coal to generate a kilowatt-hour of electricity in 1910, but by the 1960s the same amount of electricity could be generated by less than 0.9 of a pound—an enormous improvement in the efficiency with which natural resources have been used (Landsberg and Schurr, 1968: 60–62).

A further point, strongly implied in what has already been said, is of great importance to the prospects for the successful transfer of advanced technologies to less developed countries. Technological change is not a once-and-for-all affair. The introduction of a technological innovation is not something that happens only once and can then be taken for granted. On the contrary, technologies often go through innumerable improvements over their lifetimes, and they therefore require careful attention by human agents who are alert to the opportunities for such improvement and who also have the incentives to develop or adopt them. In fact, it is not uncommon for the later improvements to bring about greater advances in efficiency than the original innovation itself (Enos, 1962). The first airplane in 1903 was capable of flying only a few hundred yards, hardly an improvement over a railroad train or, for that matter, a horse. The first electronic digital computer in 1946 was over 100 feet long and required some 18,000 vacuum tubes in order to function, and that functioning was, inevitably, highly unreliable.

Of particular significance for less developed countries, it is a serious mistake to

identify technological innovation with what goes on in the so-called high-tech industries. In terms of their contribution to productivity growth, many of the most significant innovations have little or nothing to do with sophisticated scientific knowledge. No innovation since World War II has had a greater impact upon the long-distance hauling of bulk goods than containerization. Yet the technology involved was exceedingly simple: it brought about a drastic reduction in labor-handling costs essentially by the use of larger boxes! Anyone who tried to patent this critically important invention would, presumably, have been laughed out of every patent office in the world.

How Economists have Thought about Technological Change

It is thus obvious that technological change offers the possibility of generating substantial rates of economic growth by allowing a society to produce a greater output of goods and services from the same quantity of inputs. In fact, if we start from first principles, we might say that there are just two ways of raising per capita incomes. If we think of an economy in a highly abstract fashion as a mechanism for transforming inputs into output, output can be increased either (1) by employing a larger volume of inputs; or (2) by learning how to extract more output from each unit of input. In that case, an extremely interesting question is to ask, for any country, how much of the observed long-term rise in per capita output can be attributed to using more inputs, and how much can be attributed to extracting more output from each unit of input?

Curiously enough, not until the 1950s did economists actually ask the question in this way and then set out to collect empirical data to answer the question. For many decades, when economists attempted to model the long-term process of economic growth, they essentially took it for granted that the rise in output (or income) per capita was a matter of employing more inputs, especially capital equipment. The first attempt to examine the matter quantitatively was undertaken by Moses Abramovitz (1956). Abramovitz started from the observation that, in the United States between 1869 and 1953, output per capita roughly quadrupled. How much of that growth, he asked, could be attributed to the use of more inputs over this same period? On the basis of available estimates of the historical growth in the supplies of capital and labor inputs, his answer was a surprisingly small amount: only about 15 percent. Thus the residual—the portion of the growth in output per capita that could not be explained by the use of more inputs—was no less than 85 percent. Several other economists, including Robert Solow (1957), used different techniques and different data and got roughly the same answer. What seemed to emerge forcefully from these exercises was that long-term economic growth had been overwhelmingly a matter of using inputs more productively rather than simply using more and more inputs.

The next question, of course, was: granted that growth has been primarily a matter of raising the productivity of inputs, to what can that rise be attributed? The residual,

after all, captured all possible sources of the growth in output aside from the growth in inputs, as conventionally measured. It did not capture simply the benefits of technological change.

Abramovitz was highly circumspect in interpreting his findings. He said that the large size of the residual was "a measure of our ignorance," and of course he was correct. All that his study really allowed him to say with authority was that most of the observed growth in output per capita could not be explained in terms of the growth in inputs per capita. But this, in itself, was a very important finding, for the reason already mentioned: "mainstream" economics had long suggested that economic growth was largely reducible to increasing the supplies of inputs into the economy. Abramovitz's analysis strongly suggested that this was not so.

Actually, if one returns to the writings of Malthus and Ricardo at the end of the eighteenth and the beginning of the nineteenth century, one finds that these two distinguished classical economists were skeptical of the possibility that rising per capita incomes could be sustained for long periods of time. In fact, Malthus and Ricardo posed precisely the topic of this volume: what are the prospects for the long-term improvement in material well-being in view of the constraints imposed by the limited supply of natural resource inputs? Malthus and Ricardo developed models of growth that can best be understood by thinking of Great Britain as a huge farm, of fixed acreage, confronted with a potential for rapid population growth. Such growth leads to an increase in the output of products, as more labor is applied to a fixed amount of land. But, although output does indeed grow, the increments to output grow at a declining rate due to the law of diminishing returns. Eventually population growth will lead to a situation where diminishing returns drive the incremental output of additional labor down to zero—that is, at some point the addition of yet another laborer to a farm of fixed size yields no increase whatever in the output of food. At such a point, even though the working population receives no more than a bare subsistence wage, wage payments eat up—literally—the entire output of the economy. Further growth is impossible because no nonwage income is available for capital formation. The economy has arrived at a so-called stationary state, where population has grown to its maximum size and the bulk of the population is living at a bare subsistence level.

Malthus's formulation, first published anonymously in 1798, became the locus classicus for the view that, without bringing population growth under control, long-term improvements in material well-being were impossible. On this basis Malthus rejected what he regarded as the naive Enlightenment views on the future prospects for improving the human condition. Short-term increase in output would be quickly swamped by the increase in human numbers. Malthus, it must be added, strongly disapproved of all measures of birth control. In the second and later editions of his essay he softened somewhat his pessimistic predictions of the unavoidability of human misery and vice (as he termed all forms of birth control) by recognizing the possible scope of certain "prudential motives," which he defined as "virtuous abstention from marriage." But it was quite clear that he held out no firm hope that mankind could avoid the stationary state by such a drastic

modification in human behavior. It is little wonder that Carlyle dubbed economics "the dismal science."

How relevant was the Malthusian model for the historical experience of the industrialized West over the past two centuries? Its central prediction was that living standards cannot long remain above the subsistence level, because of the accelerated rate of population growth that would be triggered by any temporary increase in wage rates above that level. In fact, if one examines the experience of Great Britain for the entire nineteenth century, total population increased 3.5-fold whereas income per capita fully quadrupled. Clearly it was possible to raise living standards over a prolonged time—at least in Great Britain—in spite of a significantly high rate of population growth.

A basic feature of the classical model—at least before John Stuart Mill and Karl Marx—was that technological change did not play a role of particular importance. Malthus and Ricardo devoted hardly any attention to it in considering long-term growth prospects. Their views were dominated by the overwhelming significance they attributed to the law of diminishing returns in the context of strong population pressures. In the experience of the West since the industrial revolution, by contrast, a rapid rate of technological change has more than offset the downward pressures on living standards imposed by sustained population growth encroaching upon a limited resource base. A central feature of the Western growth experience has been the ability to extract more and more output per unit of input.

The Impact of Technological Change on Industrial Economies

Recent years have seen a surprising reversal of outlooks within academic disciplines. Highly pessimistic forecasts regarding the prospects for economic growth have emanated from sources other than "the dismal science," in particular from systems analysts, biologists, ecologists, and other natural scientists who have become concerned with a larger set of social issues. Economists, by contrast, have often been cast in the role of explaining why these same dismal forecasts—in some cases, amounting to prophecies of doom—are unwarranted.

During the 1970s, public discussion was preoccupied with visions of imminent natural resource exhaustion (as well as pollution-induced ecological disasters) that were bound to halt economic growth. The dominant theme was sounded in the title of an influential book published in 1972, *The Limits to Growth*. These concerns were powerfully reinforced by the sudden shortage of petroleum in world markets as a result of the embargo imposed by the Arab members of OPEC in the following year. The main argument was that inexorable natural resource constraints placed a rigid upper limit on economic growth possibilities. Simple extrapolation of recent rates of use of key natural resources was thought sufficient by some futurologists to generate fairly precise predictions of an apocalypse awaiting mankind not too far down the road—perhaps around the middle of the twenty-first century. The whole exercise was, once again, remarkably Malthusian. Indeed, it often seemed as if Malthus had

returned in the 1970s in the guise of a slightly off-the-rails computer programmer. Economists were placed in the position of offering elementary explanations of how market forces brought adjustment mechanisms into play, so that the growing scarcity of a particular resource gives rise to price increases that, in turn, lead to reduced utilization, the search for substitute inputs, and so on.

In the longer run, however, at least for societies that have a capacity for technological dynamism, another powerful set of forces comes into play. Indeed, at issue is nothing less than the fact that technological change had led to continuous transformations in the very notion of what constitutes an "input." For, although the natural environment may sensibly be treated as fixed and unchanging for certain purposes, this is not equally valid when questions of economic significance are involved. In fact, perhaps the most important feature of the economic impact of technological change is that it has continually expanded the resource base of the economy.

This expansion has taken a variety of forms. Improvements in techniques of drilling and extraction have made it possible to recover oil from depths of 20,000 feet or more, or from such remarkably inhospitable places as the bottom of the North Sea—accomplishments that were physically impossible not very long ago. But in Malthus's time even readily accessible petroleum deposits were of no economic value. They acquired such value during the nineteenth century, not because of any change in their physical characteristics but because of technological changes that created uses for them. Petroleum deposits had acquired considerable value by 1880, primarily as an illuminant in the form of kerosene, due to the increasing scarcity of whale oil. Only with the development of the internal combustion and diesel engines around 1900 did petroleum become valuable as a fuel.

The point is that natural resources acquired economic significance only as a function of technological knowledge, and improvements in such knowledge have regularly led to an expansion in the resource base when that base is considered from an economic perspective. As recently as the 1930s, natural gas was regarded as an unavoidable and dangerous substance that needed to be safely disposed of. Unless some urban markets happened to be nearby, it was typically treated as a waste material and flared—as it still is in some parts of the world. Eventually, the perfection of a technique for producing high-pressure pipelines transformed natural gas from a waste product into the most attractive of household fuels—a fuel that currently plays a major role in many industrial markets and now constitutes a large fraction of total energy supplies. To reiterate, the technological change accounting for this transformation was a very simple one—an improved technique for welding pipes together so that they could safely accommodate much higher pressures than before.

Similar accounts could be repeated endlessly by examining the changing natural-resource requirements of industrializing societies over the past two centuries. Rubber trees in the Amazon had only a modest economic value before vulcanization, after which their value boomed—to such an extent that Manaus was, briefly, home to one of the great opera houses of the world. Bauxite was not an economically significant mineral until a technology for aluminum smelting, the Hall-Heroult

process, was simultaneously invented by an American and a Frenchman in 1886. Before that date, aluminum was a precious metal, selling for several hundred dollars a pound. After 1886 it quickly took its place as one of the main mineral inputs in industrial societies, as aluminum and its various alloys became the basis of a major new industry. Pure aluminum, which cost \$US9.00 per pound in 1886, cost only \$US0.50 per pound in 1891 (Trescott, 1981: 23). Subsequently, the discovery of accessible bauxite deposits constituted a major economic event wherever it took place. Uranium was a common mineral deposit of no particular value in many parts of the world as recently as 1940. By 1950 it was intensely sought after, for strategic as well as economic reasons. Its physical characteristics had obviously undergone no change, but the growth in technological knowledge for releasing energy from the nucleus of a uranium atom was certainly one of the major events of the twentieth century.

The relevance of growing technological knowledge to a society's resource base has a closely related dimension. As the supplies of high-quality resources have been gradually exhausted, a main thrust of twentieth-century technology has been to develop techniques for exploiting low-grade resources, which often exist in abundance. Thus, for example, the gradual exhaustion of high-grade iron ores from the Mesabi Range in northern Minnesota was followed by innovations, such as methods of concentration and beneficiation (a technique for enriching the ore before it enters the blast furnace), that permitted the exploitation of the immense deposits of hard, low-grade taconite ores (Davis, 1964). In a meaningful sense (i.e., in an economic sense) it can be argued that, as a result of the availability of the new processing techniques, the United States has larger iron ore deposits within its borders than it did in 1950, when techniques for the exploitation of taconite ores had not yet been brought to the commercialization stage.

The flotation process, originally applied to the exploitation of low-grade porphyry copper ores, has been applied to a wider range of ores, both of lower mineral content and of more complex chemical forms. Whereas the technology of 1870 required access to ores containing at least 3 percent copper, more recent technologies successfully use ores of only 0.4 percent copper content. Techniques of selective flotation have played a major role in offsetting the decline in the quality of available resources, not only for copper but also for such important materials as lead, zinc, and molybdenum. The great advances during the 1920s in sulphate pulping technology liberated the wood pulp industry in America from its earlier reliance upon northern spruce and fir trees and permitted the exploitation of the more rapidly growing but previously unusable southern pine. In 1900 the American lumbering industry was primarily a northern industry; today, as a result of improved processing techniques, it is primarily southern.

Undoubtedly a persistent theme in the future will be the search for technologies that will make it possible to move farther down the quality gradient of mineral deposits and to rely upon other highly abundant resources for the supply of essential materials. Important examples are the nitrogen fixation process, developed in Germany just before World War I, which fixes nitrogen from an extremely abundant

source, the atmosphere; and the increasing interest in sea water, already a source of magnesium, as a source of other mineral inputs.

The intimate link between technological innovation and natural resources played a decisive role in the history of Europe as it industrialized in the second half of the nineteenth century. This is readily apparent in the most important of the metallurgical industries, iron and steel (Landes, 1969: ch. 5). Beginning in the 1850s, a series of innovations altered the economic significance of natural resource deposits for this industry and, in so doing, was responsible for major geopolitical consequences. The original (acid) Bessemer process of the late 1850s, although it represented a huge improvement in energy efficiency, could be used only to refine materials that fulfilled certain precise chemical conditions—which is to say that it required iron that was free of phosphorus. The later (basic) Bessemer process, by contrast, required ores of a high phosphorus content. As a result, the basic Bessemer process made possible the exploitation of the huge high phosphorus iron ore deposits of western Europe, and changed the course of European history as a result. This prosaic improvement, which consisted merely of adding limestone to the molten iron to draw off the phosphorus, played a major role in the rapid industrialization of Germany in the late nineteenth and early twentieth centuries.

The basic open-hearth furnace, introduced into industrial use in the 1880s, was capable of exploiting a wide range of inputs in steelmaking (in addition to permitting more precise quality control than was possible with the Bessemer technique). In particular, it could use ore of almost any proportion of phosphorus content, and its availability made it possible for the United States to exploit a much wider spectrum of the gigantic Lake Superior iron ore deposits. Moreover, the process could use a high proportion of scrap as a material input, a consideration of increasing significance in locations with ready access to such supplies. The growing abundance and cheapening of scrap in the twentieth century induced research into methods of increasing the proportion of scrap used in oxygen converters. The recent development of the electric furnace represents a technique for producing steel entirely without iron ore, since such furnaces can operate with a 100 percent scrap charge. Thus, the potential supplies of inputs into the steelmaking process have been steadily widened, even to include junkyards, and thereby have made possible the large-scale recycling of steel products. This capability represents a drastic expansion of the resource base of the iron and steel industry. Similar developments have occurred in other metallurgical industries. The electric arc furnace, for example, has made possible the highly efficient recycling of aluminum. The energy cost of recycling aluminum is only about 5 percent of the cost of producing aluminum from the original bauxite (Rosenberg, 1982: 98–99).

It seems appropriate to conclude from this analysis that technology provides the potential for altering the economic significance of a society's resource base so drastically that one cannot meaningfully discuss the role of natural resources in economic activity without first carefully specifying the available level of technological capability. To put the point somewhat differently, the growth of technological knowledge provides information that may make it possible to exploit resources that

were once totally unexploitable, or to use resources that were previously so far below some quality threshold as to be wholly neglected. Increases in technological knowledge are often functionally equivalent to an expansion of the economy's resource base. Seen in this light, the best that can be said for the intellectual parlor game of the 1970s—of calculating how long it would take to exhaust the supply of a particular strategic raw material, at recent or current rates of use—is that the long division was usually carried out correctly. Such calculations are of limited relevance to a society with substantial technological capabilities. Technological innovation has, in the highly industrialized economies, served as a powerful set of methods for overcoming specific natural resource scarcities by vastly expanding the number and the quality of resources that are capable of being exploited. In this sense, technological innovation has been the most efficient of all adjustment mechanisms for dealing with growing natural resource scarcity.

The Relevance of Technological Change for Less Developed Countries

The preceding discussion has examined the historical role of technological change in relaxing the constraints, imposed by limited natural resources, upon economic growth in the now-industrialized world. What is the relevance of this discussion to the poorest third of the world's population, those more than one billion people who, according to the World Bank's 1990 *World Development Report*, live in poverty, that is, with an annual per capita consumption of less than \$US370? Unfortunately, it is far from obvious that, at least in the foreseeable future, there is very much relevance. This conclusion turns upon two factors. I address myself briefly to each.

The first is, of course, the pressures imposed by continued high rates of population growth in the world's poorest countries. Rates of population growth in most of these countries, for the period 1960–90, were well over 2 percent per year, and in a great many cases over 3 percent per year. These rates far exceed those ever experienced in Europe. Such growth is the product of fertility rates that are also far in excess of anything ever experienced in Europe, and of mortality rates that are fast approaching or that, in some cases, have already reached present European levels. The matter of timing is important here. In contrast with the European experience, where fertility levels usually began their historical decline before the sharpest reductions in mortality were achieved, fertility levels have remained high in many less developed countries in spite of sharp mortality declines. Moreover, the balance between population size and resources, at least as measured by population densities, has been much less favorable in some of the largest and poorest Asian countries—Bangladesh, China, India, Nepal, Pakistan, Vietnam.

The relationship between population change and economic development is both complex and subtle. It seems fair to say however, that, in the successful industrialized countries, accelerated population growth rates were closely connected with prior and ongoing changes in technology. These technological improvements were

largely responsible for a gradual decline in death rates that resulted from a widening distribution of the benefits of economic development. Thus, population growth in the industrial West was primarily the consequence of successful economic developments and its benefits. Among the poorest portions of the human population in the twentieth century, by contrast, the rapid decline in mortality has not been a consequence of successful economic performance but, rather, of the rapid acceptance of the technology of death control—public health and sanitation measures, antibiotics, DDT, and so on. One of the unfortunate consequences of the rapid diffusion of this technology has been to generate a growth in human numbers that is likely to far exceed the possible increments to output that might flow from resource-augmenting technologies of the kinds discussed earlier. It is a sobering thought that the combined populations of India and China today, with per capita GNPs in 1988 of \$US340 and \$330, respectively, considerably exceed the population of the entire world at the beginning of the twentieth century.

Some sense of the scale of growth in human numbers may be communicated by reference to one of the greatest natural disasters in recent decades—the cyclone that devastated large parts of Bangladesh in 1990. The enormity of the disaster, involving around 125,000 deaths, understandably left the world griefstricken. Yet given the size of the population of Bangladesh—about 116 million—and its recent rate of population growth—about 2.7 percent per year—the deficit in human numbers resulting from this catastrophe would have been restored in slightly more than two weeks. It is difficult to imagine the scale and scope of resource-augmenting technologies that could fully offset the growth in population size in countries like Bangladesh.

There have, of course, been new resource-augmenting technologies of great importance to densely populated, low-income countries in the past 25 years. The most significant, by far, have been the high-yielding rice varieties first developed at the International Rice Research Institute in Los Baños, Philippines, in the late 1960s and early 1970s. New rice varieties were genetically redesigned to be highly responsive to additional inputs of fertilizer, but success required a carefully monitored environment of water control and the timely introduction of various nonfarm inputs. Output per hectare has been significantly increased. Other crops have also been genetically redesigned, with consequences that have transformed the food balance over much of Asia. Indeed, both India and China have become grain exporters to the former Soviet Union in recent years.

This increase in agricultural output has been immensely welcome, and one shudders to think of what the human condition in southern Asia would have been since the last great famine in India in the mid-1960s without the benefits of the new high-yielding varieties. But the result has been a vast increase in the number of persons living in poverty, admittedly above some bare subsistence level but far below levels that would be regarded as tolerable in the West. For technological change in one sector alone, even in a sector as fundamental as agriculture, may yield little or no improvement in human welfare if the press of increasing numbers reduces the potential per capita benefits of technological change. Moreover, the continued

rapid growth in human numbers may lead directly to a decline in well-being in other critical aspects of life, such as housing, fuel and energy, education, and health services, and to the further degradation and pollution of the environment (Rosenberg and Birdzell, 1986).

It is also necessary here to interject a basic point of political reality. It unfortunately serves no useful purpose in the foreseeable future to ask what is the potential "carrying capacity" of world agriculture. The industrial countries of the world have, on balance, been generating huge food surpluses as a result of large subsidies to their farm populations. Those surpluses, however, are most unlikely to be utilized for indefinite periods of time to relieve hunger and malnutrition in the poorest food-deficit countries. Nor is it likely that the European Community will open its doors to the massive immigration of hungry people from Africa or Bangladesh. Calculating how much food the world could produce if everyone used the most sophisticated agricultural technologies available, or if there existed unfettered movement of population across political borders, is not a particularly useful intellectual exercise. Nor is it especially useful to ask how much food would be available for consumption by poor countries so long as they lack the financial resources to purchase large quantities of food from the food-surplus countries.

This raises the second major category of concerns about the relevance to less developed countries of my earlier discussion of the role of technological change in expanding an economy's resource base. The resource-augmenting capabilities of modern technology are indeed striking and typically very much underestimated. But the existence of such capabilities in Europe, North America, and Japan may be of limited significance to countries like Bangladesh, Haiti, and Uganda unless it is possible to introduce social arrangements for their successful transfer and use. Certainly the existence of advanced technologies somewhere in the world simplifies the situation for poor countries. They do not need the capability to invent these technologies anew, but merely to transfer them from abroad. The possibility of acquiring technology through borrowing rather than independent invention is, indeed, a basic advantage of being a "latecomer." A country that has the capability of acquiring technology through transfer from more advanced industrial economies also possesses a huge potential for rapid economic growth. Japan has been a spectacular example in the twentieth century, as was the United States in the nineteenth century. Hong Kong, South Korea, Singapore, and Taiwan are extremely impressive instances in the past 30 years.

At the same time, there is an obverse side to this coin. The poor countries' economic coexistence with advanced industrial economies entails a potential threat as well as a promise. The threat is that the sophisticated, dynamic technological capabilities in the possession of the industrial economies will generate innovations with deleterious consequences for the less developed countries. The twentieth century provides numerous examples of the substitution of new products for old ones upon which some less developed countries have been heavily dependent in their capacity as exporters: synthetic fibers for cotton and wool, plastics for leather and for some nonferrous metals, synthetic for natural rubber, synthetic detergents for vegetable

oils in the manufacture of soap. An economy without a command of advanced technologies may be highly vulnerable to sudden changes in demand generated by these advanced technologies abroad and may have only a limited capability for adjusting.

This social capability for utilizing technology is critical. Even though transferring a technology may be less demanding than generating new technology, the difficulties should not be underestimated. The transfer of technology has typically required high levels of skill and technical competence in the recipient country. It is hardly a coincidence that, in the nineteenth and early twentieth centuries, the countries that were most successful in borrowing foreign technologies also ranked high on a world scale in the educational attainment of their populations.

But more than literacy and technical skills are essential. Technologies have to be understood as more than mere bits of disembodied hardware. They function within social matrixes where their effectiveness depends upon certain complementary skills in management and in the integration of separate functions within and between productive enterprises. Perhaps most important of all is the need for incentive systems that lead individual actors and decisionmakers to allocate resources efficiently. This requires a reasonable confidence in political stability and the enforcement of property rights. The use of improved technologies commonly involves a willingness to make long-term investments, financial commitments of a sort that are unlikely to be undertaken in a highly unstable political and legal environment (Rosenberg and Birdzell, 1986).

Ultimately, the successful exploitation of technology requires an economic environment that provides inducements and financial rewards for the achievement of higher levels of productive efficiency. In this respect, the ongoing transformations in Eastern Europe today, especially the belated recognition of the essential role of private property and market-mediated prices, represent a turning point that is also full of consequences for the poorest one-third of the world's population. In the full flood of decolonization following World War II, the Soviet Union long served as an alternative model to former colonies, with disastrous consequences that are readily apparent in many countries of sub-Saharan Africa. Government policies that totally rejected the elementary thrust of market forces, such as marketing boards that required peasants to sell their output to the state at prices that were often only a small fraction of those prevailing in world markets, have had a great deal to do with starvation and malnutrition in that part of the world in the past 30 years. The existence of highly productive agricultural technologies in other parts of the world is of no particular relevance for a society that fails, as a consequence of government policies, to permit the operation of even the most elementary private incentives to adopt such technologies.

Technological change is indeed a powerful force for improving the human condition. But it is not a panacea. As a complement to a much slower growth in human numbers and to extensive economic reforms, its potential contributions are immense. But it could be tragically misleading to look upon it as a substitute rather than as a complement.

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12 The Evolution of Economic Organization in Contemporary Societies

ROMANO PRODI

When we assess the availability and use of physical resources and their role in economic growth and performance, one fact is salient. The enormous changes during the last generation have produced entirely unexpected results in terms of how these resources are organized, combined, and managed.

The novel characteristic of the last generation of economic development is the weak correlation between the availability of resources and prospects for long-term growth in all countries of the world. This very simple observation can be taken for granted now, but it refutes the received wisdom of the past.

All empirical data demonstrate that land and raw materials have not been the foundations of the economic growth of the last generation. Granted, serious short-term crises can be induced by a lack of raw materials, as was demonstrated by the oil crises of the 1970s and 1980s. In analyses of long-term growth, however, a complete schism emerges between the possession of material resources and the level of development. This surprising finding should change our views of world economic development.

Consider the cases of Japan and Germany. Both countries were defeated in World War II, and both have limited land resources and almost no reserve of raw materials. The key to the success of these countries depends mainly, or maybe only, on how human resources are developed, organized, and managed. To be more precise, it depends, first, on how human resources are developed and, second, on how they are organized to induce economic growth. In short, the problem is not a matter of physical resources but of the development of human resources. This is the crucial point of a new debate that in recent years has spread in the international arena.

Development of Human Resources: Different Educational Systems

The patterns, the goals, and the stages of the educational process are becoming a controversial subject of debate and discussion everywhere.

The supremacy of the US educational system has been seriously called into question. In the United States policymakers and educators are examining the problem, trying to understand why the educational system is in crisis and what the negative

economic consequences could be. This debate is of great interest for other countries as well.

There is in fact a common view of the mistakes made, even if there has been no clear decision regarding what new policy to adopt. To summarize, the prevailing criticism is that too much attention has been paid to the small number of people enrolled in the university system, especially in the top universities. Too many resources have been dedicated to the top 5 percent of the population. This has created the best advanced university system in the world, attracting many of the best students, but a very poor level of general education, especially in the critical period between ages 16 and 20 years, the stage at which the skills of a generation are formed.

In contrast, Germany and Japan place less emphasis on a high level of excellence in a few chosen universities. Much greater attention is paid to general education, especially in technical schools. The whole economic system is heavily involved in the education process.

Similar differences in educational policy are evident in less developed countries. The most striking example of an extreme policy is Brazil, where almost 60 percent of government expenditure in education is at the university level, while little more than 40 percent is reserved for the primary and secondary schools. The result is not only a lack of technical skills to promote Brazilian industrial development but also the widening of the social and economic gap in the country, as a consequence of a flow of resources directed to some 500,000 university students (mainly members of the upper-middle class) rather than to the millions of the poor who are in great need of education.

The crux of the matter is not whether education should be public or private, but how far society should be involved in the process of education. Education is never purely private or public. It is always mixed. We can gain an interesting lesson from the German and Japanese school systems, in which individual industrial companies, local administrations, communities, regional trade unions, and national governments are all heavily involved in the educational process.

Organization of Human Resources

Long-term growth does not depend solely upon the level of individuals' education, but also on how individuals are organized together. Let us consider the case of the former Soviet Union. The level of individual education is comparatively good. Young people have a good knowledge of mathematics, physics, and basic science, but this knowledge has not provided good economic results. Individual knowledge is not put to the service of the society and is not translated into increasing productivity of goods and services.

We should ask ourselves why. The answer, I believe, is that the basic values and structure of the system do not provide incentives for people to work together. This is the second feature that one must have in an economic system, in order to

achieve positive results. In centrally planned economies people work together only when obliged to do so and under the condition that the economic structure is kept primitive and very simple. In these cases the economic results have never been brilliant. After the relaxing of authoritarian rules and due to the increasing complexity of their economic structure, the Eastern European systems were totally unable to work.

With the advent of new freedom in Eastern Europe, interpersonal relations must be reformed. This is the real difficulty of the transition from a centrally planned to a market economy. It is an illusion to think that this transformation can be carried out over a short period of time, since not only social organizations but also economic organizations and the structure of management must be completely transformed.

This point is valid not only for industrial countries but even for third world countries. Why is economic growth progressing faster in Asia than in Africa? This is one of the main questions that we must examine here. We have a widely accepted demonstration of the dynamism of a great part of the Asian system, which, in my opinion, will become the real center of the world economy for the next generation. When I say the center, I do not mean only in terms of numbers and quantity, I also mean in terms of quality.

The Roles of Education and Social Organization in Third World Economies

If we examine the case of newly industrialized countries—the four “tigers,” Taiwan, South Korea, Hong Kong, and Singapore—and the other growing Asian countries, such as Thailand, Malaysia, and Indonesia, we find real progress in the educational system and in the framework of social organization.

World Bank data give clear evidence of these statements. The positive correlation between economic growth and the educational level is evident (World Bank, 1991), even if there is no clear evidence of a correlation between economic growth and greater equality in income distribution. Income growth reduces the number of poor people but does not automatically produce a higher level of equality. The spread of mass education, however, is strongly associated with more equal distribution of income.

As regards political reform, recent experiments in the reduction of bureaucratic interference seem to have led to improved performance of industrial companies and to a growing number of new competitors entering the market.

These remarks are consistent with the recent growth theory of Scott (1989), who explains long-term growth not by emphasizing the quantity of capital and labor employed but by emphasizing “knowledge” (Scott, 1991). Investment in knowledge becomes crucial even in obtaining increased capital productivity.

Recent empirical studies comparing the economic growth rates of many countries at different levels of per capita income have concluded that growth does not occur

primarily by investment in physical capital but by investment in education. The lack of education is a major obstacle to growth in underdeveloped countries.

This effect of education is valid for all countries, especially for those that are trying to follow a new strategy after the collapse of a centrally based economy previously sustained by Soviet aid. This common feature does not mean that there is a high degree of social and economic homogeneity among developing countries—quite the opposite is the case. Even in countries at similar stages of development, technology and human resources are organized in very different ways.

In India clusters of rapid development arise from the interaction of universities, applied science laboratories, and science-based companies. In a short space of time these new centers have become able to export software and high-technology products to the West and to Japan, with their competitive edge created by the interaction of the low cost of labor and high technical skill. Nevertheless the surrounding areas are still backward and in deep stagnation.

In China lack of political freedom contrasts with increasing economic freedom. The gross national product has grown by more than 70 percent in real terms in the last decade. Even after the Tiananmen Square tragedy, in 1989, the rate of growth has remained around 7 percent in real terms. We cannot judge how long the split between an authoritarian regime and increasing economic freedom can continue, but in terms of development the status quo seems to work.

The case of South America is quite different. An abundance of natural resources and a relatively adequate school system lead us to expect very high rates of economic growth, but this has been made very difficult by a lack of solidarity in social and economic organization.

In many cases the South American bourgeoisie keep abroad an amount of foreign currency that is higher than or at least equal to the external debt of their country. Moreover, the spread of corruption and of unregulated bureaucratic interference (in addition to regressive fiscal policies) is a major obstacle to the development of a social organization favorable to economic growth. Over the last several years, many South American countries have shown signs of positive changes in government policies, with a concrete improvement of prospects for future growth.

International Trade

Over the last 30 years international trade has been one of the main forces driving economic growth. In the last decade the growth of trade has been consistently higher than the growth in physical production, especially in Asia and North America. The importance of raw materials and agricultural products relative to manufacturing industries and services has greatly decreased. Industrial exports from less developed countries have made important progress, while the surplus of oil-exporting countries has been progressively reduced.

Progress in trade has not been homogeneous or global but strongly based on intraregional relations. Intraregional trade has increased from 34 percent of world

trade in 1980 to 40 percent in 1989, but it has been accompanied by a substantial increase in trade between different regions. We are moving toward separate American, European, and Asian exchange systems, compatible with a world trade system.

In the long term, the American system foresees the setting up of free trade between the United States, Canada, and Mexico and a growing number of Latin American states. This interesting innovation could provide new hope for development in Mexico and in other Latin American states, particularly Argentina.

The European trade system is spreading, slowly and laboriously, through the former Eastern Bloc countries. Trade between Poland, Czechoslovakia, Hungary, and the other former Eastern Bloc countries is slowing, while their ties with the European Community continue to grow. Proof of the important responsibilities of Western Europe toward Eastern Europe lies in the relatively low level of trade between the latter and the United States.

The Asian system is, of course, making the most rapid progress, encouraged by the dynamism of Japan.

The condition of the African continent, however, is increasingly tragic, since it has not managed to follow any kind of economic organization. The countries on this continent, rapidly losing ground in international commerce, seem incapable of constructing solid economic links either among themselves or with the rest of the world.

In an age in which economic progress at the regional level is a guide to progress on the world markets, the fact that no one is, in fact, proposing a strategy to reduce the isolation of Africa is very disturbing. This observation tends to highlight the strong ties between international economic problems and political initiatives that, in the case of Africa, have been practically nonexistent.

Another important form of economic "globalization" is to be found in direct foreign investments, which, during the 1980s, increased at the unprecedented rate of 30 percent per annum. These investments, however, while greatly favoring the growth of the world economy, are concentrated in the most highly developed areas, in other words the United States, Japan, and Western Europe, although recently they have shown promising signs of expansion toward other world areas.

If the importance of natural resources to long-term growth is almost negligible, it does not follow that material resources are not important in special cases and in the short term. I do not exclude, for example, the possibility of another acute crisis in the oil market, especially considering political uncertainties in the Middle East. The only clear trend in the oil-producing countries of that region is the increasing influence of Islamic fundamentalism. Even in the aftermath of the Gulf War, I do not foresee any widespread or commonly accepted political agreement. From this point of view, there is no reason to be optimistic. But this isolated case has little to do with long-term world economic growth. This may be a case of acute crisis, but it does not lead to abandonment of the argument that I advanced above.

Contrasting Models of Capitalism

What are the social and political institutions we have to foster in order to produce better performance in terms of growth and income distribution? First of all, of course, we are not at the end of a period of history. Francis Fukuyama was very imprudent to write his article on the end of history because a new history was indeed starting at that moment, and we are probably not even at the end of the present one. So what is this new melting pot? The market economy is now the ascendant social and economic organization. The battle between capitalism and communism is over; the market economy has won because of its flexibility and its resilience. Its excellent performance is due to a capacity for adaptation to different political and social realities.

We now have to analyze some of the different answers given by modern capitalism, because these tools will be of great importance for the future development of economies. Our starting point is that there is no single form of capitalism. Capitalism is a highly mobile type of social organization. The collapse of the communist world will cause the spotlight to fall on the differences between the many market economies.

Let us first distinguish the so-called Anglo-Saxon form of capitalism, in terms of social and economic organization, from the German (or continental European or Japanese-German) form. Let us try to define them because I think that this will trigger a new challenge in terms of the development of human resources and economic competition. This new challenge is so important that it could reshape our existing world. Of course there are many similarities between the two forms of capitalism. Both are dominated by market decision rather than by planning authorities, and both are dominated by private ownership. Capital is highly valued among factors of production in both systems. But there are also big differences between them.

Anglo-Saxon capitalism has its stronghold in the United States and Canada, but during the last decade it returned to its roots in the United Kingdom. Large corporations, the symbols of this form of capitalism, are dominated by shareholders. There has been a progressive evolution from family dynasties to new ownership, generally anonymous but always present in the management of companies. The new shareholders are sometimes individuals, but more often insurance companies, trusts, or pension funds. They do not influence the company directly in its daily operations, but through financial markets. The stock exchange is therefore the center of this system. Wall Street is not a market but the symbol of an entire economy that finds its point of reference in the stock exchange. The shareholders do not directly oversee the management of the company, but they are concerned about the value of their shares, which is, in turn, influenced by the profit margin of the company.

The concept of profit is both peculiar and restricted. It signifies gain in the short term. This leads to an obsession with the quarterly reports of companies, and stock exchange analysts show their ability in making quick forecasts of profit behavior. Of course, we have a number of exceptions of companies with long-term views,

accompanied by close and stable relations between shareholders and companies. But, generally, there is an obsession with the quarterly report, and if two consecutive negative quarterly reports appear, the managers' positions become precarious.

The consequence is greater attention to optimizing short-term profits. The market reflects the value of all goods and therefore the value of companies that are bought and sold like any other type of merchandise. The company has no public relevance. The shareholders' sovereignty is such that it keeps the management in perennial tension, and therefore the Anglo-Saxon type of company is a very efficient body. But its weakness is the lack of a long-term perspective, mainly through innovative research and development and the profitable use of human resources.

On the other hand, consider what we call German (or Japanese-German) capitalism. We can give it many different names, but it was developed mainly in Germany and in some areas of continental Europe and it has been deeply absorbed and elaborated by the Japanese system. Large companies are owned by a network of shareholders linked together: banks (there is no separation between banks and companies), foundations, insurance companies, trade unions, and financial companies. These shareholders stay together over the long term. They have firm agreements and have direct control of the company. They share the balance of power with managers and trade union representatives, so companies have a continuous link with political leadership and with the local and central governments and the communities. Companies have a special status and cannot be sold or bought on the stock exchange. Frankfurt and Tokyo have major stock exchanges, but they trade only minority shares. A take-over bid is never made because the important companies are bought or sold only if the community that takes care of them wants to sell them. So it is a much more mixed form of capitalism, in that companies have some public relevance even if they are privately owned.

The interrelations between banks and industry are very tightly managed both in Germany and in Japan, in contrast with the sharp separation that characterizes the Anglo-Saxon world. The network of shared ownership of the Deutsche Bank, Dresdner Bank, Commerz Bank, and of the Regional Banks pervades all of German economic life. In Japan the relations between banks and industry are organized more through the keiretsu.

The role of the government in both countries is generally strong. The different attitude toward public ownership of the so-called natural monopolies and public utilities is also very important. The telephone and electricity systems in Germany, as in continental Europe more broadly, are owned mainly by the state or by public entities. In Great Britain and the United States, meanwhile, they are privately owned albeit under public control.

Traditionally, Anglo-Saxon capitalism has been the dominant model, and only in the most recent period have the success of the German and Japanese economies and the search for a new institutional framework by the former communist countries brought to light the fundamental differences within the capitalist system.

We are therefore encouraged to analyze the consequences of the two models of capitalism in greater depth, in terms of efficiency but especially in terms of social

justice, and to study the organization of the two models in order to draw some conclusions regarding social organization, economic organization, and the management of the less developed countries. In fact, due to the void left in many countries by the collapse of communist ideology, we need to collect additional data and ideas for the building of a new economic order. Some conclusions may be drawn on the basis of available data, but we need more extensive and analytical research for the future.

From the data at our disposal, we may conclude that within companies under the Anglo-Saxon system, there is generally a substantial difference between the wages and salaries of lower ranking and higher ranking employees (and especially between those of workers and managers). This is not the only explanation for the large differences in income levels within whole societies, but there is certainly a link between these institutional characteristics of the companies and income distribution. In some way the attention to a measure of micro-economic social justice figures more strongly in the German than in the Anglo-Saxon model.

Of course, social justice is not only that. In the United States, during the last decade, 15 million new jobs have been created. In Europe this has not been the case. So it is a very complex judgment. Nevertheless, I think it is very interesting to analyze the consequences of different institutional solutions. An explanation for the different degrees of micro-economic social justice can probably be found in the greater attention to human resources displayed by the German and Japanese system. There are obvious dangers in the close interrelationship of government and industry and dangers in terms of freedom and the balance of power. Democracy is not only the division of power between government, parliament, and the judiciary system. There is also the important problem of the delicate balance between the economy and politics. Even if we must consider this danger very cautiously, we may nevertheless come to agree that the German-Japanese systems seem to take better care of the people working inside the companies, in terms of teaching and training and of working conditions.

This consideration is full of new possibilities for the future. In fact when Eastern Europe gained its freedom, the only model was the United States. Everyone looked to the United States because of the spontaneous link between democracy, political and military leadership, and the new economic order. Yet less than two years later, the new institutions in Czechoslovakia, Hungary, and Poland were mainly shaped along German lines. There is no longer any overriding call for a stock exchange but instead for a very careful analysis of national institutions and national traditions.

Between these two contrasting models of social organization lie many others, all deeply influenced by the traditions and the history of individual nations. The French economy, for example, is supposedly based on the Anglo-Saxon model, but it has evolved away from it, creating mixed groups of banks and public and private bodies, and bringing the organization of the system closer to the German model. The *Crédit Lyonnais* or *Paribas* or the *Crédit Agricole*, in fact, openly look toward a German-type evolution of the economy. I believe that this phenomenon requires further

study, since it could have far-reaching consequences for the development of human resources and the level of income inequality.

In conclusion, while the fundamental aspects of economic systems come to resemble each other more and more, maintaining the market economy as a general framework, the institutional differences within this framework are rapidly increasing. Within the market economy there is room for experimentation and for variation, which is a great bonus for developing countries that need to integrate their strong traditions and customs with the requirements of an efficient, modern society. It would therefore be a serious mistake on the part of the industrialized nations and international organizations to impose a single organizational model and expect this to be valid for all countries. If within these highly developed industrialized nations several models of social and economic organization successfully coexist, there is no reason why this diversity should not be the case for the rest of the world.

It is therefore necessary to establish, just as in the countries already established on a market economy basis, a set of common rules that must be followed in order to guarantee a healthy development of both the domestic economy and international relations. There must be a common base for the fundamental rules regarding private property, business enterprises and associations, and the role of currency and exchange. But it is neither necessary nor advisable to impose standardized organizational models.

The relationship between different systems will soon be put to the test with the newly formed relations between the United States and Latin America. Mexico and Argentina, for example, are already privatizing many sectors of the economy to follow the American model, while the United States is transferring its most flexible industrial activities with low manual-labor costs to Mexico. However, the relationship between banks, private companies, and the government is very different in these two countries.

The same phenomenon occurs in the process of economic cooperation between Eastern and Western Europe. The economies of the various countries are becoming more integrated, due to the collapse of commercial ties with the former Soviet Union, but the forms that Poland, Czechoslovakia, and Hungary are pursuing in order to enter into the system of market economies are quite separate and diverse. The European example further demonstrates the complexity of economic doctrines. In fact, every effort has been made to ensure that the process of privatization and the new economic regulations in the three countries should be the same. This effort was made on a rational basis and no doubt had distinct advantages to recommend it—such as that of being able to devise a single set of economic rules for commerce. This proposal, which I personally seconded in various meetings and discussions, has never been accepted, precisely because each country wishes to interpret its own traditions and needs in an autonomous way.

This certainly leads to greater difficulties in the process of economic integration and development for Eastern European countries. But this “diversity,” although conforming to the general rules of the market economy, seems to be an unavoidable condition for the civil and democratic growth of the people in a community.

Organizational Models for Companies

This diversity in the organizational models of the economic community is reflected in equally pronounced differences within the organizational models of individual companies. This is another case where the collapse of Marxist models has led to an even more enthusiastic search for new modes of organization. Here again we find ourselves at the beginning, not the end, of an era, since the search for new industrial relations is free from the limitations imposed by the necessity to fight the communist challenge. In this case the most original solutions come from Japan. The organizational model within the major Japanese industries is fundamentally different from traditional Western models.

A typical example of a Western company, a car factory, presents at least ten hierarchical levels of management and often many more. This pyramidal model constitutes a major obstacle to the communication process and, at the same time, can greatly diminish the creative and expressive capacities of all the workers in the company.

This is not only a problem of communication but it means that all workers, even those at the lowest levels, must be highly educated and capable of making important decisions. They have personal responsibilities, decentralized to the lowest level, even on the assembly line. In the new model of organization the worker does not perform a single manual job, as in the old Ford-type factories. The new worker must have a good knowledge of statistics and mathematics in order to make decisions about his daily work.

Other consequences follow. The difference in wage and salary levels from the highest to the lowest paid workers is much smaller in Japan than in the United States or other Western economies. I do not cite the Japanese example as a perfect system, but because it provides a case of "diversity" and of a search for more equitable relations within the company that would be worth studying in greater depth.

We can now freely discuss the reforms that could be applied to the capitalist economic system without worrying that these reforms might diminish the strength of the system in the face of a common enemy that no longer exists. If this new range of organizational choices, both at the level of society at large and at that of individual companies, is interpreted correctly it will create new possibilities for development, with no mandate that the highly developed countries "impose" their model of organization on all other countries.

Economic, social, and management organization is not a question of a single, standardized choice that is valid in the same way for every country in the world. In order to be successful and responsive to the criteria of efficiency and justice, these organizational forms should reflect the complexity of the choices and the history of each country and its people. Only under these conditions can we avoid making the same mistakes that have, in the past, profoundly damaged the relationships between the many countries and peoples of the world.

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13 Growth and Productive Structure: A Medium-Term Perspective

ALBERTO QUADRIO CURZIO and MARCO FORTIS

One of the fundamental aims of economic systems and of the science of economics is to use resources and factors so as to increase them over time to meet human needs. This is one of the meanings of the statement that "economics is at the service of humankind." At least five major groups of resources have shaped the processes of economic growth: human; natural and environmental; technical and productive; financial; and social-legal-institutional. Each of these broad groups can be subdivided both from a logical and from a historical point of view. These resources have always been complementary and partially substitutable in the processes of growth and development; it is impossible to deal with any one of them in isolation.

Moreover, there are many types of human needs. Some of them are material—food, health, housing; others are nonmaterial—education, freedom, dignity of life, solidarity. Finally, resources and needs are often interconnected so that the greater satisfaction of some of the needs generates more resources. For instance, education is a need but also a powerful factor of production.

A variety of indexes have been developed to measure the relationship between resources and needs. These range from the most obvious and aggregate economic measures (such as per capita gross domestic product), to socioeconomic measures (such as life expectancy, per capita caloric consumption, level of education, level of employment, the distribution of income), to techno-economic indicators (such as structure of production, endowment in infrastructure, level and composition of international trade).

In principle many such indexes should be monitored in order to evaluate progress in development and the ways in which development may be influenced. Furthermore, analysis of the past trends should be complemented by forecasts, even if these are subject to wide margins of error as past forecasting experience has shown. Any evaluation of the growth process requires a large set of indexes in order to minimize the risk of errors.

This chapter is concerned with the economy outside the agricultural sector, as agriculture is discussed elsewhere in the volume. Of course agriculture remains "strategic" in every developing country for many important reasons, which include the high share of the labor force employed in agriculture (and also the high share of

hidden unemployment located in that sector); the psychological, political, social and economic significance of self-sufficiency in food production; and the commercial relevance of "cash commodities" (coffee, cocoa, tea, tropical fruits, rubber, wood, etc.) produced in agriculture, which are often the most important source of foreign exchange in developing countries.

In many situations a "food self-sufficiency" approach has been dismissed in favor of a "cash commodity" approach. This can give rise to many problems: witness the fall in the international prices of such commodities during the 1980s and the consequent instability of employment in this sector.

Our analysis is devoted to a problem that plays a small, but nevertheless important, role within the broad field of resources and population. The focus is on the technical and productive resources of the less developed countries in the context of the structure of the production systems in the processes of growth. A large part of the material wealth of the world derives from production processes through the application of knowledge and skill of human beings. The analysis of the industrial sector and the international trade of developing countries reveals the productive interconnections of these countries with the world economy. Before turning to these subjects we review, on the basis of aggregate economic indexes, the position of the less developed countries (LDCs) in the world economy.

The Share of Less Developed Countries in the World Gross Domestic Product: 1970–1989

While many LDCs have undergone remarkable growth in the last 20 years, the gap between the LDCs as a whole and the industrialized countries remains very wide (Prometeia, 1991).¹ Specifically, the ratio between GDP and the size of the population is heavily and in some cases extraordinarily unfavorable to LDCs. This is shown immediately by comparing distributions of GDP and population in 1989 by groups of countries. In 1989 the OECD countries, which are the industrialized countries, produced an estimated 66 percent of world GDP with 15 percent of the world's population; the former Soviet Union and the other former communist states

¹ Under Prometeia classification (1991): *Middle East* comprises Bahrain, Iran, Iraq, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Yemen PDR, Yemen; *Mediterranean LDCs* comprise Algeria, Egypt, Israel, Lebanon, Libyan Arab Jamahirriya, Morocco, Syrian Arab Republic, Tunisia, Turkey, Yugoslavia; *Latin America* comprises Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Rep., Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay, Venezuela; *Pacific Asia* comprises Hong Kong, Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand; *The rest of Asia* comprises Afghanistan, Bangladesh, Bhutan, Cambodia, China, India, Laos, Mongolia, Myanmar, Nepal, North Korea, Pakistan, Vietnam; *The rest of Africa* comprises Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Rep., Chad, Congo, Côte d'Ivoire, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, Togo, Uganda, Zaire, Zambia, Zimbabwe.

produced 12 percent of GDP with 7 percent of the world's population; the remaining area, mainly LDCs, with 77 percent of the world population produced 21 percent of GDP (see Table 13.1).

TABLE 13.1. *Population and GDP distribution by geographical area, 1989*

Region	Percentage share	
	Population	GDP
World	100.0	100.0
OECD	15.3	66.1
Eastern Europe	7.4	12.4
Asia	49.6	9.8
Latin America	8.2	6.0
Others	19.5	5.7

Source: Prometeia, 1991

The situation of LDCs is, however, far from uniform. Some Pacific Asian countries, especially the so-called NICs (Newly Industrializing Countries)—Hong Kong, South Korea, Taiwan, Singapore—have grown rapidly during the last 20 years. Other countries (especially in Latin America), which were already in the highest economic quintile of LDCs, have grown much more slowly or stagnated. Finally in some areas, like sub-Saharan Africa, economies have in many respects deteriorated. Subdividing the LDCs and the oil exporting countries (OECs) into six groups, we can observe the following paths of growth in the period 1970–89 (see Table 13.2):

- world GDP, measured at 1980 prices, has grown by 89 percent while that of LDCs and OECs combined grew by 132 percent;
- this faster growth of LDCs and OECs is mostly due to the sustained growth of LDCs of the Pacific (an increase of 253 percent) and other Asian areas (an increase of 209 percent);
- the Middle East and the Mediterranean LDCs, in spite of the large benefits deriving from oil revenues, have grown only by 119 percent and 107 percent, respectively; a growth higher than the world average but rather weak considering the large financial resources available to the area;
- finally, two areas have shown much slower growth than the world average: Africa's GDP grew by 63 percent and Latin America's by 86 percent.

The share of LDCs and OECs in the world GDP has grown from 17.4 percent to 21.4 percent between 1970 and 1989 because of the strong growth performance of the Pacific Asian LDCs. The weight of the other LDCs, including the OECs, within the world total has remained practically unchanged, while the share of Latin America

TABLE 13.2. *Share of the less developed countries in world gross domestic product (GDP), 1970 and 1989, and percent increase of less developed countries' GDP 1970 to 1989, by regions*

	Percentage share		GDP increase (percent) 1970-1989
	1970	1989	
World GDP	100.0	100.0	89
LDCs (including oil exporting countries) ^a	17.4	21.4	132
Middle East	0.9	1.1	119
Mediterranean LDCs	2.2	2.4	107
Latin America	6.0	5.9	86
Pacific Asia	1.6	3.0	253
Rest of Asia	4.1	6.7	209
Rest of Africa	2.5	2.2	63

^a For countries included under the six regional headings below, see footnote 1.

Note: All rates have been calculated on GDP in 1980 US dollars.

Source: Calculations by the authors based on Prometeia, 1991.

has fallen slightly and that of Africa significantly. The LDCs are therefore not a "South" with common economic situations and perspectives. In order to understand their differences we will consider, among the many factors, that of the productive structure.

Industrial and Manufacturing Output in LDCs

It is commonly accepted that increasing the share of industrial output within the GDP and that of industrial employment within the total employment are a key for a growth process starting from a low level of development. This historical wisdom must now be reevaluated from at least two new perspectives.

First, is the process of industrialization still essential to promote the growth of LDCs? Second, are ongoing changes in the industrial sector of industrialized countries a process of reshaping industry or an abandonment of it? What are the consequences of these changes for LDCs?

The answer to the first question is affirmative: the countries with the most rapid growth are those that have developed their industrial sectors and their manufacturing industries, in particular. The answers to the second set of questions are more complex and lie outside our article. However, there is no doubt that some LDCs gained large export markets for manufactured goods in developed countries where some manufacturing industries have declined.

Let us consider the situation in the various regions of LDCs, as classified by the

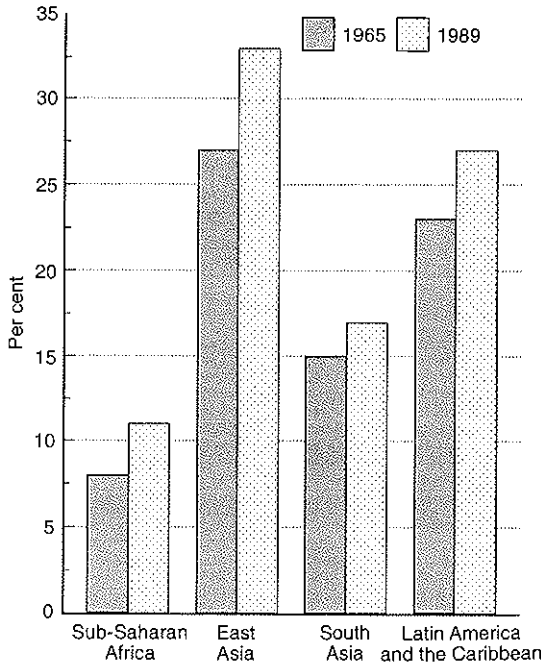


FIG. 13.1. *Contribution of manufacturing sector to GDP in four regions, 1965 and 1989*

Source: Calculations by the authors based on World Bank, 1991

World Bank. East Asia has shown remarkable growth in industry and manufacturing; this is particularly true for South Korea, Taiwan, Hong Kong, and Singapore. For East Asia as a whole the share of industrial output in total GDP reached 44 percent in 1989. In the same year the manufacturing industries had the most important role, accounting for 33 percent of GDP (see Fig. 13.1). This is the result of an average annual growth rate of manufacturing output during the 1980s of 12.6 percent, a rate much higher than that in industrialized economies (3.4 percent) (see Fig. 13.2). South Korea, for instance, has reached an average annual growth rate of manufacturing output of 13.1 percent and China of 14.5 percent. In East and South Asia combined, manufacturing employment grew by 40 percent between 1976 and 1987 (UN, 1988). Between 1970 and 1988, labor productivity in the manufacturing industries—measured by gross output per employee at constant prices with 1980 as the base year (World Bank, 1991)—has grown significantly, by over 300 percent in South Korea and by 67 percent in Singapore. In South Asia, industrial output in 1989 represented 26 percent of total GDP, the lowest value among LDC regions; the contribution of manufacturing to total GDP was 17 percent. For India alone, shares of industrial and manufacturing output in total GDP were 29 percent and 18 percent, respectively.

During the 1980s manufacturing production in South Asia increased by an

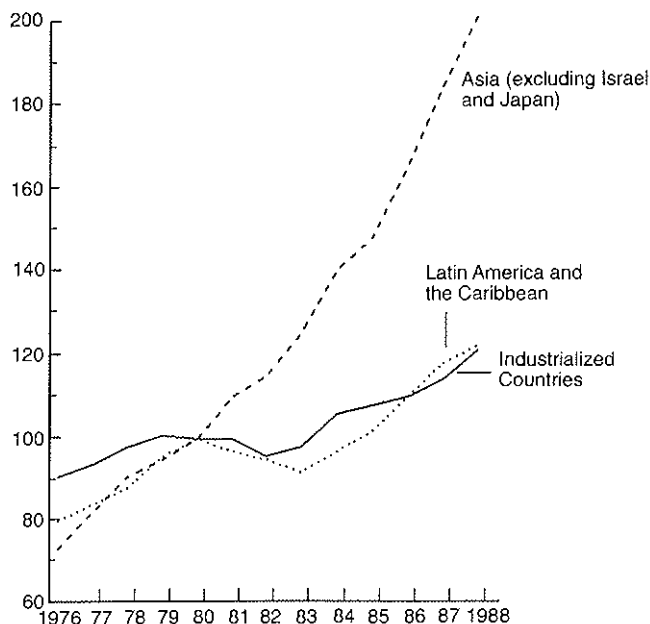


FIG. 13.2. *Index of manufacturing production in Asia, Latin America, and in the industrialized countries, 1976–1988 (1980 = 100)*

Source: Calculations by the authors based on UN, 1988

average annual rate of 7.1 percent; a rapid rate compared with the average annual rate of 4.6 percent registered in the period 1965–80. Manufacturing labor productivity in the region grew substantially between 1970 and 1988, increasing by over 300 percent in Pakistan, 101 percent in India, and 86 percent in Sri Lanka.

In Latin America and the Caribbean in 1989, the share of industrial output in total GDP was 39 percent and the share of manufacturing was 27 percent. The growth of manufacturing output in the 1980s was stagnant; at a 1.5 percent average annual rate it was well below the average annual rate of 7.2 percent registered during the period 1965–80. As a consequence, manufacturing employment declined by 9 percent over the period 1976–87. Within-region variation was significant. For example, manufacturing labor productivity during 1970–88 declined sharply in Bolivia (by 48 percent), but increased in Argentina, Brazil, and Mexico by 76, 63, and 44 percent, respectively.

In sub-Saharan Africa the share of industrial output in total GDP reached 27 percent in 1989. In some countries in the region this share declined during 1965–89; for example in Tanzania from 14 percent to 7 percent, in Sierra Leone from 28 percent to 11 percent, and in Uganda from 13 percent to 7 percent. In other countries the share increased: in Nigeria from 13 percent to 44 percent, in Chad from 15 percent to 20 percent, and in Malawi from 13 percent to 19 percent. In 1989 the

share of manufacturing output in total GDP was only 11 percent, with an annual average growth rate during the 1980s of 3.4 percent. Tanzania, Togo, and Sierra Leone showed negative rates. Little information is available from the official statistical sources regarding manufacturing employment and labor productivity (ILO, 1991). We observe only that for the majority of African countries manufacturing employment has increased during the 1980s (the exceptions were Gambia, Sierra Leone, Swaziland, and Togo), but the magnitude of increase has not been significant.

These data demonstrate the remarkable differences among the areas of the so-called "South." During the period considered, the share of industrial and manufacturing output in total GDP increased in East and South Asia, stagnated in Latin America, and declined in most African countries.

The model of growth followed in many Asian countries (especially by the NICs) is characterized by the use of labor-intensive technologies that were, nevertheless, capable of increasing labor productivity. Many factors contributed to the success of this course, including the low cost of labor, a stable institutional environment, the availability of financial capital, and a strong emphasis on international trade.

In Latin America the stagnation of manufacturing production is partly due to the stabilization policies applied in many countries in the region in the 1980s. These policies had two consequences: on the one hand they decreased inflation but on the other they reduced investments and imports, slowing the process of growth.

As for sub-Saharan Africa, the weak average annual growth rate of manufacturing production during the 1980s was associated with low annual growth rates both of agricultural production (2 percent) and of the service sector (2.3 percent). Excluding the African LDCs that have increased particular manufacturing industries based on primary commodities, the majority of African countries have developed neither their industrial system nor their agricultural sector. The short-term prognosis is also bleak. Per capita GDP in the African region is expected to grow less than 1 percent a year in the first half of the 1990s; direct foreign investments are declining; and the region is increasingly marginalized from the world free trade areas.

When 50 LDCs are ranked according to their per capita manufacturing value added (measured in 1988 US dollars), 3 countries of East Asia—Singapore, Hong Kong, and South Korea—occupy the highest positions (see Table 13.3). Taiwan, for which UN sources provide no data, has a per capita industrial value added of about US\$2,800 (estimated from Atlasco, 1990); its per capita manufacturing value added is likely to be correspondingly high, near the top of the LDC list. Four countries of Latin America (Brazil, Venezuela, Mexico, and Uruguay) are placed between the fourth and eighth position on this list, with values ranging from \$685 in Brazil to \$508 in Uruguay.

The highest-placed African LDCs in the classification are Mauritius (\$381) and Gabon (\$301), at ninth and tenth position. These two countries, however, are far ahead of the rest of the African continent. Other African LDCs start at the 20th position and range from \$153 in Cameroon to \$19 for Malawi. The bottom of the list is dominated by the African LDCs.

TABLE 13.3. *Value added in manufacturing in the 50 industrially most important less developed countries, per capita, 1988, in 1988 US dollars*

Singapore	2,849	China	130
Hong Kong	1,891	Honduras	128
South Korea	1,291	Dominican Republic	108
Brazil	685	Congo	94
Venezuela	658	Papua New Guinea	92
Argentina	592	Indonesia	89
Mexico	561	Botswana	83
Uruguay	508	Bolivia	82
Mauritius	381	Sri Lanka	59
Gabon	301	Haiti	58
Trinidad and Tobago	298	Pakistan	54
Peru	295	India	53
Jamaica	285	Rwanda	49
Thailand	271	Burkina Faso	44
Colombia	257	Kenya	38
Ecuador	214	Ghana	38
El Salvador	192	Togo	31
Nicaragua	178	Chad	30
Paraguay	166	Central African Republic	30
Philippines	164	Zaire	29
Cameroon	153	Lesotho	29
Zambia	151	Nigeria	27
Panama	143	Madagascar	25
Zimbabwe	143	Niger	23
Senegal	134	Malawi	19

Source: Calculations by the authors based on World Bank data, 1991

The countries that have achieved the highest per capita manufacturing value added have emphasized development of the machine building and transport equipment industry (see Table 13.4). In the nine most important Asian countries this industry accounted for 23 percent of manufacturing value added in 1988 (unweighted average). Excluding Indonesia and Philippines, this share exceeds 27 percent. China and India have shares of 25 and 27 percent respectively, both above the 9-country Asian average. This may augur an increasing role for these two countries in manufacturing, and a stronger position in international trade.

The machine building and transport equipment industry, in which the Asian LDCs are highly specialized, includes computers and other electronic products, telecommunications equipment, and motor vehicles—all high value-added products, and typically high-technology and science based. These latter features, combined with the relatively low prices and high product quality, make these products appealing to consumers in OECD countries. Another characteristic of the Asian LDCs is the speed of shift from less developed toward more industrialized

TABLE 13.4. *Contribution of the machine building and transport equipment industry within the manufacturing sector in the main LDCs, by region, 1988 (percent)*

Asia and Pacific		Sub-Saharan Africa		Latin America and the Caribbean	
China	25	Ethiopia	2	Argentina	14
India	27	Somalia	2	Brazil	21
Hong Kong	22	Senegal	6	Chile	4
Malaysia	23	Zimbabwe	9	Ecuador	7
Philippines	9	Kenya	12	Guatemala	4
Singapore	52	Ghana	1	Mexico	13
South Korea	32	Tanzania	9 ^a	Uruguay	10
Thailand	13	Malawi	3 ^a	Peru	11
Indonesia	3	Madagascar	5 ^a	Venezuela	11
		Zambia	14 ^a		
		Congo	4 ^a		
Average	22.9	Average	6.1	Average	10.6

^a Data refer to the year 1987.

Note: Regional averages are unweighted.

Source: Calculations by the authors based on World Bank data, 1991

economies, with a higher service component. In fact, strong industrial growth has stimulated the development of the service sector, including financial and insurance services and public infrastructure, development of which represents necessary steps in reaching the level of the industrialized economies.

In nine of the most important countries of Latin America, the contribution of the machine building and transport equipment industry to manufacturing value added was 10.6 percent in 1988 (unweighted average). However, some of these countries—Chile and Guatemala—have shares below 5 percent. The slow growth of the manufacturing sector underlying these figures was associated with industrial specialization in products that were not very productive in terms of value added (food and beverages, textile and clothing, paper and paperboard).

Finally, in sub-Saharan Africa the contribution of machinery and transport equipment industry to the manufacturing sector is very low, averaging about 6 percent, and in Ethiopia, Somalia, and Ghana it is 2 percent or less.

This picture may be supplemented by a look at the world's top 500 industrial firms as compiled by *Fortune* magazine. In 1989, the two largest companies based in a developing country were ranked 20th and 47th, respectively. These companies are Samsung and Daewoo, both South Korean, and both involved in electronics. At the 65th position is the Mexican company Pemex and at the 76th Petroleos De Venezuela, both in the oil industry. The top African company, Barlow Rand, ranked 108th, is based in South Africa and is involved in food production.

We have noted above that the indexes apt to characterize the stages of economic growth are many and varied. Our discussion has concentrated on the aspects of

TABLE 13.5. *Per capita use of steel, copper, plastics, and paper and paperboard in selected less developed countries, former Communist states, and selected industrialized countries, 1989 (in kilograms)*

	Steel	Copper	Plastics	Paper and paperboard
Developing countries				
China	61.9	0.5	2.6	14.4
India	24.0	0.2	0.8	2.6
South Korea	431.6	5.9	47.2	90.0
Taiwan	705.0	16.7	94.5	n.a.
Hong Kong	398.8	n.a.	87.6	162.1
Turkey	134.8	1.8	8.6	7.8
Indonesia	12.9	0.2	2.7	4.9
Malaysia	116.2	3.2	12.7	24.8
Philippines	35.8	0.2	4.1	9.1
Thailand	64.6	0.7	9.4	13.2
Brazil	84.5	1.2	10.2	26.6
Argentina	76.2	0.8	9.1	31.1
Mexico	83.7	1.5	11.0	40.5
Venezuela	138.6	0.5	15.4	34.3
South Africa	221.6	2.1	12.4	44.5
Africa excluding South Africa	18.5	0.0	2.1	2.3
Former Communist states				
Soviet Union	583.6	4.0	8.0	36.3
Czechoslovakia	706.1	5.0	38.3	75.3
Industrialized countries				
United States	412.5	8.8	65.2	307.5
Japan	757.7	11.7	58.2	221.9
West Germany	576.0	13.8	66.5	206.6
World	152.7	2.1	12.8	44.2

n.a. = not available.

Sources: Calculations by M. Fortis based on data from: International Iron and Steel Institute, 1990; Metallgesellschaft, 1979-89; Parpinelli Tecnon, 1987; FAO, 1979-89

growth having to do with the structure of production and with technology. To better understand a country's level of industrial development we consider the index of per capita use of raw materials and industrial materials (see Table 13.5). This index has several important advantages. The relevant data are readily available for LDCs whereas data on GDP, industrial production, and the like are scarcer or less reliable. The real (physical) nature of this index permits international comparison free of price and exchange rate complications. Finally, the raw materials and industrial materials are widely diffused in all manufacturing industries. Regarding this third

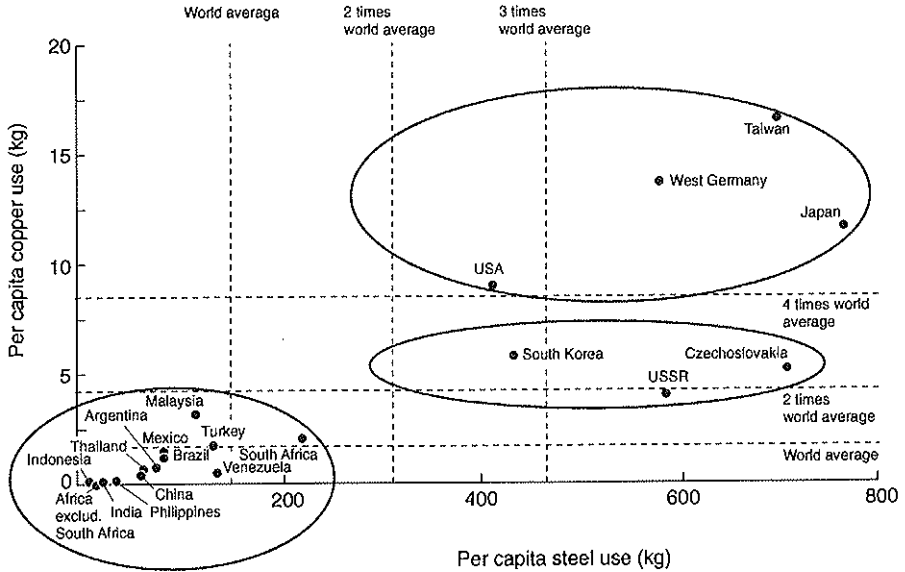


FIG. 13.3. *Per capita use of copper and steel in selected industrialized countries, former Communist states, and LDCs, 1989 (kg per capita)*

Source: Based on data in Table 13.5

aspect, the per capita use of copper and steel is a good indicator of the degree of development of the basic industries and of investment goods. In turn, the level of the per capita use of paper, paperboard, and plastics is connected to the stage of mass consumption and to the development of the service sector.

With reference to Figs. 13.3 and 13.4, we can identify three broad categories of LDCs. One category is composed of the East Asian Pacific Rim countries (Taiwan, South Korea, Hong Kong); they have a per capita use of these materials far above the world average. A second group consists of a number of Latin American countries (Brazil, Mexico, Argentina, Venezuela) and some Asian countries (such as Malaysia), characterized by a per capita use near or below the world average. In the third group are countries with a very low level of per capita use of such materials, including India, China, and, far below, all countries of sub-Saharan Africa (excluding South Africa).

According to their "age," we can distinguish four generations of raw and industrial materials. The first generation includes cotton, wool, and leather—materials mainly used during the "take-off stage of development" when new industries and related economic activities expand rapidly. The second generation includes wood, steel, zinc, copper, lead, and rubber—materials used especially in the automotive and appliance industries and in the radio-television industries. The heavy use of these materials is typical of the "stage of maturity" in development when techniques improve, the growth of new industries accelerates, and development of older

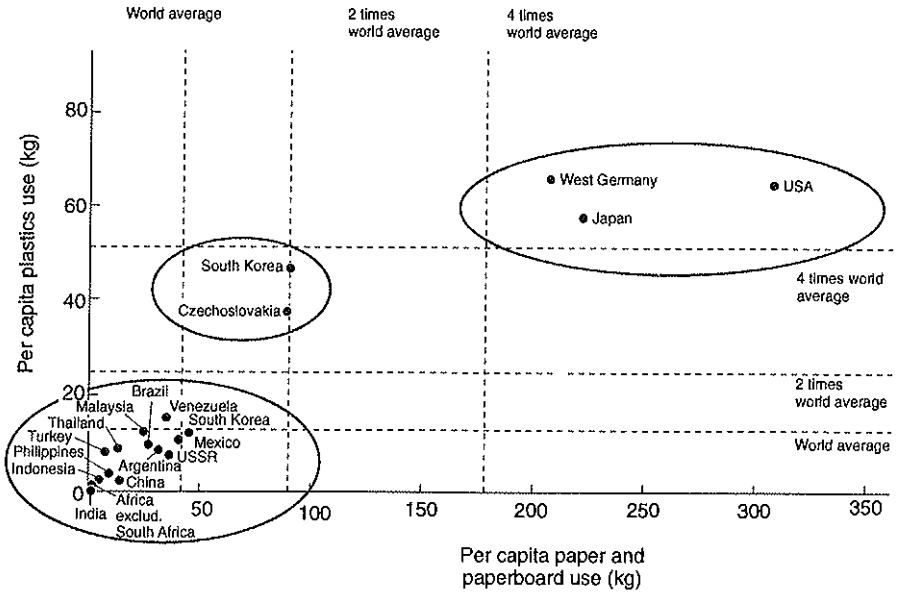


FIG. 13.4. *Per capita use of plastics and paper and paperboard in selected industrialized countries, former Communist states, and LDCs, 1989 (kg per capita)*

Source: Based on data in Table 13.5

industries levels off. The third generation includes aluminum, paper, paperboard, and plastics—materials widely used in the mass consumption stage of development, when the leading manufacturing sectors shift toward emphasis on durable consumer goods and services. Finally, the fourth generation includes the engineering plastics and carbon fibers, the materials of the 1990s, now increasingly utilized by the leading industrialized countries.

For the LDCs, the percentage share of total world use of these materials tends to decrease as countries move from the first to the third generation of materials; in the former Soviet Union and in the other former Communist states the shares are relatively high in the first and especially the second generation of materials and relatively low in third generation materials, so that we can observe a histogram resembling an inverted U; finally, the shares of industrialized countries in the total world utilization of materials are increasingly dominant as we go from the first to the fourth generation of materials (see Table 13.6 and Fig. 13.5).

The figures in Table 13.6 also show the relative position of LDCs, both within that group and vis-à-vis the industrialized countries. They demonstrate that the developmental distance even between the more advanced LDCs and the industrialized countries is enormous both in terms of quality and in quantity.

TABLE 13.6. Use of raw and industrial materials in selected less developed countries, former Communist states, and selected industrialized countries, 1986 (shares of total world use, percent)

	First generation materials (cotton, wool, leather)	Second generation materials (wood, steel, zinc, lead, copper, rubber)	Third generation materials (aluminium, paper and paperboard, plastics)	Fourth generation materials (engineering plastics, carbon fibres)
Developing countries				
China	14.6	5.4	4.7	
South Korea	3.3	1.9	1.6	
Taiwan	2.0	1.3	1.9	
Hong Kong	0.6	0.2	0.4	
India	6.2	2.1	1.3	
Turkey	2.1	0.7	0.5	
Brazil	2.8	2.4	2.4	
Mexico	1.3	1.1	1.0	
South Africa	0.6	0.8	0.7	
Africa excluding South Africa	3.9	0.9	0.9	
Former Communist states				
Soviet Union	13.6	16.9	6.4	
Czechoslovakia	1.0	1.1	0.8	
Industrialized countries				
United States	6.1	19.4	29.1	39.4
Japan	5.4	9.6	10.1	21.7
West Germany	2.3	5.3	6.4	
World	100.0	100.0	100.0	100.0

Sources: Calculations by M. Fortis based on data from: UNCTAD, 1989; FAO, 1990; International Iron and Steel Institute, 1990; International Rubber Study Group, 1991; Metallgesellschaft, 1979-89; FAO, 1979-89; Pulpinelli Tecnon, 1990; OECD, 1989

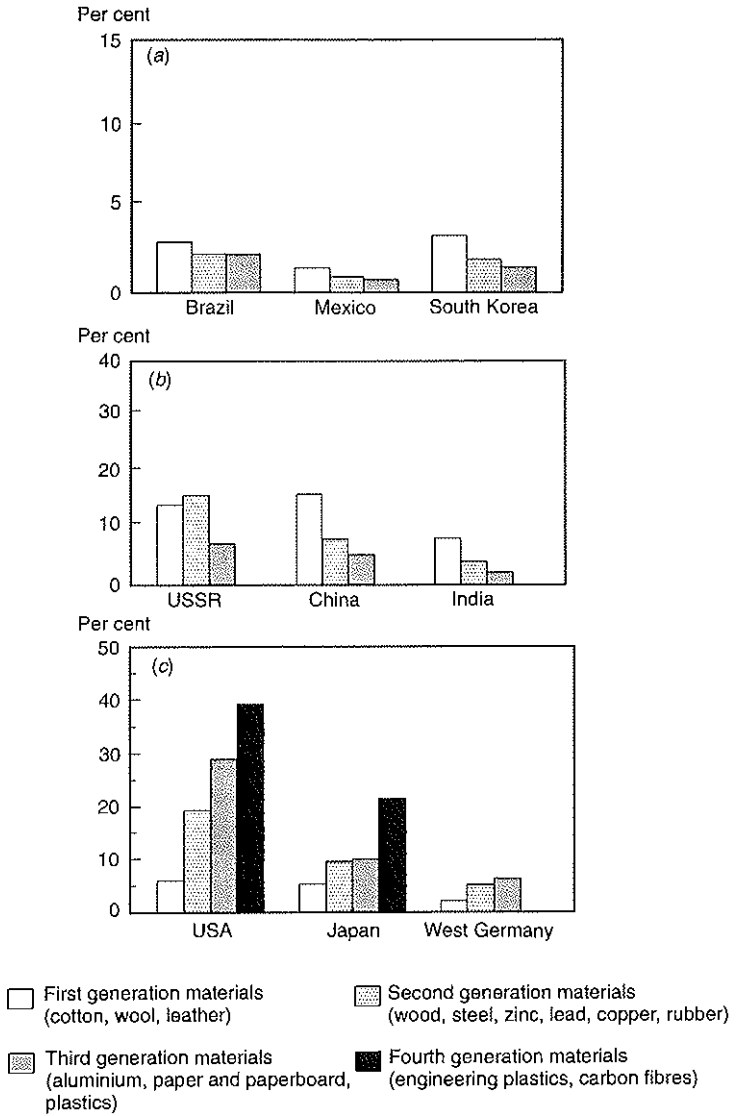


FIG. 13.5. *Use of raw materials and industrial materials in selected countries, 1986 (shares of total world use)*

Source: Based on data in Table 13.6

The Pattern of International Trade by LDCs

Examination of international trade patterns by LDCs further attests to the differences in structural change that have characterized these economies in the last 20 years. Three patterns of development may be distinguished.

Most of the Pacific Rim Asian LDCs have followed an export-led model, in which the development of manufacturing industries was oriented to the international market. The success of this policy, despite some forms of protectionism applied by several industrialized countries, is now widely acknowledged. In contrast, the majority of Latin American and Caribbean countries have promoted the import-substitution model of development, seeking to accelerate the industrialization process through a system of protective duties and other barriers to imports, thus presumably allowing an easier growth for strategic home industries. The patterns of international trade of sub-Saharan countries do not clearly identify any characteristic model of development: worried about self-sufficiency and stumbling from crisis to crisis these countries tended to be closer to the Latin American pattern of import substitution than to the East Asian pattern.

At the end of the 1980s in the LDCs of East Asia, more than 70 percent of international trade was made up of manufacturing products, with a remarkable increase of this share in both imports and exports between 1965 and 1989 (see Tables 13.7 and 13.8). In 1991 the four NICs combined (Taiwan, South Korea, Singapore, and Hong Kong) accounted for 8.7 percent of total world exports. This combined share was lower than the corresponding share of the United States (12 percent), West Germany (11.4 percent), and Japan (8.9 percent). The share exceeded, however, that of France (6.1 percent), the United Kingdom (5.3 percent), and Italy (4.8 percent). During 1965–89 the East Asian LDCs developed a specialization in the machine building and transport equipment industry, whose share has grown from 1 percent of total exports in 1965 to 22 percent in 1989. Imports of machinery and transport equipment also increased over the period (from a share of 28 percent of imports to 36 percent). This shift shows the emergence of intraindustrial relationships with the main industrialized economies. On the other hand, the strong growth of manufacturing industries caused a decline in exports of fuels and other primary commodities, from 89 percent of total exports in 1965 to 31 percent in 1989.

With a lag, South Asia appears to be following the same development course as East Asia, but with less stress on the machine building and transport equipment industry, which accounted for only 5 percent of total exports in 1989. The South Asian countries are involved mainly in manufacturing industries characterized by low value-added quotients, such as the textile and clothing industry, which accounted for 33 percent of total manufacturing exports in 1989. The composition of imports shows an increase in these countries' dependence on fuels, whose share rose from 4 percent of total imports in 1965 to 17 percent in 1989; and a decrease in food imports, from 25 percent of all inputs in 1965 to 10 percent in 1989.

During the last 25 years the countries of Latin America and the Caribbean have increased their manufacturing imports to more than 70 percent of total imports in

TABLE 13.7. *Structure of merchandise imports in the less developed countries, by region, 1965 and 1989 (in percent)*

	Food		Fuels		Other primary commodities		Machinery and transport equipment		Other manufactures		All merchandise imports	
	1965	1989	1965	1989	1965	1989	1965	1989	1965	1989	1965	1989
Sub-Saharan Africa	17	16	6	4	2	3	29	40	46	37	100	100
East Asia	17	7	9	9	8	10	28	36	38	38	100	100
South Asia	25	10	4	17	11	11	35	18	25	44	100	100
Latin America and the Caribbean	13	9	9	11	8	7	34	35	36	38	100	100

Source: World Bank, 1991

TABLE 13.8. *Structure of merchandise exports in the less developed countries, by region, 1965 and 1989 (in percent)*

	Fuels, minerals, and metals		Other primary commodities		Machinery and transport equipment		Other manufactures		All merchandise exports	
	1965	1989	1965	1989	1965	1989	1965	1989	1965	1989
Sub-Saharan Africa	24	53	69	36	0	1	7	10	100	100
East Asia	22	12	67	19	1	22	10	47	100	100
South Asia	6	6	57	24	1	5	36	65	100	100
Latin America and Caribbean	43	32	50	33	1	12	6	23	100	100

Source: World Bank, 1991

1989. In these countries the slowdown of manufacturing industries has been associated with an increase in imports of these products, so necessary to every type of economic development. The Latin American countries are specialized in exports of fuels and other primary commodities, which claim an aggregate share of 65 percent of their total exports in 1989. The remainder constitutes the export of manufacturing products.

Finally, in sub-Saharan Africa the virtually total absence of manufacturing industries has caused a strong dependence on all types of foreign manufacturing products. In 1989 such imports accounted for more than 75 percent of total imports. Nearly half of these imports involved machines and transportation equipment. Moreover, the dependence on the foreign mechanical industry increased during the period 1965–89, the share of such imports rising from 29 percent to 40 percent of total imports. The failure of the agricultural sector to take off has caused both a decrease in the share of the primary commodities exported (from 69 percent in 1965 to 36 percent in 1989) and an increase in the share of fuels, minerals, and metals (from 24 percent to 53 percent).

Conclusions

Our discussion has illustrated two fundamental economic phenomena: the wide differences between and within developing regions and the role of industry and manufacturing in the process of economic growth. Our main conclusion is that no process of growth can be sustained without a dynamic industrial sector backed by a solid agricultural sector. This is the reason our discussion has not considered the service sector. Of course many public services (such as education and health) are essential to industrial development, and many marketable services (e.g. tourism) can provide foreign exchange, but in a populous country the service sector cannot be at the core of sustained economic growth. Industrial sector growth also involves a crucial learning process with regard to techniques and to collective behavior. Concerning the latter, the saving and accumulation behaviors are especially important influences on economic growth as they represent crucial choices affecting the welfare of future generations.

Some East Asian countries have experienced remarkably rapid economic growth. Comparison with the past growth pattern of Japan appears appropriate, as some of these countries seem to follow a Japanese path of development. Some indexes also suggest that China and India are poised for rapid industrial growth in the next few decades in spite of their large populations. Other countries of Southeast Asia (notably Thailand, Malaysia, and Indonesia) are strong candidates to be the future NICs.

The stagnation experienced in Latin America is worrying, even if some recent developments are a cause for optimism. Within that region, of course, countries show a wide variation of patterns. The economies of Mexico, Venezuela, and Chile exhibit the following positive features: political stability, as a consequence of the fall

of military governments; reduction of domination of the state over the economy and the consequent liberalization through the creation of free trade areas; and increasing successes in reducing inflation and controlling public expenditures. These factors could produce in the short-to-medium run an increased influx of foreign capital, as some recent statistical data have shown. Other economies, such as Argentina's, are still stagnating while others, such as Brazil's, are experiencing a period of negative growth. Peru and Colombia continue to exhibit high inflation rates and low levels of international trade, and face heavy foreign debt burdens.

The gap between sub-Saharan Africa and other less developed regions has increased markedly during recent decades. The economic needs of this area are enormous and clear: a radical restructuring of the agricultural system through improved incentives and the introduction of modern techniques and greater allocation of resources to education being especially urgent tasks. Such objectives cannot be achieved unless governments strengthen their reform efforts. Some African countries are still beset by civil war, such as Somalia and Mozambique, but others, notably Sierra Leone and Gambia, are turning away from autocracy and state domination of the economy. Such political changes promote development.

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14 Population Change: The Status and Roles of Women

CHRISTINE OPPONG

This essay focuses on women's occupational, maternal, conjugal, and domestic roles and ways in which they are altering in the context of economic and population changes. The latter include labor migration, changes in infant, child, and maternal mortality, fertility, and the age structure of populations. The geographical scope is the developing world, where more than one and a half billion women and girls live. They belong to several thousand ethnic groups, with as many languages and systems of kinship reckoning and customary marriage, childbearing, and childrearing practices.

In spite of the rapid expansion of studies of women in the past decade and a half, relatively little is known about gender—the culturally defined roles and relationships of the women and men in different societies, in diverse marriage, family, and kinship systems, in communities, and in the household and other places of work. Nor can any coherent concept or index of the “status of women” be compared across a range of cultures (Whyte, 1978). Neither is there any universal pattern of male dominance or of male/female cooperation or segregation. Rather there is wide variation from culture to culture among and within different socio-economic groups, in the positions of women relative to men. Moreover, different aspects of women's status vary independently to a considerable extent.¹ It is clear that a number of economic and demographic changes are placing tremendous pressure on traditional female and male roles and that women are particularly vulnerable, as they try to cope with the conflicting reproductive and productive tasks and responsibilities confronting them, where old familial systems of cooperation and support are weakening and new ones are either not yet in place or being whittled away.

In the process of economic development family subsistence production diminishes and more and more is produced outside the family in specialized enterprises and needs to be bought by family members with cash. At the same time, physical protection, health care and education formerly provided by the family are to a greater or lesser extent taken over by public institutions or specialized private agencies causing radical changes in family relations (Boserup, 1990). Traditional solidarities of kinship and marriage, founded on sibling solidarity, filial piety,

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¹ Whyte (1978: 183–184) concluded that “there is no key barrier to the equality of women such that if it falls all other barriers will fall as well.”

parental authority and the potential substitution of family members, often tend to dwindle under the impacts of education, labor migration, wage employment, and self-employment, and the spatial and social mobility and growing individualism which these entail. Meanwhile inequalities based on sex tend to persist or be exacerbated in a variety of contexts and the current economic crises are curtailing opportunities for income and occupational security with profound effects on kinship, marriage and parenthood (Oppong, 1993a). This chapter examines some of the implications of such changes and the special vulnerability of women and the stresses they endure as these systems fail.

Productive and Reproductive Strategies

A common thread running through many of the studies of women's lives, in different cultures and time periods, is their strategies and struggles to combine reproduction and production; to bear satisfactory numbers of children (whether few or many) and then to maintain and rear them in culturally sanctioned and appropriate ways.² In this process women typically undergo multiple, often dangerous pregnancies, as well as prolonged and physically stressful infant nursing, and they battle, often without success, to provide sufficient shelter, food, medicine, schooling, and other necessities for their dependent children. This continuous struggle—to balance and combine potentially conflicting and demanding productive and reproductive tasks, under conditions of scarce resources—is, from relative youth to old age, the common fate of the majority of women.

Throughout the human evolutionary process the reproductive success of women has been linked to the kinds of assistance, support, and protection they have attracted from various categories of others (Irons, 1983). Women's main strategies for assuring themselves of such assistance have been established systems of reciprocal exchange with the fathers of their children or their current partners and with their kin (mainly mothers, sisters, aunts, older daughters). The early ethnographic record of the variety of forms of domestic organization, kinship, and marriage testifies to the cross-cultural diversity of these systems of exchange. They are ultimately concerned with the reproduction and rearing of the next generation of young and the transmission of the cultural and material inheritance.³ Mothers increase the resources available for parenting, through residential and affective attachment of spouses and

² These reproductive strategies employed are increasingly being examined in an evolutionary framework (e.g., Betzig, 1988). Historians and anthropologists have documented a diverse range of culturally sanctioned infant care, ranging from detached, passively infanticidal and even sadistic to the most intense personal bonding, attachment, continuous solicitude, and sacrificial altruism (e.g., Scheper-Hughes, 1987). Profound changes in these modes of care over time have been observed in the process of socioeconomic development (Stone, 1977).

³ There has long been detailed evidence of the complexity and diversity of systems of kinship, marriage and domestic organization across cultures and through time (e.g., Radcliffe-Brown and Forde, 1950; Fortes, 1962; J. Goody, 1972). Such diversity is increasingly being taken into account by population scholars (e.g., Desai, 1991).

kin, including through fostering arrangements.⁴ Women in different time periods and cultures have also adjusted numbers and timing of births and the ways in which children are reared, to contextual constraints and cultural values. This has been on the one hand of necessity—according to the resources they have available for child support and care, including food supplies, which are often subject to seasonal scarcity.⁵ On the other hand when feasible it has been by choice—according to the preferred life options open to children in adulthood.⁶ Different cultural styles of child care, typical of different ethnic groups, socioeconomic strata and educational levels, are associated with varied child development outcomes, including survival rates (e.g., Bicego and Ties Boerma, 1991; Caldwell, 1990).

Various strategies have served to promote devotion of male as well as female energy and material resources to reproductive success and long-term investment in the development of the next generation. These have often involved strict controls by senior generations over the sexuality and procreative powers of adolescents and young adults by a variety of means, including puberty ceremonies and marriage transactions. The latter in some regions have involved protracted bride price payments and the sexual protection of potentially vulnerable and nubile females, through spatial segregation of the sexes or precisely monitored relations.⁷ These widespread systems of control and protection, focused upon young girls and motherhood and the birth and care of infants, have frequently been facilitated by coresidence or close proximity of the parental with the grandparental generation and have promoted care and socialization of the youngest by two generations of adults.

Among the still widespread but declining customary methods for promoting healthy child development through ensuring adequate birth spacing and controlling conception are the strict observance of postpartum sexual abstinence for mothers with nursing infants and suppression of ovulation and postponement of conception

⁴ Fostering of children by nonparental kin is an increasingly well-documented mode of sharing and delegating maternal responsibilities, as is sibling-caretaking. See, for example, earlier ethnographic work (E. Goody, 1978; Weisner and Gallimore, 1977) and more recent analyses based on survey evidence (Page, 1989; Desai, 1991), and studies which have demonstrated the function of fostering in containing potential conflict between women's work, childbearing and rearing over the life cycle (Blanc and Lloyd, 1994).

⁵ For example, see De Garine and Harrison, 1988 on food scarcities, security, and uncertainties according to fluctuations and seasonality in supplies and differential allocation in households by sex and age. Loosening of traditional kinship and community ties, and the melting away of the associated moral dictates diminishes the capacity to cope with scarcity.

⁶ As Irons (1983: 170) describes this process from a neo-Darwinian perspective, "they reduce the number of children born and increase nurturing per child when they can gain genetic representation in future generations by doing so. When they can gain by the reverse strategy, they increase the number of children born and reduce parental investment per child." For an African example of the former in urban, educated contexts see Oppong and Abu, 1987.

⁷ For example with regard to sub-Saharan Africa, Lesthaeghe (1989: 22) writes, "Gerontocratic control and its correlate, polygyny, not only lead to post-partum abstinence and child spacing, but also account for specific characteristics of the use that is made of the overall reproductive age span. . . . [A] gerontocracy restricts the rights of younger men who have to await their turn before being granted official access to the procreative and productive capacities of women."

through intensive and prolonged breastfeeding (e.g., Adekun, 1983 on sub-Saharan Africa). These traditional practices both protect maternal investments in children and facilitate women's continued participation in production, especially food production and processing.

These systems of intergenerational monitoring and support for sexual relations and procreation and spacing of births have been subject to erosion in many regions and communities, as the traditional institutions of kinship and marriage, and the rituals, practices, and sanctions upholding them have withered.⁸ Indeed, the solidarities and moral bonds of these institutions are visibly disintegrating in the face of profound spatial and social movements of people; both voluntary, as migrant laborers seek new sources of sustenance, and involuntary, as in the case of refugees from political and environmental crises and famine. Migrations occur as traditional resources are seriously stressed, appropriated, diminished, or no longer suffice for rapidly growing populations, many of which are doubling in size every two decades.

The historical record is replete with the evidence of what can be the demographic outcomes when customary controls exercised over sexual congress break down and when females with inadequate support from partner, kin, or community feel forced by economic circumstances to put survival of self or the group above the health and welfare of individual infants. Abortion, abandonment and child neglect, precipitating infant and child mortality, have been documented on all continents and many time periods, correlated with periods of economic crisis.⁹

Somber Statistics: Deprivation and Discrimination

Globally more than a billion people live in absolute poverty, and income per head has even declined over the past decade in Latin America and sub-Saharan Africa (UNDP, 1991: 24). There is evidence that in the global accounting of these deprivations women and girls fare worse than their male counterparts, in spite of the heavier demands of the physically taxing, biological as well as economic, aspects of their roles.

The global statistics recently compiled by United Nations agencies on women's lives are incomplete and partial and in some instances based on guesstimates (UN,

⁸ See, for example, Mabogunje, 1981 on the effects of the breakdown of traditional birth spacing practices in Africa.

⁹ See United Nations (1987: 15) regarding the situation in Europe during the seventeenth to nineteenth centuries. Many examples of infant and child abandonment and child neglect are cited as in working mothers often leaving babies alone for long periods, resulting in their illness and death. Such events have been apparent particularly at harvest time when maternal/occupational role conflicts become intense. Recent studies of high risk mothers with low-birthweight infants have identified such crucial factors as lack of conjugal and kin support and lack of use of available community services for mothers and children (Newman, 1987). Scheper-Hughes (1987) has described among deprived and powerless shantytown mothers of northeast Brazil apparent detachment and indifference toward infants judged too weak to survive.

1991c). They do, however, provide a unique compendium of economic and demographic facts recorded during the past two decades. They accordingly set broad parameters of continuity and change concerning birth, marriage, work, poverty, and death. They document women's major responsibility for family care and household work and management, and their heavy and increasing economic burden of work both outside and inside the home. High levels of maternal morbidity and mortality, high rates of infant and child loss, and the persistence of child/teenage marriage and motherhood form part of the picture.

In addition evidence has accumulated of continuing discrimination of all kinds against girls, including physical neglect, leading to inflated female mortality rates and even female infanticide in some regions, notably in Asia.¹⁰ A growing number of studies have documented the differences in the amounts of food and medical attention invested in daughters and sons.¹¹ In the case of education, the gaps are huge. This is so in spite of the fact that women have made considerable progress over the past 30 years, with levels of education for women in developing countries steadily rising, especially at the primary school level (UNDP, 1991: 26).¹² Three-quarters of women aged 25 and above in much of Africa and Asia remain illiterate, however (UN, 1991c: 45); and in some countries the already low enrollment rates are stagnating.¹³ In developing countries as a whole female enrolment in education is 44 percent, 40 percent, and 37 percent at primary, secondary, and tertiary levels (Ballara, 1992: 8).¹⁴ The gap between girls' and boys' schooling following the onset

¹⁰ Indeed, the mortality bias against females is in some countries such that a rough estimate has been made of 100 million females "missing" in south and west Asia and China. Given the greater natural resistance of females to disease in populations in which girls and boys receive similar treatment, there are about 106 females for every 100 males in societies that do not practice systematic life-threatening discrimination against girls. Waldron (1987) has reviewed the patterns of sex differences in mortality for children in developing countries and has analyzed evidence concerning the possible relationship with sex discrimination. Data reviewed have shown infant mortality to be slightly higher or equal among females in a few countries stretching from southern Asia through western Asia to North Africa; in these regions too there is excess mortality among females aged 10-14. Among young children aged 1-4 there is evidence of higher female mortality in a number of developing countries in Africa, Asia, and Latin America.

¹¹ Regarding household allocation of food in South Asia, see Behrman (1990) on the favoring of boys over girls. The geographical pattern of the sex ratio is not perfectly reflected in data on nutrition, morbidity, and access to health facilities. Explanations using Indian evidence have variously emphasized women's roles in agricultural production and the labor force, kinship systems, and property control, and differential access to food and health care (e.g. Miller, 1981; Basu, 1989; Kishor, 1993). Svedberg (1990) and others have not found such domestic discrimination in sub-Saharan Africa.

¹² In 1985 there were 597 million illiterate women in contrast to 352 million illiterate men. By 1990 there were still 948 million illiterates in the world—917 million in developing countries, the majority women, with projections indicating only a slight decrease by the end of the century unless efforts are intensified (Ballara, 1992: 4).

¹³ In sub-Saharan Africa some countries have very low rates. Burkina Faso, Ethiopia, Guinea, Mali, Niger and Somalia enrolled only 20-40 percent of children in 1987. In the past decade enrolment rates stagnated or fell in countries hitherto performing well. For example, in Tanzania gross primary enrolment rates fell from 93 percent in 1980 to 66 percent in 1987 and in Zaire from 94 percent to 76 percent (UNDP, 1991).

¹⁴ In the least developed countries in the mid-1980s fewer than half the school-age girls were enrolled in primary school, less than 10 percent in secondary education, and less than 1 percent at the post-secondary level.

of puberty is aggravated by the extent to which girls drop out of, or are removed from school for reasons of pregnancy, marriage, or economic need (e.g., Yeboah, 1993 on Africa).

Schooling has potentially profound impacts on the ways in which mothers and fathers perceive and care for their young, and gaps between girls and boys in educational enrollment have significant enduring effects in terms of the human development of the next generation.¹⁵

Comparative country evidence to demonstrate the dimensions of the resource and opportunity discrimination gap between females and males has been provided by the construction of the gender-sensitive Human Development Index (HDI).¹⁶ The indexes demonstrate that for individual countries gender disparities in access to resources have been narrowed in such areas as education and health, but in developing countries female-male disparities continue to be very wide and the female index is still less than two-thirds the male HDI in many countries. Inequalities between males and females are frequently reinforced by laws that are now being more systematically analyzed as institutional barriers to economic empowerment of women (e.g., Martin and Hashi, 1992).

Pressure to rectify this imbalance is growing, not only among those concerned to safeguard human rights and to promote equality of opportunity and treatment for women and men, but also in population forums, given the serious demographic implications.¹⁷ For there is mounting evidence of the extent to which investments in girls and women—nutritional, medical, educational, monetary—not only affect family welfare but also levels of mortality and fertility and are linked to current global issues of population and development (UNFPA, 1989b).

A recent World Bank Report on *Gender and Poverty in India* (1991a) provides the kinds of telling evidence currently being amassed. Like several preceding country reports it has shown just how pervasive and deleterious sexual discrimination can be and how it is linked to low levels of economic development, continuing impoverishment and failure to achieve population policy goals. The study shows that in spite of their invisibility in statistics—a “statistical purdah”—

¹⁵ Countries which achieved near universal primary education for boys in 1965, but in which enrollment rates for girls lag far behind have about twice the infant mortality and fertility rates 20 years later of countries with a smaller gap (World Bank, 1991b: 55).

¹⁶ The UNDP *Human Development Report* of 1990 proposed a Human Development Index (HDI), which combined national income with two social indicators—adult literacy and life expectancy—to create a composite measure of human progress. In 1991 it was modified. The HDI attempts to reflect how economic growth translates into human well-being (UNDP, 1991: 15). To create the gender-sensitive index, separate female and male estimates for life expectancy, adult literacy, mean years of schooling, employment levels, and wage rates were used. This was introduced and updated in the annual *Human Development Reports* of UNDP (1991, 1992). By 1992 only 33 countries had adequate data for making these calculations. This exercise revealed wide disparities in many developing countries. For example, the female HDI is only half that of males in Kenya, two-thirds in the Republic of Korea, and over three-quarters in the Philippines (UNDP, 1991: 17).

¹⁷ For example, the International Forum on Population in the Twenty-First Century, held in Amsterdam in 1989, recognized that “women are at the center of the development process and that the improvement of their status and the extent to which they are free to make decisions affecting their lives and that of their families will be crucial in determining future population growth rates” (UNFPA, 1989a).

women are vital productive workers in the Indian economy, working in agriculture, dairying, forestry and the urban informal sector. Their economic activity is especially important for the estimated 60 million households below the poverty line. Indeed, there is clear evidence that the poorer the family, the more it depends for its survival on women's work. In addition, women bear children and have the main responsibility for childrearing, household welfare, and maintenance. The report demonstrates, however, that India invests far less in its women workers than in its working men. Women also receive a smaller share of what society produces in terms of health care, education, and productive assets, which could increase their incomes. Female infants are even weaned earlier. The outcome of discrimination includes higher female mortality and morbidity rates. This evidence demonstrates that gender discrimination has significant implications for both human and national development.

This report and many others demonstrate that if economic and demographic goals of households and states are to be achieved, goals whereby economic resources and people are to achieve a more harmonious balance; if the toll of high levels of infant and maternal mortality are to be reduced; if dire poverty and the suffering it entails are to be alleviated, then women need fairer shares of resources—nutritional, medical, educational, technical, monetary, agricultural, productive—to enable them more effectively to carry out their productive and reproductive tasks and fulfil their multiple responsibilities.¹⁸

Women's Work

In the past two decades women have begun to be employed more often outside the home, though in less secure, lower paid, lower status jobs than their male counterparts. This has occurred to such an extent that a trend to feminization of the global labor force has been observed. Sex segregation of labor markets and male domination of workplaces are pervasive. Women and girls are still seriously under-represented in scientific, technical, and vocational education, training, and employment. They have unequal access to machinery, tools, credit, and the like and wage discrimination persists.

In sub-Saharan Africa and southern Asia, women continue to be recorded as economically active well into old age. Proportions of women in the service sector and industry vary from region to region, being highest in the newly industrializing countries of Asia. Whereas economically active women in Latin America and the Caribbean were more likely in the 1980s than men to be in wage employment (62 percent of women, 56 percent of men), less than half that proportion are wage or salary earners in Africa (UN, 1991c:88). In fact, most women in Africa and Asia still work in agriculture. Indeed, African women are estimated to produce and process the bulk of food crops. As men migrate in growing numbers to cities and towns for

¹⁸ See UNFPA (1989b), *State of the World Population Report*.

wage labor, women left behind in rural areas in many countries become the primary agricultural workers.¹⁹

Cuts in government spending resulting from stabilization and adjustment policies have disproportionately pushed many women out of salaried public sector employment (UN, 1991c: 95).²⁰ Simultaneously cuts in public services—including maternal and child health and education—have hit women hard. Many have had to increase their hours of work just to ensure family survival.

Unable to find opportunities for wage employment or needing income from activities that can be combined with child care, many women are own-account and informal sector workers involved in petty trade, home-based production and services, especially in sub-Saharan Africa, southern Asia and Latin America (e.g. UN, 1991c; UNECLAC, 1993a). Much of women's economic activity is very labor intensive and accordingly back-breaking and energy consuming. Such activity depends, of course, heavily on the assistance of children. In the past decade incomes from women's informal sector work have formed an increasing proportion of total family income and have become increasingly important for survival (UN, 1991c: 92).²¹ Profits in such small-scale enterprises tend to be low, however, and job security negligible (ILO, 1987: 130). Moreover, a variety of familial constraints tend to hinder women's business expansion.

Even where hours women spend on paid activities are equivalent to those of men, women spend many more hours than men in nonmarket, unpaid domestic activities.²² Under conditions of environmental degradation such critical subsistence activities as carrying water and fuelwood become more and more arduous and time-consuming. Regional evidence compiled on the increasing scarcity of potable water and fuel wood and fragmentary evidence available of women's time use patterns, in conditions of drought and fuel scarcity, indicate the dimensions of this problem, both globally and for individual women and their dependent families.²³ Such stress affects

¹⁹ At the 1992 Geneva Summit on the Economic Advancement of Rural Women, the International Fund for Agricultural Development (IFAD) reported that the number of rural women living in poverty had increased by almost 50 percent in the past two decades—to 374 million in Asia, 130 million in Africa, 43 million in Latin America and the Caribbean, and 18 million in the Near East and North Africa. This was attributed not simply to rapid population growth but also to the sharp jump in the number of female-headed households. IFAD asserted that while poverty among rural men has increased over the last 20 years by 3 percent, among women it has increased by 48 percent. Sub-Saharan Africa is identified as the region with the largest proportion of female-headed households.

²⁰ In all developing regions the growth in female labor force participation of women aged 25 to 44 that took place in the 1970s and 1980s appears to have been undercut by economic recession (UN, 1991b). In Africa the growth in the formally documented female labor force has dropped behind population growth, indicating the extent to which economic recession and unemployment is affecting women (ILO, 1991).

²¹ Even women in purdah, together with their children, may be contributing a substantial and officially unrecorded proportion of goods and services (e.g., Pittin, 1987 on Northern Nigeria).

²² See the global evidence used as indicators on time-use in UN (1991b: 101–102). Unfortunately this evidence is nearly all from industrialized countries. Only five developing countries have data sufficiently complete to be included. Hours spent in 10 countries in drawing and carrying water have been tabulated (UN, 1991c: 75). They range as high as 17.5 hours per week and show that hours spent may increase fivefold during the dry season when water is scarce.

²³ See, for example, Cecelski, 1987 regarding the rural energy crisis and women's work. The biggest differences between male and female hours spent on work occur in Africa, Asia, and the Pacific, where

women's time and energy available for breastfeeding, for weaning infants, for child care and use of whatever health and social services are available.²⁴

Problems of definition, concepts, methods of data collection and the unavailability of censuses and surveys, mean that much of the data on women's economic activity in the developing world is based on guesstimates (e.g. Anker, 1994 on sub-Saharan Africa). Such are the serious continuing gaps in official records, that women's labor, including domestic, nonmarket work—supporting survival for so many dependent children and the aged—remains virtually unaccounted for in national statistics, to a far greater degree than the parallel neglect of men's urban, informal sector and agricultural labor (e.g. Goldschmidt-Clermont, 1991). Consequently, much of women's work not only remains invisible but is neglected by population and development planners, in spite of nearly two decades of heightened concern and increased statistical activity. For if governments lack reliable information on women's economic activities, and the kin-based production systems within which many of these activities are performed, they are unlikely to formulate efficient economic policies that take women and their work into account (Dixon-Mueller and Anker, 1988). This oversight deprives women workers of potential incentives or possibilities for technical innovation, increased productivity or alternatives to labor-intensive tasks. It also may have subtle and profound demographic impacts. These include a press for high fertility and the infant and maternal mortality this entails, when coupled with material deprivation and harsh labor regimes (Palmer, 1991).

As in the case of the statistical evidence on economic activity, the evidence on migration for employment, both national and international, is also more deficient regarding females than males, although the issue has recently become the focus of growing international concern.²⁵ Indeed a striking response to unemployment in developing countries has been the entry of women into international labor markets as contract laborers, many as first-time job seekers. This makes a significant feature of economic adjustment processes the increasing feminization of international migration flows. Deregulation of labor and measures to cut costs have increased

micro-studies have demonstrated that women average 12 to 13 more hours of work a week than men. In fact in many developing countries, hit by recession and harsh structural adjustment policies, women now work 60 to 90 hours a week, simply trying to maintain the survival levels achieved years earlier (UN, 1991c: 95).

²⁴ Carr and Sandhu (1987: 38) write, "The overwhelming picture coming out of the available data on women's time and energy allocation is one of constantly competing demands on women's time and of an unyielding round of energy-consuming, dreary . . . tasks. Together the studies reviewed seem to make a convincing case for the introduction of technology packages which would lighten women's load and increase the productivity of their labor, and this indeed has been a strong recommendation arising out of many of the individual case studies." Surprisingly there is little systematic evidence on the impact of the introduction of new simple technologies on women's time use and family welfare.

²⁵ See ILO Labor Report 3 (1987: 129): "Despite a common misconception to the contrary, women constitute a majority of rural-urban migrants in many developing countries, and many teenage girls enter the urban economy through low-level, low paid and insecure forms of employment." See UNECLAC (1992: 103) on rural-urban migration in Latin America. The theme of the UNFPA 1993 on The State of the World Population is migration. In this the gender dimension is highlighted *inter alia*.

opportunities for casual employment. Changes have been such that between 1970 and 1987, 48 percent of people counted outside their country of birth were women (Zlotnik, 1992).

Women and girls who migrate for jobs unaccompanied by husbands or relatives are especially vulnerable to abuse, both economic and physical (Oppong, 1993*b*). A number of studies have highlighted these issues.²⁶ For increasing numbers of the most vulnerable and exploited women workers, often international migrants, economic activity falls into the category of commercial sex work, most dangerous for health in view of the rapid spread of HIV/AIDS. For some women, becoming a domestic or sex worker is a form of target migration, endured for a time for the family's sake and the remittances of income sent home.

The accelerated movement of foreign workers to resource-rich countries of Europe, northern Africa, and western Asia and the movement of workers within sub-Saharan Africa have resulted in the widespread escalation of the numbers of potentially vulnerable women. There are large foreign-born populations of unaccompanied migrants in many countries, with attendant serious economic and social pressures and potential opportunities for discrimination (Adepoju, 1991). These situations highlight local needs for development and employment creation (Böhning, 1991).

Labor migration is frequently examined in terms of macro-economic impacts. However, the effects in terms of marriage delays and separation of spouses clearly have profound and widespread implications for the assumption of parental responsibilities and child survival and development; for the maintenance of monogamy and reproductive health; for family income and stability; and for the spread of sexually transmitted diseases.²⁷

Wives and Mothers too Soon

Societies differ widely in the timing of the end of the life stage concerned mainly with learning; that is the stage from birth until giving birth or begetting, which is correlated with years of schooling. Women's age at marriage and literacy levels are closely associated. Todd (1987) has argued that the degree of cultural advancement of any human group is connected with the length of this learning process. Since females as mothers characteristically pass on comparatively more of their available resources to the next generation, their levels of schooling and other resources have

²⁶ See ILO (1987: 129) regarding the vulnerability of migrations. Regarding the often exploitative conditions of work and life of migrant women in domestic service, see Weinert (1991). UNFPA (1993) has underlined the kinds of abuses which have been documented—both economic and social—and has stressed the urgent need for protective measures and concerted legal intervention at the national and international level, a task in which the International Labor Organization, among others, is becoming increasingly involved.

²⁷ See Carael, 1992 and Gordon and Kanstrup, 1992 and the deliberations of the Expert Group meeting on the Feminization of Internal Migration, organized by the UN Population Division in Mexico, October 1991.

many measurable, direct effects upon child survival and well-being, impacts that are observed in all major developing regions (Cleland, 1989).

Teenage marriage and teenage childbearing are the norm for women in many developing countries. Nearly half of African girls, 40 percent of Asian girls, and 30 percent of Latin American girls are married by age 18. In the extreme case—Bangladesh—more than one in five girls have borne a child before reaching age 15, and the majority have borne a child by age 18 (UN, 1989: 11). In most countries of Latin America, the Caribbean, and Africa more than 10 percent of all births are to teenage girls. Early teenage marriage and childbearing are linked to illiteracy, truncated school attendance, and low levels of training and restricted employment options for girls, as well as to high rates of maternal disability and death, caused by too early pregnancy and childbearing. They are also closely associated with high levels of both infant births and deaths. In a large number of developing countries child marriages for girls are still common, even where laws set minimum ages for entry into legal marriages (UN, 1989: 1). Given the inadequate diets of most pregnant girls, not to mention the pervasive lack of available prenatal health care, the adverse physical consequences for child mothers are frequently very serious.

In Africa among unmarried, educated, urban girls, often unsupported by family, there is rising incidence of unwanted and unintended pregnancies. These result in births to immature girls, who have neither husbands nor mothers, nor other kin or affines to give them and their infants the support and care they need. A recent review of evidence on adolescent fertility in Africa and Asia, where trend data exist for the 1970s and 1980s, showed rising rates in 15 countries including Liberia, Malawi, Bangladesh, and Yemen, where rates are already high (over 150 births per 1,000 teenage girls aged 15–19) (UN, 1989; Population Reference Bureau, 1992).

Teenage motherhood is also on the rise in Latin America and the Caribbean, and in this region these are likely to be unmarried girls (UNECLAC, 1991: 15). In nine Latin American and Caribbean countries, 30 to 50 percent of girls in their teens bear a child (Singh and Wul, 1991). Births to teenage girls and especially those with no husbands have ill effects on the health of the girl-mother and her baby, and on educational and employment opportunities (UNECLAC, 1993*b*: 66). In the Caribbean, school drop-out rates and unemployment rates among teenage mothers are very high. The outcome is often abortion or child abandonment. There is mounting evidence from urban areas in all regions of deviant forms of maternal behaviour such as baby dumping and high mortality among teenage mothers, as teenage girls become mothers too soon, not infrequently as a result of sexual coercion and exploitation.²⁸ Moreover, teenage mothers are recognized as reproducing cycles of poverty from one generation to the next. There is a generally widespread expression of anxiety by many governments about high levels of adolescent fertility,

²⁸ It has been noted in global analysis as well as individual case histories that child abandonment occurs more often in situations where customary kin solidarities have been most eroded and fostering of children by nonparental kin is not practiced (UN, 1987: 15).

particularly in so far as too early childbearing is not only linked to infant deprivation of several kinds but also cuts short girls' opportunities for education, training and employment.²⁹ There are considerable differences from country to country and in various culture areas regarding national policies and programs related to teenage pregnancy, including the provision of support mechanisms to enable teenage mothers to continue and complete their schooling.

Given the widespread sex biases in the collection of statistics—with their focus on females' reproductive and males' productive activities—there is little evidence of the effects of adolescent fatherhood on boys (UN, 1989: iii). On the whole men tend to be older at marriage and parenthood, with age gaps of a decade or more between spouses quite common, especially in Africa. Implications of this age gap include greater likelihood of inequalities and dependence for young wives and increased likelihood and duration of widowhood. Life-cycle analysis reveals that large proportions of women past the age of 45 live alone with their children (UN, 1991c: 15). In Africa and Asia, 30 percent of women past age 45 are widows. The risk of widowhood increases the demand for children to provide company, maintenance, and support in mother's old age.

In Africa, the Caribbean, and Latin America increasing proportions of men are not marrying the women with whom they beget children. Their subsequent neglect of the children means that there are increasing numbers of mothers alone in all age groups struggling to cope with parental responsibilities (e.g. UNECLAC, 1991: 15).

In the past two decades, the proportion of adult women without husbands has increased in all regions, both divorcees and single women. Many individual women have testified to the increasingly widespread breakdown of relationships between women and men. The proportion of men without wives has increased everywhere except in Africa, where for men remarriage after divorce and polygyny remain norms.

Domestic Groups and Family Size

Declines in household size are widespread in all regions other than north Africa and west and southern Asia. Households in developing regions are larger than those in the developed world, because of both high fertility and kin coresidence. A notable worldwide phenomenon is the growth of female-headed or female-maintained households, which make up 20 percent or more of households in different parts of Africa, Latin America, and the Caribbean.³⁰ Many household heads are elderly

²⁹ In the United Nations Sixth Population Inquiry, among governments of 54 countries responding on this issue 44 indicated concern and 17 of the 21 countries with especially high fertility rates for ages 15–19 (more than 100 births per 1,000 women of that age) replied that adolescent fertility was a source of major anxiety. In all regions, concern was expressed that adolescent childbearing would impair girls' educational opportunities (UN, 1989: 32).

³⁰ See, for example, UNECLAC, 1991 and Folbre, 1991.

women. In Africa about half the women household heads are widows. Others are mothers separated from their partners by labor migration or desertion. Still others are unmarried teenage mothers.

At least 20 to 40 percent of the Latin American region's households are headed by women, usually young women who accordingly represent one of the most vulnerable groups of women in the region and have greater difficulty in fulfilling their maternal roles (UNECLAC, 1993*b*: 65–66). Teenage mothers are one of the most visible categories of single-parent households. Their number is increasing in the region and they combine the precarious position of head of household with extreme youth and poverty.

Female-headed households tend to be poorer than those with both partners present. The evidence for the Latin American and the Caribbean region clearly show that female headship has a negative effect on child welfare (UNECLAC, 1991: 17). There is some evidence that a greater proportion of resources in female-controlled households is directed toward the daily needs of dependent children and that the latter may be better served when several adult females coreside.

Maternity

During the past two decades total fertility in the developing world fell from 5–7 births per woman to 3–6. For the least developed countries, especially in Africa, declines have been slight or nonexistent and the average remains over six children. In Asia, the average total fertility rate dropped from 6.1 to 4.6. In Latin America and the Caribbean, total fertility has declined from 5.5 to 3.6 births. In Latin America and the Caribbean, there are also marked urban/rural differences in fertility. More urban women are engaged in wage employment there, in types of economic activity incompatible with child care—a conflict related to a lowering of customary family size aspirations and to more widespread adoption of both modern and traditional modes of controlling births.

Breastfeeding, intense and unsupplemented, is nature's way of ensuring child development and natural birth spacing. It is, however, taxing for poorly nourished mothers, and is difficult to combine with excessive hours of manual labor and economic activities located at a distance from the home.

In Africa 90 percent of mothers are estimated to be still breastfeeding at six months, but the intensity and duration of the practice are declining. This decline is due to an array of factors, but especially mothers' work schedules, which frequently involve separation of infants and nursing mothers with consequent deleterious impacts upon child survival, development, and natural birth spacing. Ethnographic evidence has indicated the significant links between breastfeeding, weaning practices, and mothers' workloads.³¹ However, contemporary attempts to trace such connections are fragmented and comparative analyses is seriously hampered by the

³¹ See, for example, Nerlove's (1974) analysis of Human Relations Area Files.

inadequacy of cross-national survey data on women's work (Lloyd, 1991). There is also a dearth of descriptive field studies of mothers' and babies' and other caretakers' interactions in natural settings.³²

Controlling the spacing and stopping of childbearing has become much easier with the spread of modern contraception. Acceptance and availability of these methods are uneven, however. In the 1970s and 1980s the World Fertility Survey and subsequently the Demographic and Health Survey data showed that large numbers of women said they did not want more births, but were not using any form of modern contraception, for a variety of reasons, including inaccessibility and costs and conjugal constraints.³³

Maternal mortality is among the leading causes of death among women of reproductive age in most of the developing world.³⁴ The highest rates occur in sub-Saharan Africa. Figures of up to 1,000 maternal deaths per 100,000 live births have been reported in several rural areas and rates of over 500 in some cities. Given the persistently high fertility rates in the region, an African woman's lifetime risk of dying from pregnancy-related causes is often greater than 1 in 20, or 100 times higher than rates in the wealthiest developed countries. In South Asia the maternal mortality rate is also very high, with recorded rates of 600 in rural Bangladesh and nearly 900 in parts of north India (see Royston and Armstrong, 1989).

Overall, mortality from pregnancy-related causes is estimated to account for half a million deaths a year and is crucially linked to lack of resources for pregnant women. The lack of maternal and child health services is particularly acute in rural areas. Malnutrition also threatens women's health, particularly during pregnancy and lactation. This problem is noticeably aggravated by sex-linked biases in access to nutritious food, observable in some parts of Asia. Anemia is known to be a contributing factor, and iron deficiency is especially common in southern Asia and parts of Africa.

Abortive mortality worldwide is estimated to be between 100,000 and 200,000 women per year (WHO, 1991a: 9). This is so because many conceptions are not planned or wanted, since they occur too early, too closely spaced or too late in the reproductive cycle and lack support from partners or kin. This is one time-worn and

³² Among the few exceptions are Winikoff and Castle (1988) and Vitzhum (1988), who notes: "For most populations little is actually known about the practices surrounding infant nutrition and the modifications in diet and behaviour that may occur in the face of changing economic and social conditions."

³³ In two recent articles Bongaarts (1990, 1991) has used existing cross-national survey data to demonstrate the extent to which a substantial proportion of births is unwanted. He estimates that the average reduction in the birth rate that could be achieved by eliminating unwanted births is around 22 percent and that there is accordingly a large unmet need for contraception on the order of 100 million women and their partners. There are indications that the greater the paternal involvement in childraising the more salient are family planning and size issues for fathers (e.g., Oppong, 1987).

³⁴ Only in the past decade when the results of community surveys on maternal mortality were widely publicized was the stage set for national, regional, and global action. The Safe Motherhood Conference in 1987 in Nairobi, Kenya made clear the dimensions of the human tragedy and highlighted practical means for combating the problems involved. Publications of the World Health Organization have compiled the available evidence (WHO, 1991a, 1991b).

often lethal way used to try to balance numbers of offspring and available resources.³⁵ As numbers of women and girls in the reproductive span increase, numbers of maternal deaths are predicted to increase, especially in the African region.

There is widespread demographic and medical evidence of mothers' inability to marshal the resources required to ensure survival and adequate development of the children they conceive. This evidence comes from global statistics on abortion, infant and child mortality and morbidity, malnutrition, child abuse and child labor, and growing evidence of numbers of abandoned street children. This inability is critically linked to lack of support from partners and kin (Betzig, 1988).

Even though a general decline in child mortality has been observed since the 1950s throughout the less developed regions of the world—with evidence of a fall of about 50 percent between 1960 and 1989 (UNDP, 1991: 27)—one out of every five children born in the least developed countries dies before the age of 5 (UN, 1990a). Disparities have remained observable however, not only among countries, but also among different social and economic groups within countries (UN, 1991a). Rates of child mortality remain highest in the least developed countries and in Africa; an estimated 25 million children die each year.

Malnutrition is implicated in a third or more of child deaths. A considerable contributor to malnutrition and its disastrous outcomes of disability, physical impairment, and death is the fact that so many births are not adequately spaced or occur too early in the mother's life cycle or at too high a parity. Mortality for those born to teenage mothers remains 30 percent higher and for those born to mothers over 40 years of age 47 percent higher than for those born to mothers in their twenties. Thus in countries such as Bangladesh, where 85 percent of first births are to teenage mothers, many births are high risk births.

Increasing attention is currently being paid to the fact that throughout their life cycles poor women are likely to experience serious stress and strain because of the conflicting time, energy, and material demands made upon them by their maternal, domestic, and occupational roles, and the inadequacy of support they receive in playing these roles. The intermittent and continuing demands of pregnancies, child-births, nursing, care, and maintenance throughout the reproductive span take their toll (e.g. Ware, 1983 on West Africa). The physical energy required by the biological demands of pregnancy and lactation often competes with hard manual labor for women's nutritional intake, while their economic activities compete for their time in child care, home production, and other social roles (McGuire and Popkin, 1990).

The crucial precipitating factor in most cases of child deprivation, failure to

³⁵ A recent World Health Organization study has stressed that "The number of maternal deaths in developing countries reflects two factors: (a) a high risk for the individual woman in becoming pregnant and giving birth; and (b) high fertility (i.e. the frequency with which women become pregnant). Family planning has the potential to save lives on both counts, by enabling women to plan their pregnancies in such a way that they avoid becoming pregnant at an age or achieving a parity that carries additional risks, and by lowering fertility generally, i.e. by reducing the absolute number of pregnancies in the population. In addition, family planning can reduce the number of unwanted pregnancies and hence the number of illicit abortions and the deaths that these cause" (Royston and Armstrong, 1989: 185).

thrive, and death is the too great strain put upon the resources available to the mother for child maintenance and care. The level of this strain has escalated most in contexts in which traditional birth spacing and birth control mechanisms—that is intensive breastfeeding and sexual abstinence—have broken down and modern means have not yet been effectively substituted for them.

The importance for child survival and well-being of maintaining a balance between births and maternal resources available for child care, through responsible timing of pregnancies, has recently been re-emphasized by the United Nations Children's Fund in its report on *The State of the World's Children* (UNICEF, 1992).³⁶ As this report clearly notes the alternative practical modes available for effecting such responsible parenthood, through maintaining manageable balances between parental resources and numbers of offspring, are now so many and so diverse as to cater for the sensitivities and choices of virtually all cultural and religious groups. The potential gains to be made by more adequate spacing and timing of births in terms of human lives and health and well-being are increasingly admitted to be enormous.³⁷ The physical, economic, social, and psychological stresses and strains endured by untold numbers of mothers prevent them from investing in their children the amounts of loving care, attention, and resources that children need for healthy development.

Women's Roles and Resources: Some Impacts of Population Change

Three demographic changes with profound implications for current and future female roles are the rapidly increasing size, youthfulness, and mobility of impoverished populations. These signify rapidly growing numbers of dependent, uprooted, and dispersed family members. They entail dwindling conjugal and kin solidarity, cooperation, and support for girls and women in both urban and rural communities. They also imply a diminution of the control and protection traditionally afforded by family groups to the young, the old, and the economically and sexually vulnerable. A number of outcomes accordingly prejudice women's productive and reproductive roles.

³⁶ The tenth of the propositions put forward by UNICEF to contribute to a new order for children is, "That the responsible planning of births is one of the most effective and least expensive ways of improving the quality of life on earth—both now and in the future—and that one of the greatest mistakes of our times is the failure to realize that potential" (UNICEF, 1992: 4). Indeed, it is the considered opinion of that organization that "Family Planning could bring more benefits to more people at less cost than any other single 'technology' now available to the human race. But it is not appreciated widely enough that this would still be true even if there were no such thing as a population problem." In other words scientifically sound methods of spacing and timing births are needed so as to balance maternal resources and children's needs in all contexts of both high and low fertility.

³⁷ They are estimated to include saving over a hundred million women's and girls' lives and the lives of several million children; preventing unknown millions of debilitating conditions and illegal abortions (UNICEF, 1992: 58–59).

Vulnerable girls: Unprotected and unsupported

The social, economic, and sexual protection offered by a supportive kin group is decreasingly available to adolescents, especially girls, when they become spatially and socially mobile, as the result of several years of primary schooling, urban-ward migration, and the often unsuccessful search for wage employment. The numbers of such teenage girls are increasing rapidly. Failure to invest sufficient resources in their development and to provide programs and services for this group, including educational and vocational opportunities, counselling, social services, family welfare, family planning, and maternal and child health, will have grave consequences for them and their children (UNFPA, 1989*a*; UNICEF, 1992).

Increased burdens of dependency and strain

There is evidence that women are bearing heavier household burdens of familial dependency and are, with their children, suffering greater levels of impoverishment, with serious economic and demographic as well as humanitarian implications. The latter include pressures resulting in child labor and abuse and increasingly widespread malnutrition. Concern regarding these issues is reflected in current programs to eliminate child labor and promote food security (e.g., ILO, 1988*b*).

Maternal role strain and mortality

Numbers of women of reproductive age without adequate access to maternal and child health services, or to traditional or modern means of birth spacing or means and support to rear their children are rapidly increasing with serious consequences for fertility, morbidity and mortality rates. This situation is also critical for reproductive health and family welfare, giving added urgency to the need for the many national and international programs seeking to promote Safe Motherhood and reproductive health (Royston and Armstrong, 1989; WHO, 1991*a*).

Mothers alone: Dwindling familial support

Women's attempts to balance productive and reproductive roles through sharing and delegation of child care and cooperation between family members are being destabilized by growing streams of labor migration and the consequent separations of spouses and dispersal of kin (UNFPA, 1993). This has potentially serious consequences for child survival and development, and for women's ability to fulfill simultaneously maternal and occupational responsibilities. The latter add urgency to attempts to assess impacts of migration on family life and effects of paternal and conjugal deprivation.

Occupational/maternal role conflicts

In globalizing economies and deragulated labour markets there is growing

separation of many of women's occupations from the home, especially in rapidly growing urban agglomerations. Increasing numbers of women find it impossible to combine breastfeeding, child care, and productive or income-earning work within the home. Too few urban workplaces provide suitable conditions for child care and feeding. This constrains mothers' employment opportunities, reduces the intensity and duration of breastfeeding, as well as putting at risk the quality of weaning care for toddlers and young children. This has untold potential consequences for women's occupational status, as well as for child spacing, child development, and child survival. Women pay in terms of unequal employment opportunities; children pay with their lives (UN, 1990a: 125). Few countries are making sufficiently concerted efforts to promote effective equality for workers with family responsibilities and to protect the right of working mothers to breastfeed (ILO, 1993b; WHO, 1989).

Wives alone: Increasing sexual vulnerability

There is growing concern that migrant workers and their spouses, in addition to suffering special economic vulnerability, are also more vulnerable sexually and with respect to reproductive health. Evidence links labor migration and mobility and consequent weakening of marital bonds with heightened susceptibility to sexually transmitted disease. Furthermore, women alone are particularly vulnerable to sexual coercion and exploitation, both physically and in the light of their relatively weaker positions in labor markets. This points to the need for new forms of sexual protection for women at work outside familial contexts (ILO, 1992).

Fatherhood: Diminishing responsibility

Women's share of parental responsibility for child survival and maintenance has been growing unequally, as compared to that of the fathers of their children over the past two decades. The most telling and widespread evidence of this trend is the proportion of births occurring outside marriage and the increase in numbers of women and children living without fathers. This has resulted in growing numbers of female-headed households of women and children living in poverty in both urban and rural areas. This unequal division of parental responsibilities has widespread implications for the design of social and economic policies and programs, including employment (ILO, 1993a, 1993b).

Inequality in domestic power

The fact that women tend to have less education, fewer years of work experience, fewer productive assets, and less income than their partners frequently puts them at a disadvantage. They are unlikely to be able to establish egalitarian conjugal relationships. Cooperative decisionmaking and planning of family resources and activities are potentially difficult, and an egalitarian sharing of domestic tasks and responsibilities and flexible negotiation of sexual and procreative activities and

outcomes are difficult if not impossible. This has a profound impact on the programs designed to prevent domestic violence, to promote family welfare and planning for the future. Hence, there is increasing concern for women's empowerment.

Maternal dependence upon children

For many women, increasing burdens of work through growing poverty and environmental degradation, as well as diminished and inadequate kin and conjugal support, entail increased dependence upon children for help in subsistence tasks, agricultural labor, and small enterprises, including trade. Moreover, as links with spouses and kin are increasingly attenuated and subject to risk, sons and daughters provide the only certain hope of help in the present and care, security, and sustenance in old age. The numbers of destitute elderly widows and separated women are increasing in the developing world. Child labor and support from adult children in old age accordingly remain strong props to continued high fertility.

Concluding Comment

During two decades of global concern to focus attention on evidence of sexual discrimination and to highlight the lack of information about women and their roles, a number of remarkable advances have been achieved. These have included promotion of anti-discriminatory legislation; highlighting of the needs to promote equality and protect women in workplaces; the need to invest in the development of girls and women; to engender structural adjustment policies; to stem the tides of maternal and infant mortality; to protect the breastfeeding process; and to halt the marginalization of women in national population and development policies and programs.³⁸

The accumulation of global evidence has been such that by 1990 young girls had become the focus of a global campaign to promote their more equal access to food, health care, education, training and employment opportunities. For by then sufficient statistical evidence had accumulated to demonstrate clearly the existing biases and discrimination. Moreover, the intimate connections between the latter and high rates of morbidity and mortality were clear, and also their links to poverty and human development.

Now, in the 1990s, the profound effects of economic globalization and consequent widespread labor migration on women and children, and on family life are also being increasingly recognized. Moreover, it is clear that if the far-reaching implications of the worldwide breakdowns in familial forms of support and protection for young girls and mothers are not noticed; if the potential impacts of the new forms of discrimination, exploitation, vulnerability, and insecurity encountered

³⁸ See Commonwealth Secretariat, 1989; ILO, 1988*b*, 1990, 1992, 1993*a*, 1993*b*; UN, 1987, 1990*a*, 1990*b*, 1990*c*, 1991*a*, 1991*b*; UNICEF, 1992; UNFPA, 1989*a*, 1991, 1993; World Bank, 1991*a*, 1991*b*; WHO, 1989.

by girls and women in the world of work are not adequately addressed, the socio-economic and demographic outcomes could be catastrophic.

If the gravity of the changes taking place are ignored, the needed social and economic policies taking account of the gender issues involved are not likely to be designed and put in place. Then appropriate programs to promote food security, health, child care, education, and employment will not be formulated and executed. Sex discrimination and protection of youth and maternity and supports for the workers with family responsibilities will not feature prominently enough in labor legislation or the activities of workers' groups and employers. National and local leaders of governmental and nongovernmental organizations will not have the knowledge and foresight to realize the dimensions of the human development problems involved, or the vision and political will to devise effective national, community, and household policies and strategies to overcome them.

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15 Population Change, Social Security, and the Family in sub-Saharan Africa

PAUL TRAPPE

In this chapter I focus on traditional social structures and their change. This is social change, the change of social institutions, in particular the family, the social security network, and its economic basis. Since I emphasize the notion of change, my approach to the problem is necessarily historical.

I concentrate on sub-Saharan Africa to the exclusion of other third world regions. The complexity of my task makes a narrowing of the focus necessary. My focus on sub-Saharan Africa means that I consider this area a clearly defined unit. Hence, I accept such phrases as "African Unity," "African Identity," and "African Personality" without reservation.

The focus on sub-Saharan Africa relates to my own research interests in the sociology of socioeconomic development. With the help of research assistants I have carried out several sociological investigations in sub-Saharan Africa and in arid zones of Mediterranean countries. However, the exclusive focus on this area is necessary for an emphatically more significant reason, which I should like to offer as a conclusion to my inquiry: sub-Saharan Africa is a special case, whose historical record confronts us with a horrific experience. Today this historical experience informs the tendency to crises and the harsh conditions of social reality in sub-Saharan Africa. Among its adverse legacies are: disintegration of traditional social structures; a lack of social reintegration; high infant and child mortality; high and increasing population growth rates; high percentage of victims of disease, including AIDS; high illiteracy; increased propensity to natural and climatic disasters; and persistent decline of agricultural production per capita. Sub-Saharan Africa, however, is also a special case in positive terms: the development potential exists that could overcome the area's vulnerability to crises as well as provide its population a better future.

It is imperative to consider sub-Saharan Africa as a development area *sui generis*. I am convinced that the "African Identity" is a viable proposition that satisfies contemporary socio-political requirements. Also, I believe that an understanding of the historical dimension offers the key to constructive (and successful) policies. Even if written historical records are scarce or missing, it is profoundly erroneous to commit the sub-Saharan region to a historical vacuum. While given less attention than other regions or continents, sub-Saharan Africa has a history in its own right.

Its peoples have founded institutions that have survived for centuries and continue to influence and sustain contemporary social reality.

In the following, I shall adopt a historical perspective to trace the problems that face sub-Saharan Africa today.

The period of direct colonization was both recent and short—from 1884/85 to about 1960. It was determined by the enforcement of direct as well as indirect rule over the indigenous populations. In Latin America many countries declared independence long before sub-Saharan Africa was colonized: Venezuela (1810), Paraguay (1811), Argentina (1816), and Panama and Peru (1821).

Contacts between Europe and sub-Saharan Africa before colonization were characteristically limited to the coast. There was hardly any reconnaissance of the “hinterland” bordering on the coastal factory plants and fortifications. The conquest of the hinterland mainly started after the Berlin Congress of 1884–85.

Slave trade, however, was established as early as 1500 and flourished until 1820. Thus, the deportation and exportation of human resources from western sub-Saharan Africa to America and from eastern sub-Saharan Africa to the Ottoman Empire and other Islamic countries (i.e., Oman, Shiraz, Hadramaut) continued for over three centuries (in the East even longer). Ultimately, this horrific practice caused the destabilization of sub-Saharan African societies. René Dumont has characterized the situation after independence in his convincing book, *L’Afrique noire est mal partie* (1962).

Since sub-Saharan African societies were mostly spared direct external influences until about 100 years ago, indigenous social structures were maintained and managed to survive the large-scale destabilization effected by colonization. They remain viable socio-political structures. In macro-sociological terms, we can distinguish two types of societal forms:

First, Type *A*, community- or tribal-based societies; and Type *B*, kingdoms, even called “empires,” or, in other terms, subjugated societies. The configuration of Type *B* societies resulted from local socio-political power being usurped, expanded, and used by a dominant community to subjugate several neighboring community-based societies. The governmental and ruling structures of these societies were, and remain, essentially different from the common European ideas of ruling systems and practices.

We are looking at autochthonous, or indigenous, structures rather than at mutations or variations of such structures, which have been under foreign rule for centuries. (Islamic rule in the Sahel zone is a case in point.) Since these kingdoms are the result of subjugation processes, I shall direct my discussion toward a more comprehensive understanding of Type *A*.

Essentially, Type *A* societies are, to use a term commonly used in sociology since 1958, “tribes without rulers.” The number of these self-sufficient small social units is very large. Emile Durkheim popularized the term “société segmentaire” in the social sciences in the late nineteenth century, defining it as follows:

[N]ous donnons le nom . . . de sociétés segmentaires à base de clans aux peuples qui sont constitués par une association de clans. Nous disons de ces sociétés qu’elles sont

segmentaires, pour indiquer qu'elles sont formées par la répétition d'agrégats semblables entre eux, analogues aux anneaux de l'annelé, et de cet agrégat élémentaire qu'il est un clan, parce que ce mot en exprime bien la nature mixte, à la fois familiale et politique. (p. 150)

Durkheim was not referring to sub-Saharan Africa in particular but universalized the segmentary system, although it had in fact ceased to exist in parts of many countries as a result of the continuing development of more complex social structures (nation-building). In 1967 Raymond Aron identified the main characteristics of a "société segmentaire" as follows: "On peut imaginer une société globale, répandue sur une large espace, qui ne serait rien de plus que la juxtaposition de segments, tous semblables et tous autarciques" (p. 321). George Peter Murdock's 1959 statement—"The most widespread type of political system is one which may be called a primitive democracy" (p. 33)—has continuing validity today.

A "société segmentaire" (Type A) is determined by the segmented nature of its social reality, especially the social order or normative system. Everyday social life (including social security) is not ordered by a central governing body but by a small, clan-like unit in quasi-autonomous fashion. In fact, there is no central governing body structuring the entire social system from top to bottom. The absence of a central body is a defining characteristic of the segmentary (or acephalic/headless) social system.

Subjugated societies (Type B) are not kingdoms in the European historical or legal sense but, once again, ruling systems *sui generis*. They have been termed "fiscal dictatorships." The ruling class holds only certain political offices because it either is unable or declines to establish a more complex ruling system. This kind of social structure can also be described and perceived in the Marxist terms of "oriental despotism" and "oriental means of production," which refer explicitly to the functional restriction of power. Karl August Wittfogel (1962) has shown how this kind of ruling system can develop into an extremely powerful structure. Although these ruling systems were responsible for "public works," they did not enforce social policy. The responsibility for social policy was assigned to those directly concerned, that is left to self-management. However, this policy of delegating responsibility clashed with the segmentation of the majority of the population, which was, in Marx's words, organized as "stereotypical units—too primitive to form free associations."

Against this background of sociological theory and with explicit reference to contemporary sub-Saharan Africa, I should now ask, first, whether the segmentary social security system is functional; second, whether its particular structural principles are still relevant.

To anticipate two conclusions, these structural principles have not been replaced or eroded: quite the contrary, they are operative in societies ranging from the Atlantic coast of sub-Saharan Africa to the Indian Ocean. They continue to form the basis of social security in these societies. They even support today's social security systems, since, as Gerhard Ritter (1991) suggests, the security quotient held by the state is about 3 percent. Second, centralized government institutions of social security were first established during colonial rule. Following colonial rule, these

institutions were an expression of the restricted nation-state activities of societies declared independent. The reach of such activities, especially regarding social security policies, is limited. In other words, social security policies are either founded on traditional social institutions or refer back to these. As a result of this process, however, traditional norm- and value-systems are weakened.

The diverse influences of centralized colonial rule determine the circumstances and terms of social change in sub-Saharan Africa. Social change has occurred in a fragmented manner, restricted to particular regions. As a result, new ways of life have arisen that erode tradition and custom.

Dual systems continue both in economic and social spheres. Dualism weakens the principle of the "nonmarket economy," on the basis of which the peoples of sub-Saharan Africa have operated for thousands of years. Dualism is responsible for the coexistence and the antagonism of state law and customary law.

Superstructures of this kind have been formed elsewhere; yet nowhere have such structures emerged at such an accelerated pace (within one century) as in sub-Saharan Africa. Autochthonous social structures have been subjugated by centralized colonial administrations, which have merged territorially distinct ethnic groups into new territorial units. Some ethnic groups, for example the Maasai, Mangbetu, and Galla, have been divided by arbitrarily drawn colonial maps. The Senoufo now dwell in three separate states. Considered in George Jellinek's terms of European nation-state/public law doctrine, such territorial divisions have, however, not promoted fully fledged characteristics of nation-state doctrine in sub-Saharan Africa, that is, the equation of a state with one people, one state administration, and a clearly defined state territory.

Social policy was based on self-sufficient and self-governing segments, such as clans, neighborhood units, age groups, and others, with strong principles of cooperative self-management, self-administration, and self-responsibility. In 1931, Alfred Vierkant used the term "co-operative social structure" to describe this kind of segmentation. The implementation of a Western European cooperative system was expected to promote economic and social development in sub-Saharan Africa. In socio-political terms it was important that social welfare be provided for the aged and for those separated from their ethnic group and thus in need of social integration. This was vital in societies that had previously scarcely experienced isolation, destitution, alienation (anomy), and the concentration of economic power in the hands of the few. Julius Nyerere's observation (1967) regarding the changing social institutions in sub-Saharan Africa and the challenges a centralized government posed to traditional government remains apt:

In traditional African life the people were equal, they co-operated together, and they participated in all the decisions which affected their lives. But the equality was an equality of poverty; the co-operation was on small things; and their government was only the government of their own family unit, and of their clan, or at most of their tribe. Our task, therefore, is to modernize the traditional structure so as to make it meet our new aspirations for a higher standard of living. (p. 15)

The autochthonous system resisted change. Economic enterprise clashed with the

egalitarian principles of social control. In the long term, these egalitarian principles were unable to prevent the gradual erosion of traditional structures. Migration to urban centers weakened social cohesion and, by implication, social productive power and performance. Nation-building imposed and enforced detribalization and social fragmentation. This process had two serious effects. First, it eroded agrarian self-sufficiency, which had existed under the traditional land tenure system; freehold now replaced leasehold. Second, detribalization endangered social institutions, such as norms of sexual behavior. I shall discuss the latter effect below. If a social history of sub-Saharan Africa is ever written, it will have to focus on these autochthonous institutions and the community-based society.

There is a general uncertainty and lack of orientation with regard to family norms of sexual behavior among Africans as well as among those concerned with sub-Saharan Africa. Africans seek to preserve their families and family structures. In so doing, however, they encounter externally erected barriers. The peoples resist this effort to impose Western norms, especially when these norms either are not practiced or are neglected in industrialized countries in which they originated and from which they have been imported. I think it is asking too much of African peoples to adopt and accept behavioral forms undergoing change outside Africa.

The norms of sexual behavior have traditionally been more liberal in African societies than in European ones. Explicit requirements exist in many traditional societies regarding the age of marriage, often following long and tedious "rites de passage," correlated with age differences and premarital relationships between the sexes, and quasi-marital arrangements on a trial basis. In most social groups the last of these relationships seldom involves actual intimacy. For very different reasons, promiscuity and polygyny are both tolerated and common. These norms are in a state of profound flux today, with adverse demographic repercussions. I cite a case in point: the disregarding of the norm concerning age of marriage in the traditional rural environment, with strict social supervision, leads to a dramatic increase in early—that is, teenaged—marriages and, by implication, to a prolonged period of female fertility in the urban environment where there is less social control. Hence, marriages at an early age accelerate population growth rates. Traditional family norms obey the principle of "natural" birth control in terms of the extended family. The nuclear family, however, is a new phenomenon, which is less susceptible to social control.

The rise of the nuclear family is accompanied by the disintegration of marriages and families, which cannot be overcome in traditional terms, that is by the re-integration of the respective marital partners into their family of origin following a divorce. Nevertheless, the desire to have numerous offspring is unbroken. This should be understood in terms of maintaining lineal descent rather than, as is commonly and erroneously assumed, as a social policy of providing for the aged or of countering high infant mortality. Ancestors, the living generation, and future generations form a unity, and children are considered a viable way of guaranteeing the continuity and survival of a family. An adult without children is poverty stricken

in terms of the African attitude to life. He/she is divorced from continuity and is socially inferior as a result. Hence, each adult, male and female, is made responsible by his/her ancestors for the survival of his/her family. The African attitude to life after death must thus be seen in the terms sketched here (see Table 15.1) as well as the significantly dominant desire to have more children in comparison with other areas of the world (see Table 15.2).

TABLE 15.1. *Percentage distribution of responses to the question "Do you believe in life after death?"*

	Yes	No	Don't know/ no reply
Latin America			
Total	49	40	11
Brazil	53	38	9
Mexico	33	53	14
Africa (sub-Saharan)	69	17	14
South and East Asia			
Total	61	22	17
India	76	11	13
Japan	18	36	46
Australia	48	40	12

Source: The Baloise Insurance Group, 1978, summary volume: 93

Current social change has disintegrative, fragmentary, and anomic effects on traditional social structures. It is beyond the scope of this chapter to go into great detail, yet I should like to emphasize the most essential forms of this process of social change.

First, migration, in particular child migration and rural-urban migration, break down social structures in the rural areas of origin, whose function it should be to renew larger social structures.

Developmental politics lacks clear strategies to address and resolve the problems of uprootedness and urban poverty within urban agglomerations. There is some indication that mobilization of the "informal sector" could benefit urban populations. Calculations of the gross national product consistently overlook the achievements of the informal sector, however.

Second, Africa's traditional north-south migration, which has been a natural consequence of the desertification of the Sahara for millennia, is now impeded by the process of nation-building. The establishment of national borders has erected new barriers, which are most stringently enforced against the impoverished. This is not an argument for resettlement of large numbers of people to central or southern Africa. My point is that the natural process, which used to serve as a long-term outlet, has been stopped. Also, the enormous resources of agriculturally productive

TABLE 15.2. *Percentage distribution of responses to the question "If a young married couple could have as many or as few children during their lifetime as they wanted, what number would you, yourself, suggest?"*

Response	Latin America		Africa (sub- Saharan)	South and East Asia			Australia
	Total	Brazil		Mexico	Total	India	
One	2	2	4	1	1	*	2
Two	26	22	34	29	32	41	38
Three	24	25	35	37	40	41	25
Four	22	21	17	15	13	6	20
Five or six	11	13	6	14	9	8	7
Seven to nine	2	4	2	*	1	—	1
Ten or more	4	5	*	1	2	1	1
None	1	1	—	1	1	—	2
No reply	8	7	2	2	1	3	4

Source: The Baloise Insurance Group, 1978, summary volume: 93

soil in central Africa could give new homes to and provide for those starving in the northern regions.

Third, the sweeping processes of social change have stifled the emergence of new social welfare institutions in the rural areas to compensate for the loss of traditional integration systems. In particular, I have in mind new forms of social cohesion reaching beyond family bonds. The literature abounds with examples of the development of group cohesion among unrelated members of a society in Europe. The *Rerum novarum* documents a variety of such new forms of cohesion. Adolf Kolping designed new forms of cohesion and association for the socially deprived and destitute. In the Encyclical *Mater et magistra* (1961) and *Pacem in terris* (1963) the idea of group formation in the development process is strongly promoted:

In der Enzyklika 'Mater et Magistra' haben Wir selbst sehr eindringlich darauf hingewiesen, wie sehr es Not tut, dass recht viele Vereinigungen oder Körperschaften, die zwischen Familie und Staat stehen, gegründet werden, die den Zwecken genügen, die der einzelne Mensch nicht wirksam erreichen kann. (see Utz, 1963)

Unlike in Europe, where this occurred on a large scale, these new forms of association did not have widespread effect in sub-Saharan Africa. In the latter there is a lack of "mediating powers," "intermediate groups," "social differentiation toward a complex society." Social scientists have recognized for some time the need to overcome this deficiency. In his investigation of the formation of voluntary associations in Ghana and the Ivory Coast, and influenced by Georges Balandier, Immanuel Wallerstein drew the following conclusion in 1964:

The development of a network of voluntary associations within the social structure is one of the most striking aspects of modern Western civilization. It is noteworthy that as non-Western societies modernize, similar networks of associations are developing. (p. 83)

In the final section of this chapter I shall describe the possibilities of overcoming such structural deficiencies, particularly with regard to group association. For the moment, I want to emphasize that there are several reports on the successful formation of social and economic unions at the level of community development, cooperatives, or self-management units. These forms have been applied effectively in some countries. The next step is to base a large-scale socio-structural takeoff on these successful cases. If this foundation is neglected, then the uncontrollable and frenetic nature of social change in sub-Saharan Africa will disadvantage its peoples even more profoundly.

These tendencies of social change shatter family and parental bonds. Also, we need to consider the demise of social systems in rural areas after substantial out-migration. Those left behind are too frail to carry out hard labor. In addition, the weakening of family bonds has destructive effects on larger tribal structures and communities. Once more, this often leads to the subversion and fragmentation of traditional norms and value systems. Reintegration processes in traditional terms, such as the formation of tribal unions, which are operative and effective in the informal sector, may certainly follow disintegration. These unions also function as social security systems among relatives, and provide a social welfare network for

those suffering the effects of migration. This concerns children in particular, who have followed the example of urban migration of their parents and relatives to be hired by large factories as cheap labor.

The economic consequences of social change include declining agricultural productivity and consequent increasing dependency on imported foods; a shortage of foreign currency; state poverty, caused by exported income (flight of capital); the lack of funds for agriculture; and, instead, price controls on and state subsidies for basic foods for the urban population. Indigenous agricultural products remain noncompetitive. This situation demands a solution that would have positive and advantageous effects for the indigenous farming community.

Several measures that have been applied on a trial basis in the past could be taken in this extraordinarily complex situation, even if they weakened the economic, administrative, and social infrastructure further in the first instance. In suggesting these options, I emphasize once again that sub-Saharan Africa has outstanding socioeconomic potential. Internal as well as external incentives and measures of promoting development can succeed. Results, however, can be achieved only through long-term and continuous efforts. I have in mind the following options.

First, the basic principle should be that development is based on existing social structures, even if these are residues of structures that used to be functional. The renewal of social institutions as well as the implementation of new ones should also be based on those already existing. The call for "institution building" or "social differentiation" in recent socioeconomic literature is by no means an original one; the topics have long traditions with sound experiences. A positive case in point of this blending of traditional and new institutions is the cooperative movement. There was a demand for a particular type of cooperative, that is, the single-purpose cooperative (marketing, processing, supply, consulting) following the well-established Western European model. If traditional structures are taken into consideration, then free clubs and groups will necessarily be assigned fundamental responsibilities. Here, I refer to traditional finance corporations, monetary associations, and non-complex saving institutions, such as the "esusu" and "tontines" common in western sub-Saharan Africa. Peasant associations and farmers' and women's associations should be mentioned in this context. In the process of change and modernization it is imperative that the noncollective nature of these institutions be respected. There is no historical evidence whatsoever of collectivization in sub-Saharan Africa. Attempts to collectivize, if they were considered at all, failed. Besides the family and the kin group, no collective with highly integrated social relations among its members existed. Quite the contrary, highly integrated social relations are founded on family and parental structures, whether in Western and Eastern Europe or, as I have observed repeatedly, in sub-Saharan Africa.

Second, it is imperative that appropriate social and economic premises be established for self-sufficient economies. African property law is based on land tenure issued by either a tribe, community, or chief for a limited time period; land use is subject to constant social control. While European property laws led to the privatization of property, this was the rare exception under African land use rights.

This situation is, of course, changing: private property now exists in urban environments, and irrigation has introduced a de facto right to private property in rural communities. Ways of bridging the transition from a traditional to a modern property law are conceivable. One might consider introducing appropriate forms of private property to stabilize the traditional land tenure system under national jurisdiction. To my mind, the deprivation and the lack of self-confidence of the peasant community could be overcome by ensuring property rights.

Third, such socioeconomic measures could be considered as a basis for the revival of valid and sound social welfare systems. However, neither in sub-Saharan Africa nor in Europe (for that matter) can state institutions take full responsibility for social welfare. State institutions, as well as relief and development assistance agencies, can only provide a helping hand where subsidiarity does not suffice. Subsidiarity was unknown in sub-Saharan Africa because social unity was on a clan basis and self-sufficient. Individual and group rights vis-à-vis state institutions are comparatively recent, effecting the increasing rise of intermediate social powers. The social security system can now be complemented by subsidiarity policies.

To conclude, despite the depressing nature of the issues discussed, I emphasize the considerable potential for development of natural, human, and agricultural resources in sub-Saharan Africa. The know-how of agricultural production units should not be underestimated, and the African farmer's knowledge of local economic and self-provision conditions generally exceeds that of the foreign relief worker or consultant. Local human resources and autochthonous institutions are due full respect and credit because they remain functional. There are no obvious alternatives, merely certain steps toward adaptation that can be taken. Institutional change takes time, and there is enough tragic historical testimony that it can be destroyed overnight. Experiments with institutional change, at the expense of the indigenous peoples, must be adamantly resisted. It is most sensible to base change on the existing autochthonous structures, that is, on structures that the peoples have lived with, practiced, and trust. I do not favor reviving African socialism, which veered off its projected course, although it was based on a positive understanding of the existing structures. I disagree with those who reject this particular form of African socialism, "Ujamaa socialism." Primarily, it failed because a particular principle was overdetermined together with a partial disregard of the unity of social autochthonous groups.

The fundamental problem with state social policy in third world countries is that it depends on and requires additional social policies of an informal sector. This is particularly the case with soft states. In the past decades, the performance of the informal sector in sub-Saharan Africa has deteriorated significantly, although it was responsible for social policies before the onset of nation-building. Today, the soft state is faced with social institutions unable to complement state social policies. These institutions should be given full support to make them more effective in contending with and resolving mass poverty. I reiterate that state social policy will necessarily continue to depend on the overall social policy performance of the informal and traditional sector.

This relies on indigenous social structures and institutions. My conclusion, then, is that the development of sub-Saharan Africa depends on expertise and not on ideological programs. To my mind, it is a tragedy to see how few development programs for sub-Saharan Africa are founded on expertise. Not that I have offered a program myself. However, I am convinced that the key to the resolution of fundamental problems lies in the issues I have raised.

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Part V

Human Health and Potential

16 Introduction

GIOVANNI BATTISTA MARINI-BETTÒLO

An important relationship exists in every part of the world between health and the environment, whether the environment is predominantly natural, as in tropical countries, or humanly modified, as in the industrialized countries.

Health is the most important of the many factors that determine everywhere the quality of life and the welfare of peoples. For each individual, health represents his or her working capacity and, thus, the means to a better life for himself or herself or for the family. If a substantial number of people in a given country are affected by a disease, for example blindness, that society is disadvantaged because blind people are incapable of working at what is normally understood to be full capacity.

The focus of this section is on the relationship between health and the environment in developing, mainly tropical countries. It is in the tropics that natural factors cause serious human health problems and indirectly affect people's social, cultural, and economic development. Before elaborating on this statement, I would like to call attention to the influence of the environment on health in industrialized countries. In recent years, considerable research into the correlation between pollution and health has been carried out in these countries, particularly in urban settings. Studies of sample populations to correlate the presence and the concentration of pollutants in the air, water, and soil with the state of human health have proven difficult because of the number of factors that influence the results. For example, lung cancer cannot be directly correlated with the quality of air because of the presence of smokers and nonsmokers in targeted study groups. The exposure to lead from automobile exhaust is certainly harmful, but lead can also be found in many house paints and even in drinking water.

Environmental damage to health caused by primary or secondary pollutants in the air has been fully demonstrated in many instances. An example is asbestos-caused lung cancer. The pollutant, which is vaporized in the air, was used in the manufacture of car brakes and tires. Likewise exposure to air-borne particulates, sulphur dioxide and nitrous oxides, produced by industrial plants and by automobiles and trucks, may cause respiratory disease with particularly severe repercussions on the elderly. Secondary pollutants, derived from the interaction of primary pollutants with climatic conditions (e.g., light), as peroxy-acyl-nitrates, may cause respiratory difficulties and eye irritation, among other disturbances.

A 1983 Study Week, organized by the Pontifical Academy of Sciences, on the theme "Chemical Events in the Atmosphere and their Impact on the Environment," documented the effects of air pollution on natural ecosystems, especially on aquatic

life and on vegetation. The damage to forests caused by acid rain is an example. At that time, however, it was more difficult to establish a correlation between human health and these modifications of the environment.

The Study Week on industrial and energy production, "Energy for Survival and Development," held at the Academy in 1984, could not establish a direct connection between average states of health of given populations and atmospheric pollution. On the other hand, such a correlation is quite significant for industries in which workers for years are exposed on a daily basis to specific pollutants. Indoor pollution is quite easily related to specific diseases as demonstrated by studies of occupational health. Indeed, these relationships were already clear two centuries ago when Ramazzini wrote his "*De morbis artificum*" (On diseases of workers).

Water and soil pollution in an urban environment may affect human health. The water may be polluted by bacteria or viruses—a highly uncommon occurrence in modern towns—or by chemicals, such as chromium VI or detergents, which have filtered through the soil into underground water layers.

Many contaminants enter the food chain and thus become part of human consumption. Contamination may take place at any stage in the process, which begins with the cultivation of crops and concludes with mass distribution of foodstuffs. Examples are pesticide residues, toxins due to improper conservation of crops, metallic residues, and permitted additives and preservatives.

Although health in industrialized societies is adversely affected by the risks of urban environments and the mismanagement of residues of human activity, rough statistical figures—that is, not those referring to single diseases—indicate a noteworthy increase in life expectancy in the last 40 years. Life expectancy at birth has now reached 75–76 years, largely because of the reduction in child mortality and a higher quality of life produced by better hygiene, preventive medicine, health care services, and the use of new drugs and vaccines.

The fact that these medical advances may neutralize the negative effect of the environment on health should be considered in projections of future population size. At the same time, the effects of some pollutants may become evident only in the future.

Turning our attention to the developing countries, where some 75 percent of the world population live, we can state that the natural environment is of the greatest importance in affecting health in those regions. The majority of the developing countries are located in the tropics and are therefore characterized by a high temperature climate, this being particularly true in humid and in arid zones. These countries are endowed with a variety of wildlife. These climatic and environmental conditions foster a number of diseases that operate on health in addition to the diseases present in industrialized countries—infectious, degenerative, and old-age diseases.

The "tropical diseases" cause high mortality rates and also give rise to a great number of disabled persons who are relegated to the margins of their societies. Poverty, almost nonexistent health care, and poor hygiene worsen the health of these peoples.

The diseases of the tropics can be divided into two branches: infectious diseases and parasitic diseases. To these two major divisions, we should add the common disease of malnutrition, which is caused by poverty and reduces resistance to other diseases.

Parasitic diseases are connected with the environment; their transmission is governed by a common mechanism. The link between humans and the environment in parasitic diseases is represented by three factors: (1) the parasite; (2) the vector; and (3) the reservoir. Commonly, the parasite enters the human body through a vector, which injects the parasite, in general a protozoa in one of its different stages and phases, into the body. The vector, generally an insect, takes the parasite from an animal, usually wild, or from an infected human. Parasitic diseases are difficult to eradicate because of their complex life cycle.

Taking into account that many people are affected by more than one disease, it is easy to imagine the health situation of the people who live in unprotected areas with few hygienic facilities. As is evident, in order to eradicate the disease the link between the environment and the infected person must be interrupted.

I believe that nothing illuminates the link between the diseases and the environment so well as the traditional names of the diseases. The Italian word *malaria*, that is, bad air, links the disease to a specific area. In the past, the very topography of Rome depended on the fact that it was not possible to expand the city into areas affected by malaria, or bad air.

Not until the beginning of the present century did epidemiological, entomological, and clinical research make it clear that malaria was due to the action of a special mosquito, *Anopheles*, and the vector of the parasite of malaria, the *Plasmodium*. Only from this moment was it recognized that it was possible, through land management, to sever the link between humans and the environment where the *Anopheles* lives.

Before the campaign to reclaim the land for cultivation by draining channels and marshes, I remember well that malaria was dangerous even in the outskirts of Rome, and people would not stay at sunset in Fiumicino or Ostia. Through that campaign, however, the whole region south of Rome, once called the Pontine marshes, was rendered safe and cultivable. The alteration of the natural environment made the survival of the *Anopheles* difficult, and the mosquito was definitively eliminated with the use of DDT in the early 1950s.

Considering its climate, however, Italy is marginal to the conditions of the tropics. The world campaign to eradicate malaria, based on the use of chlorinated insecticides, approached success in the early 1970s, but it failed completely at that very moment because of the induced resistance of the *Anopheles* to the insecticide and because of the impossibility of creating in vast regions of Africa, Asia, and South America those environmental conditions in which the *Anopheles* could no longer develop. The parallel campaign of recent years, based on the wide distribution and use of anti-malarial drugs—mainly chloroquine—as a preventive measure against malaria and as a means to eliminate *Plasmodium* from the bloodstream, was not sufficient and now represents a complete failure

because of the resistance of Plasmodium to the main drug employed in that campaign.

Infectious diseases, the second major division of tropical diseases, are transmitted by bacteria, fungi, and viruses. These diseases exist worldwide but they acquire a particular character in the tropics, where they are favored by the climate and the poor conditions of housing and hygiene. Some of the so-called biblical diseases exist in the tropics. One of these, leprosy, affects some 20 million persons who become disabled and relegated to the sidelines of society.

Bacterial diarrheas affect children in the tropics in great number and frequently cause death because resistance is reduced in the presence of malnutrition and other diseases. Bacterial diarrhea is the main cause of child mortality in Africa. The principal cause of the disease is use of contaminated water to prepare milk from milk powder or to dilute cow or buffalo milk. Indeed, polluted water may be considered the main transmitter of 80 percent of all parasitic and infectious diseases in the world.

The appearance in recent years of a new viral disease—AIDS—complicates the situation in countries that are severely affected by tropical diseases. The number of casualties from AIDS may be higher in the tropics as a consequence of the generally lowered resistance of persons to infectious agents in those regions.

Mismanagement of natural resources in efforts to increase soil productivity or to produce energy also promotes the wide spread of tropical diseases. Irrigation projects meant to improve agriculture in sub-Saharan Africa have contributed to the diffusion in vast areas of Planorbis, the snail vector of Schistosomiasis. Such projects have also extended malarial areas in the region. Similar unwelcome results have been achieved with the creation of manmade lakes for the generation of electric power or for irrigation purposes.

In terms of the theme of this volume, "Resources and Population," when we calculate the number of people in the world, we ought to take into account that in tropical regions, where the birth rate is high, the death rate is also high and, even worse, diseases cause a great number of permanently disabled people, who represent a very high burden for their communities, societies, and countries. Consequently, if there is an increase of population, we may have an increased number of persons who cannot sustain themselves. This exacerbates the consequences of poverty and in turn may cause the overexploitation of the environment and thus creates the conditions for the spread of these diseases.

Within the scope of this volume, it is not our purpose to set forth strategies to reduce the impact on populations of diseases that are endemic to the tropics or linked to that particular environment. Better environmental management, that is, control of vectors and reservoirs wherever possible, may improve the overall health of many populations, especially if it is accompanied by hygienic measures (sewage, potable water and better housing) and by preventive medicines.

Our main task is to evaluate the impact on human resources and human potential of diseases, in particular those dependent on the environment, and to consider the impact of numerous disabled or handicapped people on their communities. Even

taking into account the great progress of modern medicine, the overall impact of tropical diseases on population health is dramatic. In a WHO report, we read that some 50 percent of the world's population is exposed to the threat of malaria and that some 80–100 million persons are newly infected each year, of whom at least a million will die. Furthermore, the report continues, throughout Africa, South America, the Middle East, and the Far East people and their livestock are exposed to a variety of other debilitating and fatal diseases.

It is thus necessary to have more information and data about the physiology and the ecology of vectors and their relation to the environment in order to establish strategies for the protection of people's health. Better management of the environment, as is now in progress in various countries, may break the link between the environment and diseases in the countries of the South and, thus, substantially reduce in developing countries the number of disabled and handicapped people, thereby contributing to the improvement of the quality of life.

17 Strategies to Maximize Health and Functioning and Increase Life Expectancy

KENNETH G. MANTON and ERIC STALLARD

The populations of many developing and developed countries are aging. Infant mortality has fallen and life expectancy has increased in many countries, so that large proportions of birth cohorts survive to age 65. Fertility rates often decline in response, further increasing the average age of the population and the proportion elderly. Population aging also shifts, sometimes rapidly, public health priorities from infectious and infant diseases to chronic disease. In Shanghai, China, birth rates declined from 33.2 to 14.8 per thousand between 1960 and 1980, decreasing the proportion aged 0–4 years from 16 to 7.5 percent; meanwhile cancer mortality rates rose from 23.5 to 142.3 per thousand, making it the first (from sixth) ranked cause of death (Xing-Yuan and Mai-Ling, 1982).

In industrialized countries social, environmental, and behavioral problems may increase age-specific disease rates. Stress, social isolation, and family dissolution, air and water pollution, and cigarette, alcohol, and drug use have all been implicated. Chronic disease increases in importance as elderly survivors accumulate multiple diseases and disabilities, and lose autonomy. Because of the potential health effects, the consequences of development on the relation of chronic disease, disability, and life expectancy must be determined.

Population aging, because of fewer social and economic resources, is a larger problem in developing countries. In China in 1985, 5.3 percent of the population were aged 65 and older (190 million); by 2025, 12.9 percent will be in this age group with 4.1 percent (60 million) over age 75. By 2025 in India, 9.7 percent (119 million) will be 65 and older; in Indonesia 23.7 million; and in Brazil 22.8 million. In the United States in 2025 for comparison, 19.5 percent (58.8 million) will be aged 65 and older.

In a stable population, the proportion 65 and older is a function of the gross reproduction rate (GRR) and the level of mortality, as shown in Table 17.1.

Life expectancies at birth, e_0 s, were calculated from Gompertz functions estimated for US and Swedish cohorts. Births and deaths are in balance if the GRR is 1.0. With a male e_0 of 77 years (in Okinawa it is 77 years; in Japan 75 years), 81 to 82 percent of a male birth cohort survives to age 65. For a female e_0 of 87 years (in Shimane

TABLE 17.1. Changes in proportion over age 65 (percent) in stable populations for selected GRRs and life expectancies at birth

GRR	e_0 US		e_0 Sweden	
	Males	Females	Males	Females
	75.7	88.2	77.2	86.4
0.5	37.0	53.4	37.8	50.5
1.0	18.4	28.5	19.0	26.7
1.5	10.5	16.5	10.9	15.5

Source: Duke University, Center for Demographic Studies

prefecture it is 83.3 years; for Japan 82 years), over 90 percent reach 65 (Manton, Stallard, and Tolley, 1991). Twenty-four percent of Japan's population is forecast to be 65 and older by 2020. As developing countries approach an e_0 of 65 years (in Cuba the male e_0 is 72; in China 70), the proportion 65 and over increases rapidly if $GRR=1.0$, and the elderly population is disproportionately female because of higher female life expectancy. Quantitative trends are clear. Less clear is how the health and social status of the elderly will change by 2025.

Recent evidence suggests greater potential for life expectancy increase and maintenance of function than previously envisioned. Below, we discuss ways to maintain function to late ages. How much of this potential is realized depends upon social, political, and economic conditions in a country and the elderly person's "self-image." Positive self-image increases one's motivation to improve health and lifestyle. Planning and education may increase the human capital of an elderly population—even in a developing country with resource constraints.

A Model of Life Expectancy, Chronic Disease, and Disability

Interactions of demographic and epidemiological changes are depicted in Figs. 17.1 and 17.2. Outermost in the figures is the survival curve (A). Innermost is the age to which persons live without chronic disease (C). Intermediate is the age to which persons live without disability (B). The curves' relations determine the health impact of population aging. I_1 and I_2 are intersections with individual health histories. A person dying earlier (I_1) spends less time disabled.

Fig. 17.2a displays four states for persons dying of an acute disease (e.g., heart attack). Life expectancy is not high but the distance between A_1 , B_1 , and C_1 is small relative to C_1 so the time lived disabled is short. Occult disease (e.g., atherogenesis) begins with risk factor exposure (D_1) (Fig. 17.2a). A disease may have a long latency (i.e., $C_1 - D_1$ is "large") but at some biological threshold, death occurs rapidly.

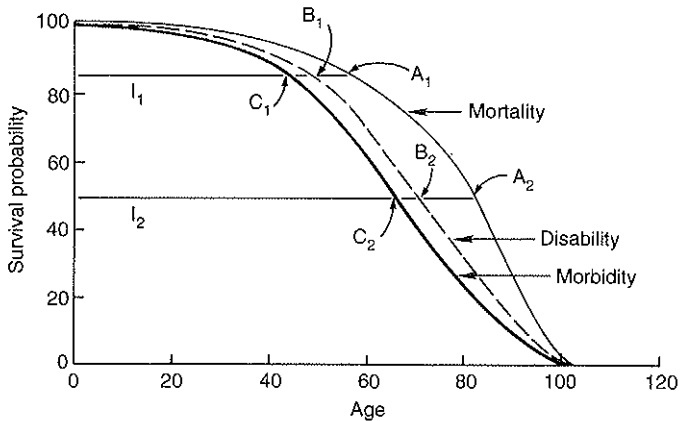


FIG. 17.1. A model of age-related change in health, function, and survival for the population and for two hypothetical individuals, I_1 and I_2

Figure 17.2b represents a chronic disease (e.g., osteoporosis). Life expectancy is high but the distance between A_2 , B_2 , and C_2 is large relative to C_2 ; more time is spent disabled. Risk factor exposure (D_2) is lengthy (e.g., it starts for osteoporosis premenopausally) and the disease progresses slowly—osteoporosis is not life threatening until spinal or hip fracture reduces mobility, causing debilitation and declines in cardio-pulmonary and renal function.

The population mix of diseases determines the relation of A , B , C , and D . The areas between curves represent person-years. If interventions change the disease mix, the “human capital” (i.e., social and economic productive potential) of the population changes. Active life expectancy is used to monitor health in Canada, Japan, France, and the United States. Designing ways to change active life expectancy requires modeling biological determinants of chronic disease and disability in individuals.

Population aging and economic development burden traditional long-term care resources within the family due to a decrease in the number of family members providing care to elderly family members (e.g., women take jobs as wages rise). The burden of acute and long-term health care may retard economic development. In Japan the social and medical costs of population aging are expected to significantly reduce economic growth by 2020 (Nihon University, 1982). Easterlin questioned whether population aging slows growth because the total dependency rate is stable (i.e., as older dependents increase, younger dependents decrease) if life expectancy changes slowly and migration is stable.

It is unclear whether the economics of health care are now being accurately assessed. Investment in the health sector generates employment and spurs technical innovation. It is also unclear how to measure “human capital” changes. Returns are large for the young: for example, reducing lost workdays due to illness increases productivity. Consequently, US and Japanese companies invest in worker health

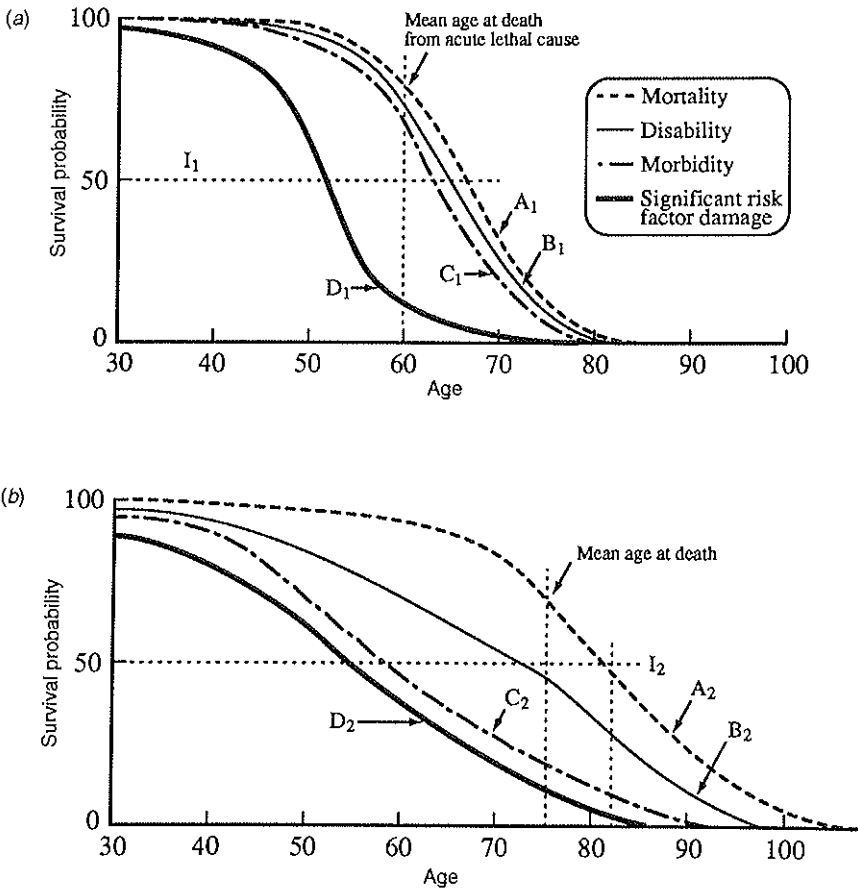


FIG. 17.2. Survival probabilities for (a) a hypothetical individual with acute disease, and (b) a hypothetical individual with chronic disease

programs. In addition to improving health, increases in productivity at later ages will require changes with respect to social norms about retirement, the workday and week, at-home economic activity, and job mobility patterns.

At a life expectancy of, say, 70 years, chronic disease is prevalent. Where coronary heart disease (CHD) is prevalent, as in United States, Norway, and Sweden, females predominate at later ages because estrogen lowers total cholesterol and raises HDL cholesterol, slowing atherogenesis. Estrogen also has immunological effects. Epithelial tumor mortality for females declines by 55 to 65 percent after menarche (Adami et al., 1990). The adverse effect of diabetes on female mortality is a relative, not absolute, disadvantage (female diabetics' relative risk is 3.3; male diabetics' relative risk is 1.8), because female mortality is lower in middle age.

Female diabetic mortality rates approach those for males only after having the disease 11 years (Barrett-Connor et al., 1991).

With better treatment (i.e., thrombolytic therapy for heart attacks; aspirin to prevent second heart attacks and strokes; beta blockers to reduce heart attack risks), coronary heart disease becomes a chronic disease, that is, its natural history is changed. Congestive heart failure (CHF) prevalence increases as myocardial infarction fatality declines. From 1973 to 1986 US hospital admissions for CHF increased 99, 127, 118, and 143 percent for white and nonwhite men and women respectively; increases partly due to improved treatment of heart attacks and high blood pressure. Functional declines are manifest to varying degrees for diseases when survival is improved. In the United States survival has increased for coronary heart disease and for congestive heart failure—a disease which is affected by aging changes in the heart.

Coronary heart disease is common in countries with “Western” diets (Aldercantz, 1990). With development, diets tend to “Westernize,” as in Japan. Higher income increases tobacco and alcohol use. Physical activity at work may decline with development. These changes also increase CHD risks. Non-Western diets, however, are associated with elevated risks of other chronic diseases. The traditional Japanese farm diet, high in salt, causes hypertension. Farm villages in Japan, and urban and rural areas in China, have high hemorrhagic stroke risks. Elderly (60 to 96 years) first-generation Chinese migrants to the United States (N = 346; Choi et al., 1990) were active, seldom obese, had a high carbohydrate (57 percent of calories) and low fat (24 percent of calories) diet, drank and smoked moderately, and had low blood pressure and cholesterol. This lifestyle is similar to that in China’s urban areas, where stroke increased from the seventh to second (in most urban areas, first) ranked cause of death between 1955 and 1978. Stroke mortality increased 126 percent (from 43.1 to 97.3 per 100,000); CHD increased 60.4 percent (from 73.8 to 118.4 per 100,000).

Thus, developing and developed country diets affect common risk factors but produce mortality through different mechanisms. As a result, neither Western nor traditional diets are “optimal.”

Life Expectancy, Chronic Disease, and Senescence

Until the last 20 years, many chronic diseases were viewed as a normal part of aging. If this were true, health changes would be self-limiting with disability, disease, and mortality driven by common processes. Life expectancy was not anticipated to increase much because the observed life expectancy at age 65 was static and consequently thought to be near biological limits. Life expectancy limits were built into the 1975 US Social Security Trust Fund and Japanese economic forecasts (Nihon University, 1982).

In the United States CHD and CVD mortality started to decline in the mid-1960s due to reductions in smoking, cholesterol, and hypertension and to medical

innovations. Life expectancy increases at ages 65 and 85 are continuing. Early advances against acutely lethal disease were rapid. As life expectancy at later ages increased, so did the time spent disabled, because progress against degenerative diseases, initially not a major public health priority, was slow. It has now become clear that chronic diseases are not simply related to "senescence." The "decoupling" of chronic disease from mortality by modern medicine caused social and economic problems. If properly exploited, the decoupling may provide solutions. Popular concepts of the "natural" outcomes of chronic disease are not consistent with evidence on human biological potential. The view that physiological change at later ages is genetically programmed was suggested by research which used representative samples of elderly. Since disease prevalence increases with age, functional declines with age were confounded with age increases in disease prevalence. This biased estimates of "rates of aging." Recent studies control for both manifest and occult disease (Rowe and Besdine, 1988) and show a different relation of "senescence" and chronic diseases. Lakatta found that myocardium in healthy 80- and 90-year-old men was as functional as at age 30. In some studies, genetic effects weaken with age, that is, genetic factors operate more strongly in early death than in deaths at later ages. This was shown in a US study of twins (Reed et al., 1991) and in a study of the genetic predispositions to CHD for persons over age 90 years (i.e., Thieszen et al., 1990).

Recuperative potential at advanced ages may be higher than expected. Weight training in frail, institutionalized 86- to 96-year-olds increased muscle strength 174 percent (Fiatarone et al., 1990). Recuperation of function was demonstrated in trials of geriatric evaluation units and in national surveys (Manton, 1992). Physical activity reduced mortality by improving multiple parameters (e.g., glucose tolerance; blood pressure; lean body mass; organ weight; bone density; fibrinogen; growth hormone (GH) secretion). It reduced circulatory and cancer mortality (Blair et al., 1989) even in diabetics.

Viewing functional decline as age determined is self-fulfilling. Social isolation of the elderly produces depression, self-imposed role limitations, and poor self-image. Well-intentioned policies have reinforced this. In proposals to extend US Medicare to cover long-term care, only personal assistance long-term care was considered—though most disabled elderly use assistive devices. In the United States reliance on assistive devices and the "built" environment (i.e., housing modification) increases as numbers of informal caregivers decline and education increases (Manton, 1992).

Forecasting Health and Functioning

To distinguish functional loss due to age-accumulated pathology from "senescence," one must describe both changes in risk factors and the relation of mortality to risk factors. The evaluation of human aging is often restricted to fitting a unidimensional failure process (e.g., the Gompertz) to mortality data. If neither functional loss nor risk factors are used, mortality and risk factor changes cannot be distinguished.

Gompertz parameters were compared with the age rate of loss of individual functions in experimental and population data. These comparisons are ad hoc. The Gompertz does not describe human mortality above age 85: mortality above age 85 rises less rapidly than the Gompertz. The possible explanations are: (a) loss of function is described by a Gompertz for an individual, while the population reflects differential mortality of individuals with different aging rates; (b) loss of function may be Gompertzian between ages 30 and 80 but slower at younger and older ages; or (c) human mortality may be determined by multiple time-varying, and environmentally influenced, covariates.

Distinguishing between these options requires measuring physiological change. Validating a model of senescence against mortality data is tautological. "Senescence" may reduce some types of mortality. The immune system increases in potency in infancy. Persons surviving influenza have conferred immunity. The accumulation of experience, and response patterning, reduces "accidental" deaths despite slower neurological reaction times. Age decline in immune function may reduce the severity of auto-immune disease—though possibly raising the risk of infection. Metabolic declines may decrease tumor risks. Hormonal changes may reduce cancer risk by denying necessary autocrine and paracrine growth factors. Many prevalent age-related chronic diseases, even if genetically determined, are reversible (e.g., atherosclerosis).

A model that unconfounds multiple risk factor time series from mortality describes the change of J risk factors, x_{ijt} , as,

$$\dot{x}_{ijt+1} = \underline{u}_{0i} + \underline{\beta}_0 \cdot \text{age}_{it} + \underline{\beta}_1 x_{ijt} + [\underline{\beta}_2 \cdot \text{age}_{it}] \cdot x_{ijt} + \underline{\beta}_3 \cdot y_{ijt} + \underline{\beta}_4 (x_{ijt} \cdot y_{ijt}^T) \underline{1} + \underline{e}_{it}(\text{age}_{it})^d. \quad (1)$$

Though (1) is linear, arguments can be nonlinear. \underline{u}_{0i} represents individual (genetic) effects on each variable. A study (Reed et al., 1991) of 1,028 male twins showed differences in concordance (.44 vs. .14) for MZ and DZ twins at baseline for dyslipidemic hypertension. After 14 years the differences declined to .32 vs. .24. Thus, early expression of disease was determined by genetics while late expression was dominated by environment.

$\underline{\beta}_0$ represents the effect of age. $[\underline{\beta}_2 \cdot \text{age}_{it}] x_{ijt}$ represents the age-dependent contribution of each x_{ijt} to changes in itself and other x_{ijt} . $[\underline{\beta}_0 + \underline{\beta}_2 x_{ijt}] \cdot \text{age}_{it}$ represents senescence mediated by x_{ijt} , which declines as more variables are measured. $\underline{\beta}_1 \cdot x_{ijt}$ is an age-stationary component. If x_{ijt} describes an individual's "state" then $\underline{\beta}_1$ is sufficient to describe physiological change and terms involving "age" are insignificant. $\underline{\beta}_1$ can include "lags," e.g., dependence on $x_{ijt-1}, x_{ijt-2}, \dots, x_{ijt-N}$. However, if state variables are properly defined, lags are not required, e.g., LVH may represent the time "integral" of hypertension's effect on the heart. $\underline{\beta}_3 \cdot y_{ijt}$ represents exogenous effects on state changes and $\underline{\beta}_4$ interactions of environment and state variables. \underline{e}_{it} represents diffusion of the x_{ijt} with d being a scale factor ($d=0.0$ for Gaussian processes). Ignoring diffusion in predicting risk factor changes produces biased estimates. This is different from adjusting for lack of reliability in measurement as done in meta-analyses. Modeling disability requires a generalized "diffusion" function which is bounded by 0.0 and 1.0 (Manton, Stallard, and Singer, 1992).

The relation of state variables at t to mortality is,

$$\mu(\underline{x}_{it}, \text{age}_{it}) = (\underline{x}_{it}^T Q \underline{x}_{it}) e^{\theta \text{age}_{it}} \tag{2}$$

where Q is a matrix containing the constant, linear, and quadratic effect of \underline{x}_{it} on mortality—assuming that the first element of \underline{x}_{it} is a constant. $e^{\theta \text{age}_{it}}$ reflects the average effect of unobserved variables on mortality at t . θ describes the senescence rate. As more variables are measured, effects transfer from θ to \underline{x}_{it} . For example, “frailty,” once considered a “consequence” of senescence, is now described as osteoporosis, osteo- and rheumatoid arthritis, etc.—potentially treatable disease states. Susceptibility to infection (e.g., pneumonia, influenza) is linked to immunological changes with age—as is the accumulation of auto-immunological responses in humoral immunity (Rowe and Besdine, 1988). Many auto-immunological diseases have been recently defined. “Dementia,” once viewed as a “consequence” of aging, is now viewed as many different diseases requiring treatment (e.g., anti-hypertensives for micro-infarct dementia) or prevention. As molecular biology progresses, “senescence” becomes less useful as a concept.

Since θ is the per annum increase in mortality, (2), in effect, is a multivariate, time-varying Gompertz. If \underline{x}_{it} represents all “state” variables, then $\theta = 0$, and age changes in mortality are explained by (1). Thus, the effect of “senescence” on either state change (1) or death (2) can be tested by the model. Biomarkers of aging are the \underline{x}_{it} and (1) describes their change. Many risk factors are correlated with age, e.g., age changes in the hepatic metabolism of cholesterol (Rowe and Besdine, 1988) and in glucose metabolism with effects at organ (e.g., insulin stimulates smooth muscle growth in artery walls) and molecular levels (e.g., effects of glucose on long-lived proteins). Vital capacity is related to collagen degeneration in the lung. It predicts mortality in nonsmokers as well as smokers. Glucose metabolism and pulmonary collagen changes are modifiable. The ability to modify “senescence” increases as the role of nutrition and physical activity in chronic disease is better understood.

If mortality is due to K causes then (2) is a multidimensional, time-varying Gompertz,

$$\mu(\underline{x}_{it}, \text{age}_{it}) = \sum_{k=1}^K \mu_k(\underline{x}_{it}, \text{age}_{it}) = \sum_{k=1}^K (\underline{x}_{it}^T Q_k \underline{x}_{it}) e^{\theta_k \text{age}_{it}} \tag{3}$$

Because (2) is quadratic the K functions are additive. A quadratic form allows high and low values of \underline{x}_{it} to increase risk. The relation (Q_k, θ_k) of each disease to \underline{x}_{it} may be different, that is, each cause may have its own “aging rate.”

Life Expectancy and Disability Intervention

From (1) and (3), life tables can be calculated that describe survival and risk factor trajectories. If age is used as a risk factor (in \underline{x}_{it}) the values of \underline{x}_{it} having the lowest mortality for (3) are biologically implausible (Manton, Stallard and Singer, 1992). This is because mortality doubles every eight to nine years, dominating risk factor

effects. The Gompertz in (3) isolates age from risk factor effects on mortality. Equation (3) defines a set of \underline{x}_{it} producing the lowest mortality for each cause. The dynamics in (1) move \underline{x}_{it} toward a homeostatic "profile." Differences between the age trajectory of homeostatic profiles and the K minimum mortality profiles determine how each \underline{x}_{it} contributes to a cause of death.

From the coherence of \underline{x}_{it} over time, latent variables can be identified for subsystems of the organism (Manton, Stallard and Singer, 1992). Thus, unobserved variables influencing atherogenesis may be represented by the cross-temporal correlation of the \underline{x}_{it} . For example, reducing diastolic blood pressure by 5.0 mm/Hg (and not changing systolic blood pressure) increases mortality, that is, elevated pulse pressure implies peripheral resistance and atheroma.

With the model, the relation of senescence to mortality and disability can be examined and the physiological dimensions involved can be ascertained. For example, "senescence" may be a stochastic accumulation of errors in macromolecules imposing limits to cell replication, or it may be the active inhibition of DNA synthesis in cell replication to protect against neoplasia (Rowe and Besdine, 1988). In the latter case, senescence is an active response to errors induced by retroviral and other environmental insults. The heterogeneity of senescent cells favors a stochastic model. "Senescence" and measurable risk factors have to be related to higher levels of biological organization to evaluate interventions. We briefly review the mechanisms that may be affected.

Nutrition

Aging research suggests life span is extended by dietary restriction or by lowering (Rowe and Besdine, 1988) an organism's internal temperature, e.g., a 2°C drop reduces mortality as much as (assuming a Weibull and a thermodynamic constant) eliminating cancer and coronary heart disease. Dietary restriction may reduce the "wearing out" of cellular mechanisms by reducing active oxygen species affecting carcinogenesis and atherogenesis (Rowe and Besdine, 1988). Dietary restriction reduces cholesterol, body mass index, and insulin resistance. Effros et al. (1991) showed dietary restriction increased resistance to influenza by changing lymphocyte membrane viscosity.

As calories are reduced (e.g., 30 to 50 percent), maintaining micro-nutrient intake becomes more difficult. Thus, dietary restriction does not guarantee life prolongation, and may shorten life—especially if it occurs during ages of rapid growth. Japanese males going through puberty during World War II had worse survival than other cohorts because of dietary restriction at a critical growth stage. A decreased ratio of birth to placental weight (and lower weight at age 1) implies intrauterine growth dysfunction. This dysfunction, due to a tendency to preserve brain development, may "program" organ deficits that increase hypertension, heart disease risks, and chronic respiratory disease. Thus, lack of adequate nutrition in pregnancy, pathological states affecting intrauterine development, and early growth retardation may affect chronic disease risk to age 65 and beyond (e.g., Hales et al., 1991).

Physical activity balances caloric intake by increasing output. Though the metabolic rate is not reduced, many benefits of dietary restriction are achieved (Blair et al., 1989) and micro-nutrient intake is more easily maintained. In older persons, metabolic efficiency declines—in part due to reductions of growth hormone (Kelijman, 1991) or to adiposity that blunts stimulants of GH production (e.g., exercise and estrogen). Supplementation of anti-oxidant micro-nutrients (beta-carotene, vitamins A, C, and E) controls free radicals in atherogenesis, carcinogenesis, and possibly viral infections. Malnutrition-decreased immunity in the elderly may be reversed by anti-oxidant and caloric supplementation.

The dietary restriction hypothesis may, given economic and agricultural exigencies, be attractive for some developing countries. However, dietary restriction requires an "isonutrient" diet that is difficult to maintain. Furthermore, the evidence for dietary restriction is based on animal models. In many human clinical and epidemiological studies the elderly are found to be malnourished, which produces both debilitation and increased mortality from decreased immunity and bacterial and viral infections (e.g., pneumonia). Thus, in the elderly, body mass index has a U-shaped relation to mortality, with intermediate body mass index having the lowest mortality (e.g., Manton, Stallard and Singer, 1992). Body mass index peaks at ages 55 to 60, and then declines as GH and related growth factors decline. Obesity may mute stimuli to GH production so that a low body mass index with high adiposity has adverse consequences. Consequently, dietary restriction is too simple a model for adequate "nutrition" in aging organisms, which is a nonstationary dynamic process with feedback between multiple hormonal systems.

Physical activity

Activity improves metabolic parameters and reduces cause-specific and total mortality to extreme ages. In developed countries physical activity at "work" may decline as technology improves. In many developing countries the level of physical activity remains high. This suggests, given equivalent nutrition, that a developing country might have health advantages at later ages. However, health awareness increases with education, and in developed countries physical activity is often a leisure time activity designed for optimal effect (i.e., higher aerobic index; less peak stress, reducing myocardial infarction and stroke risk; less musculoskeletal degeneration). In developing countries physical activity often ceases abruptly at retirement.

Coordination of nutrition and physical activity requires education and public information. Supplementation of diet with micro-nutrients and minerals (e.g., calcium and vitamin D for postmenopausal women) may be less costly and more beneficial than changing caloric and protein levels. Soya and other naturally occurring plant sources of estrogens have potential anti-estrogen, anti-cancer, and anti-mitotic effects possibly naturally reducing fecundity, disability (osteoporosis), and lethal chronic diseases (coronary heart disease and cancer) at later ages. Work conditions may be modified to eliminate health effects (i.e., osteoarthritic degeneration) while

maintaining high aerobic levels. Socially and economically productive roles could continue if work-related physical activity, and nutrition, were modified in a coordinated fashion.

Viral and infectious diseases

Such diseases affect life expectancy and functioning both early and late in life. Children and the elderly are susceptible to infectious disease by virtue of their less effective immune systems; for example, both frequently have reduced gastric immunity due to nutritional deficiency. Survivors of epidemics, with adequate nutrition, have improved immunological response. The higher leukemia rates among white children in the United States may be due to less viral exposure in small families. Multiple sclerosis is also more prevalent in middle-class families. In developed societies, disease resistance is enhanced by immunization, for example, influenza and pneumococcal vaccination for persons at high risk. Immunization is not effective in malnourished organisms. Micro-nutrient supplementation has been proven effective both in children (e.g., vitamin A supplementation and iodized oil) and the elderly.

Viral exposure can trigger auto-immune disease by inducing antibody production in persons with susceptible HLA profiles, that is, persons for whom a viral antibody is responsive to normal tissue receptors. This occurs in middle age (e.g., rheumatoid arthritis; the "post-polio" syndrome). There are other changes in the immune system at advanced ages; for example, above age 85 "plasma cell dyscrasias of unknown significance" have a prevalence of 10 to 15 percent. Isolated monoclonal gammopathies at advanced age may indicate subclinical immunopathological states that cause death by enhancing inflammatory responses in coronary heart disease and stroke. Epstein-Barr Virus (EBV) is 95 percent prevalent in human populations and affects B-cells (production of immortal clones). In developed societies EBV infection produces infectious mononucleosis. In East Africa, EBV interacts with malarial infection, and possibly with *E. ticullara* to cause Burkitt's lymphoma. In Hodgkin's disease, EBV is isolated from Reed-Sternberg cells in a significant proportion of patients. Retroviral infections (by inclusion in host DNA) can be latent for years. Endogenous retroviral RNA has been isolated from the brain, liver, and kidney of elderly subjects. The role of viruses is established in some cancers (e.g., hepatitis and liver cancer, breast cancer) and suspected for others.

Little explored is the genetic drift of viruses and bacteria. Mutations of carpine lentivirus in England and Wales may have led to the emergence of rheumatoid arthritis. Genetic drift causes cyclical influenza activity. Studies in Finland show high rates (40 percent) of streptococcal resistance to erythromycin (Seppälä et al., 1992). Recent resistant strains of TB have been emerging in the United States. Genetic changes producing antibiotic resistance need global monitoring. Mutations in streptococcal infections have led to virulent strains and re-emergence of rheumatic heart and other disease. *Helicobacter pylori* (identified in 1983) infection from water produces 60 percent of the stomach cancer in developing countries (Forman, 1991)

and causes much gastritis. Declines in immune function with age make the elderly more susceptible to viral and bacterial genetic drift. Decreased cell-mediated immunity predicted both total and cancer mortality among the elderly in a nine-year study (Wayne et al., 1990). The use of anti-virals (e.g., amantadine against influenza; acyclovir against herpes zoster) raises the risk of viral resistance. Thus, treatment of chronic bacterial infections (stomach cancer), immunization against influenza and pneumococcal pneumonia, treatment of papilloma (cervical and penile cancer) and hepatitis (liver cancer) viruses, and nutritional maintenance (to generally improve gastric and other immunity) are important interventions.

Hormones

Hormones have numerous physiological effects. Loss of response to neurohormonal response (decreased beta receptor density) affects organ function and produces diverse chronic diseases, including congestive heart failure. Four influential hormones are GH, angiotensin converting enzyme-II (ACEII), estrogen (sex steroids), and vasopressin and oxytocin. GH controls glucose tolerance, reduces cholesterol, and increases nitrogen retention and lean body mass. GH is stimulated by exercise, treatment of old-age depression (GH is released during sleep), and estrogens. ACEII regulates cardio-renal function and vaso-dilation and constriction. It mediates aldosterone-generated fibrotic changes in the heart and kidneys. Estrogens affect cell-mediated immunity, release of GH, and hepatic metabolism of cholesterol—stimulating higher HDL and lower LDL levels. Estrogens affect metabolism and are used to treat osteoporosis, a major cause of disability in elderly females. The hypothalamo-neurohypophysial-renal system controls water and electrolyte balance—which may be important in countries with few sources of high-quality drinking water.

Hormonal interventions are now feasible due to recombinant technology. Estrogen augmentation in postmenopausal women is extensive in developed countries and significantly (50 + percent) reduces coronary heart disease and osteoporosis (50 to 60 percent). Low-dose (0.625 mg) estrogen supplements reduced cancer risks 20 percent. An estrogen antagonist, tamoxifen, may be used as a preventative in women with high breast cancer risks. This is important as fertility declines, since breast cancer risks are related to age of first birth. In developing countries, hormonal factors can be influenced by diet. Phytoestrogens that occur naturally in plants mimic some of the biological activity of estrogens. Thus, increasing phytoestrogen intake—as in rye, wheat, garlic, apples, soya beans—may produce several beneficial effects. First, coronary heart disease, cancer, and other chronic diseases may be reduced for postmenopausal women, increasing life expectancy. Second, skeletal integrity is improved, reducing disability. Third, phytoestrogens derived from foodstuffs may naturally down-regulate fecundity. Thus, increasing phytoestrogen intake is a natural hormonal nutritional intervention that already occurs in many populations. For example, low rates of breast and colon cancer occur in Finland, with high consumption of rye breads, and in Singapore, with high consumption of soya protein (Aldercreutz, 1990).

Environmental exposures

Such exposures, both natural (e.g., food spoilage producing aflatoxins) and due to forest clearing and the burning of hydrocarbon fuels, may be tetrogenic, mutagenic and carcinogenic. In developed countries increases in asthma mortality are evident—possibly due to increased air pollution. A related area is public sanitation and hygiene. The most susceptible populations to waterborne infectious diseases are the young and the elderly.

Education

Improvements in environment and lifestyle can be motivated by education. Smoking and alcohol use are affected by education. Smoking has a number of health effects, including cancer, coronary heart disease, and stroke. Smoking, once initiated, is difficult to stop. Alcohol affects the heart, liver, and skeletal muscles. If interventions are imposed early, at the societal level, their cost-effectiveness is greater. In the United States, smoking declined more rapidly in educated populations. In addition, education is a “positive” risk factor for Alzheimer’s disease (Evans et al., 1992). Education increases cognitive function and the use of assistive devices to deal with age-related functional deficits.

Education also has direct physiological effects even controlling for known risk factors. Pulmonary function is higher among nonsmokers, who in turn tend to be better educated. In Alzheimer’s disease, education may train neurological processes to produce reserve mental capacity. Ornish et al. (1990) used stress management to reduce atherogenesis triggered by catecholamine release. This is important in work with chronic stress.

Education is important for women’s and children’s health. Education of women increases age at first birth and produces longer birth spacing intervals. This positively affects child health and improves female health postmenopausally. In a study of 1.2 million postmenopausal (i.e., age 45 to 74) female deaths, mortality was higher for parous compared to nulliparous women for many causes. For 100,000 deaths in 1959 and 1960, total mortality was 20 percent higher for parous women. Women with 5+ births had 1.8 times the risk of myocardial infarction (Croft and Hannaford, 1989). Circulatory effects may be due to the suppression of HDL cholesterol postpartum (Barrett-Connor et al., 1991), increasing atherogenesis. Thus, education has both direct physical, and facilitating, effects (e.g., dietary supplementation with anti-oxidants and phytoestrogens).

Social support

Social support for the elderly has psychiatric, biomedical, and social implications. Depression associated with social isolation reduces immune function and GH production (Kelijman, 1991), affecting metabolic parameters. It affects the effort to maintain function, namely, to seek health care, perform physical activity, and

maintain nutrition. It has direct effects on disease survival rates (Williams et al., 1992).

Medical organizations

Facilities and organizations designed to deal with the health problems of the elderly are important especially to counteract negative images of health and functioning at late ages. Geriatric evaluation units prove cost-effective by identifying undiagnosed disease, improving function, and increasing survival. They fulfill socio-legal roles by identifying abuse of the elderly and psychiatric disorders (with possible physical effects) arising from social isolation. The medical care system can promote primary and secondary prevention among the elderly; for example, smoking and high cholesterol continue as risk factors at advanced ages. Moreover, the efficacy of medical treatments for the elderly is increasing. In surgery on persons age 90 to 103 (Hosking et al., 1989), long term (five-year) survival rates improved. In managing the elderly patient the physician has to be aware of contributing diagnoses and age-related changes in physiology. Most urgent is the need to recognize the therapeutic effect of nutrition and exercise, and that many physically abnormal findings are not due to aging; for example, hypothyroid states are frequently misdiagnosed. There is a need to become aware of new treatment modalities (e.g., etridionate and salmon calcitonin for osteoporosis). The reduction of risk factors after disease manifestation needs emphasis.

Dependent competing risks

The efficacy of intervention depends upon whether diseases operate dependently or independently, that is, whether the expression of a chronic disease depends only upon life duration or on interactions with host physiology as well. Table 17.2 shows the risk factor dependency of circulatory disease (CD) (both coronary heart disease and CVD) estimated from the 20-year follow-up of males in the Framingham Heart Study.

Table 17.2 contains: l_t , the survival function at age t ; d_t , the number of deaths between t and $t+2$ (the follow-up interval was two years); $q_t = d_t/l_t$, the probability of death at t ; and $e_t = \int_t^\infty l_\tau d\tau/l_t$, life expectancy at t . Also presented are the means of eight risk factors for survivors to age t : pulse pressure (mm Hg.), diastolic blood pressure (mm Hg.), body mass index (kg/m^2), cholesterol (mg/dl), blood sugar (mg/dl), hemoglobin (dg/dl), vital capacity index (l/m^2), and cigarettes (no./day). Systolic blood pressure is the sum of pulse pressure and diastolic blood pressure. All measure "hypertension." Hemoglobin, a measure of the blood's capacity to carry oxygen, indexes anemia and possibly hemochromatic states that elevate circulatory and cancer risks. Vital capacity, correlated with maximum oxygen intake, normed by height squared, indexes physical "fitness." Other risk factors were discussed above.

The "baseline" life table and risk factor means are calculated from equations (1)

TABLE 17.2. Observed (baseline) and cause-elimination life table values assuming no change in risk factors (independence) and altering the risk factor distribution (dependence): circulatory disease elimination, males, Framingham Heart Study

	l_t	d_t	q_t	e_t	Age(t)	Pulse pressure	Diastolic blood pressure	Body mass index	Choles-terol	Blood sugar	Hemo-globin	Vital capacity index	Ciga-rettes per day
Baseline	100,000	260	0.003	43.80		45.83	79.57	261.88	215.22	79.55	142.11	139.29	13.24
Dependence	100,000	122	0.001	53.98	30.00	45.83	79.57	261.88	215.22	79.35	142.11	139.29	13.24
Independence	100,000	122	0.001	54.88									
Baseline	94,289	1,203	0.013	25.70		47.62	83.40	277.11	241.12	83.70	149.63	127.60	12.61
Dependence	97,798	461	0.005	34.92	50.00	47.64	83.42	277.26	241.27	83.76	149.64	127.59	12.67
Independence	97,801	460	0.005	35.84									
Baseline	68,166	5,355	0.079	10.79		62.97	82.85	266.77	222.97	98.57	150.74	100.90	4.78
Dependence	86,685	2,552	0.029	17.76	70.00	63.25	83.01	266.37	223.39	99.07	150.74	100.32	5.09
Independence	86,789	2,498	0.029	18.78									
Baseline	5,818	2,722	0.468	2.86		77.34	80.87	250.65	204.64	111.89	151.91	78.01	0.00
Dependence	36,316	7,325	0.202	6.00	90.00	79.36	81.68	242.69	205.59	115.04	151.30	73.30	0.00
Independence	39,670	6,756	0.170	7.17									

Note: Mean values under independence are same as under baseline model.

Source: Duke University Center for Demographic Studies; calculation based on individual record follow-up data from the first twenty years of the Framingham Heart Study, Framingham, MA, USA; see Kannel and Gordon (1978).

and (3). "Dependence" life table and risk factor means refer to computations with Q_k for CD set to zero (i.e., $Q \sim \text{TOTAL} = \sum Q_{k \neq \text{CD}}$). Two changes resulted: (1) survival improved dramatically— e_{30} increased from 43.8 to 54.0 years; (2) risk factor means moved toward values associated with CD risk. The dependence effect for CD is not large until a significant proportion of high-risk persons die. For CD risk factors common to other diseases this occurs above age 70. The "independence" life table is based on Chiang's independent cause elimination method where q_t s are decomposed into cause specific terms, q_{tk} , with the q_{tk} for CD set to zero, and life tables recomputed with $q_{t,k}$ replacing q_t :

$$q_{t,k} = 1 - (1 - q_t)^{(q_t - q_{tk})/q_t} \quad (4)$$

Risk factor means do not affect these computations; hence, they are unchanged. Independence overestimates life expectancy gain due to disease treatment (even if 100 percent effective, other disease risks are elevated) with bias increasing with age.

The linkage of risk factors and mortality in (1) and (3) also allows interventions to be simulated. Risk factors are not intervention variables but represent the physiological impact of the intervention. For example, in (1) the exogenous term could represent the use of a drug to control hypertension for persons with systolic blood pressure above 160 mm Hg. Alternatively, it could represent dietary changes to reduce total cholesterol (or blood pressure). Exogenous relations would be estimated from trials where an intervention produces an effect (and lag) on the \underline{x}_{it} . For a factor like physical exercise we know that unmeasured factors are affected. We first determine whether this effect is represented by changes in the \underline{x}_{it} over time (e.g., pulse rate, BMI, vital capacity index, or LVH, for physical exercise). If not, it is represented by θ_k . Interventions are illustrated in Table 17.3.

The pivotal intervention changed means at age 30 to "optimal" values. Other interventions are incremental. Reading across the columns, a 10 percent aging reduction is simulated by multiplying each θ_k by 0.9 (e.g., an effect of physical exercise; Blair et al., 1989); a 50 percent reduction in cancer is simulated by multiplying its Q_k by 0.5. Reading down the rows, cause elimination of the "dependence" type sets $Q_k = 0$ for the selected cause. Risk factor controls are of two types: (a) setting β_s to an identity; (b) setting the initial covariance matrix to zero and assuming that (1) was deterministic (i.e., $\Sigma = 0.0$). Row interventions are combined to illustrate intervention synergisms.

Cause elimination effects are small except for CD (21.4 percent increase of e_{30} ; 3.8 percent for cancer; 4.0 percent for residual). Although chronic diseases are unlikely to be "eliminated," the estimates represent a bound for a given percent reduction in age-specific death rates, for example, a 50 percent reduction in cancer yields a 2.6 percent increase in e_{30} ; 68 percent of the cancer effect (3.8 percent). Risk factor controls have greater effects. Mean control increases e_{30} by 15 percent; variance control, 11.5 percent; both mean and variance control, 52.8 percent. The increment of variance over mean control, 37.8 percent (i.e., 52.8 - 15.0 percent) suggests interactions. Thus, a 30-year-old maintaining an optimal risk factor profile might expect to live to age 99.2 years (i.e., 30.0 + 69.2 years).

TABLE 17.3. Illustrative estimates of residual life expectancy (in years) remaining at age 30 under selected interventions and combinations of interventions initialized to "optimal" profile at age 30, males, Framingham Heart Study

Intervention	"Optimal" profile	Δe_{30} (percent)	10 percent aging reduction	Δe_{30} (percent)	50 percent reduction in cancer	Δe_{30} (percent)
Optimal profile	45.3	0.0	47.9	+2.6 (5.7)	46.5	+1.2 (2.6)
Cause elimination Cancer	47.0	+1.7 (3.8)	49.7	+4.4 (9.7)	47.0	+1.7 (3.8)
Circulatory disease	55.0	+9.7 (21.4)	58.4	+13.1 (28.9)	59.2	+13.9 (30.7)
Residual	47.1	+1.8 (4.0)	49.8	+4.5 (9.9)	48.5	+3.2 (7.1)
Risk factor Mean control*	52.1	+6.8 (15.0)	56.4	+11.1 (24.5)	55.6	+10.3 (22.7)
Variance control*	50.5	+5.2 (11.5)	53.0	+7.7 (17.0)	51.1	+5.8 (12.8)
Mean + variance control*	69.2	+23.9 (52.8)	75.4	+30.1 (66.4)	74.9	+29.6 (65.3)
Cause elimination and mean + variance control*	75.8	+30.5 (67.3)	83.0	+37.7 (83.2)	75.8	+30.5 (67.3)
Circulatory disease	77.1	+31.8 (70.2)	84.5	+39.2 (86.5)	97.1	+51.8 (114.3)
Residual	70.7	+25.4 (56.1)	77.1	+31.8 (70.2)	77.4	+32.1 (70.9)

* Cigarette smoking eliminated by controlling the mean and variance at a zero level.

Note: Figures in parentheses are percent change.

Source: see Table 17.2

Risk factor control alters their trajectories. Altering θ_k changes the age effects of unobserved risk factors. A 10 percent reduction in θ_k increases e_{30} by 5.7 percent—more than eliminating cancer or residual causes. As noted below, physical activity preventing functional impairment reduced θ_k by 50 to 60 percent—implying e_{30} increases of 30 to 35 percent.

Designing and Monitoring Interventions

From the life tables describing survival and age changes in risk factors, the costs and savings of interventions can be calculated. These can be compared with those of reducing case-fatality rates. Cost analyses of disease prevention among young persons showed negative benefits because the intervention was applied to the entire population over a long time and exerted an impact on diseases with low prevalence. In elderly populations the calculus for the cost of disabling conditions is different because the prevalence of such conditions is high.

A metric has to be selected to evaluate health and functional changes. Life duration, though desirable, may not be the best criterion because disability may become disassociated from survival at latter ages. Subjective valuation of a year of life in a particular state of health has ethical and technical problems. Disaggregating life expectancy into components using multidimensional health scores produces a vector-valued, duration-weighted social welfare function (Manton, Woodbury, and Stallard, 1991). This represents distinct dimensions of ability (e.g., cognitive, locomotive, and fine motor control), and is graded, that is, a continuously valued score is used to determine the level of ability (and disability) on each dimension. Thus, a high prevalence of specific types of disability will not obscure human capital reserves.

When functional scores are used as x_{it} in (1) and (3), θ_k declined by 50 to 60 percent, that is, most of “senescence” is explained. This is because improved function allows individuals to remain physically active and affects multiple physiological parameters. In autopsy studies of elderly persons, 56 percent of mortality is due to causes associated with impaired mobility (Gross et al., 1988).

The effect of interventions depends on technology. In blood pressure control, diuretics that decrease fluid volume adversely affect blood lipids and glucose metabolism. ACE inhibitors do not affect blood lipids and improve glucose metabolism. Thus, though both drugs control blood pressure, their net physiological benefit is different. Total mortality was not reduced in the MRFIT trial until the 10.5-year followup because the antihypertensive drug was not changed until after 6.8 years.

Whereas risk factors have to be monitored at frequent intervals, often using costly laboratory assays, decomposing life expectancy by level and type of function may be done with less expensive survey data. Functional status can be reliably determined from self-reports. As shown in Table 17.4, six classes were determined from 27 items on self-reported functioning in a survey of the frail elderly population (Manton, Stallard, and Woodbury, 1991). The validity of the six classes is shown in

TABLE 17.4. *Male and female life expectancy components for different functional classes at ages 65, 75, 85, and 95 years*

Age	Total	Class						Institutionalized	
		1 Healthy	2 Early cognitive impairment	3 Moderate physical impairment	4 Heavy physical impairment	5 Frail	6 Highly impaired		
Males									
65	Married	16.37	14.53	0.301	0.243	0.143	0.367	0.467	0.328
	Unmarried	12.91	10.75	0.267	0.175	0.155	0.559	0.314	0.686
75	Married	11.50	9.71	0.330	0.196	0.119	0.324	0.461	0.359
	Unmarried	9.12	6.98	0.283	0.150	0.132	0.499	0.314	0.753
85	Married	7.09	5.33	0.311	0.166	0.092	0.300	0.468	0.430
	Unmarried	5.95	3.89	0.328	0.154	0.078	0.482	0.299	0.715
95	Married	4.60	3.23	0.221	0.118	0.072	0.210	0.398	0.353
	Unmarried	4.25	2.59	0.291	0.121	0.052	0.344	0.252	0.600
Females									
65	Married	20.67	17.16	0.434	0.423	0.345	0.748	0.736	0.830
	Unmarried	20.10	15.64	0.576	0.587	0.464	0.734	0.586	1.511
75	Married	14.17	10.82	0.439	0.305	0.265	0.714	0.714	0.913
	Unmarried	13.93	9.64	0.568	0.464	0.379	0.669	0.584	1.629
85	Married	8.10	5.00	0.404	0.185	0.160	0.640	0.738	0.970
	Unmarried	8.49	4.61	0.514	0.358	0.278	0.513	0.563	1.658
95	Married	4.40	1.85	0.329	0.040	0.103	0.571	0.340	1.167
	Unmarried	5.58	2.61	0.457	0.236	0.182	0.326	0.503	1.262

Source: National Long Term Care Surveys, 1982 and 1984

their ability to predict mortality and health service use; for example, impaired Class 6 has a risk 20 times greater than nondisabled persons for total mortality.

The table decomposes life expectancy at ages 65, 75, 85, and 95 by functional class, sex, and marital status. For example, 65-year-old married males have an e_{65} of 16.4 years, of which 14.5 years (88.8 percent) are healthy, 0.7 years are moderately impaired (Classes 2–4), 0.8 years are highly impaired (Classes 5 and 6), and 0.3 years are spent in institutions. Life expectancy decreases with age and, for males, with marital status change. Institutional use is higher for the unmarried and for females, independent of age. There are large sex differences in life expectancy because females, despite greater longevity, have a higher prevalence of functional disability. Their longevity may be due to continuing physiological protections in females against atherogenesis and cancer. Despite a better endowment for survival (some due to physiological differences necessary for pregnancy) females have lower muscle strength (adjusted for muscle mass) and males maintain higher levels of functioning.

In making projections, education affects cohort differences in health and functioning; education caused disability to decrease among US elderly between 1982 and 1989 (Manton, 1992). A larger education effect can be expected in developing countries.

Effects are weighted by cohort size. This is illustrated in Fig. 17.3 for the US where the disabled and institutionalized distributions estimated for 1990 and projected to 2020 are presented.

In Fig. 17.3 we plot functional Classes 2 to 6 and the institutionalized, in order. The disabled population aged 65+ increases for both males and females between 1990 and 2020. The male distribution is similarly distributed over age in 2020. For females, their greater survival produces a change of the distribution in impaired states.

Conclusion

We presented a model which represents the effects of nutrition, exercise, and other nontechnical interventions, societal conditions, and the interface of individual physiology and social conditions on functioning and survival. This model can be used to forecast changes in active life expectancy in developing and developed countries. A review of possible interventions suggests a large potential for mitigating the consequences of population aging by modifying age-specific levels of functioning. Whether or not gains are realized depends on the social, economic, and political conditions in a country. What is not often understood is that nutritional and other factors in developing countries increase chronic disease risks and that developing country populations are aging rapidly. Since the financial resources are often lacking in developing countries to support extensive pension, social welfare, and health insurance programs, it is necessary to try to preserve the elderly's health and function to keep them in socially and economically productive roles as long as possible.

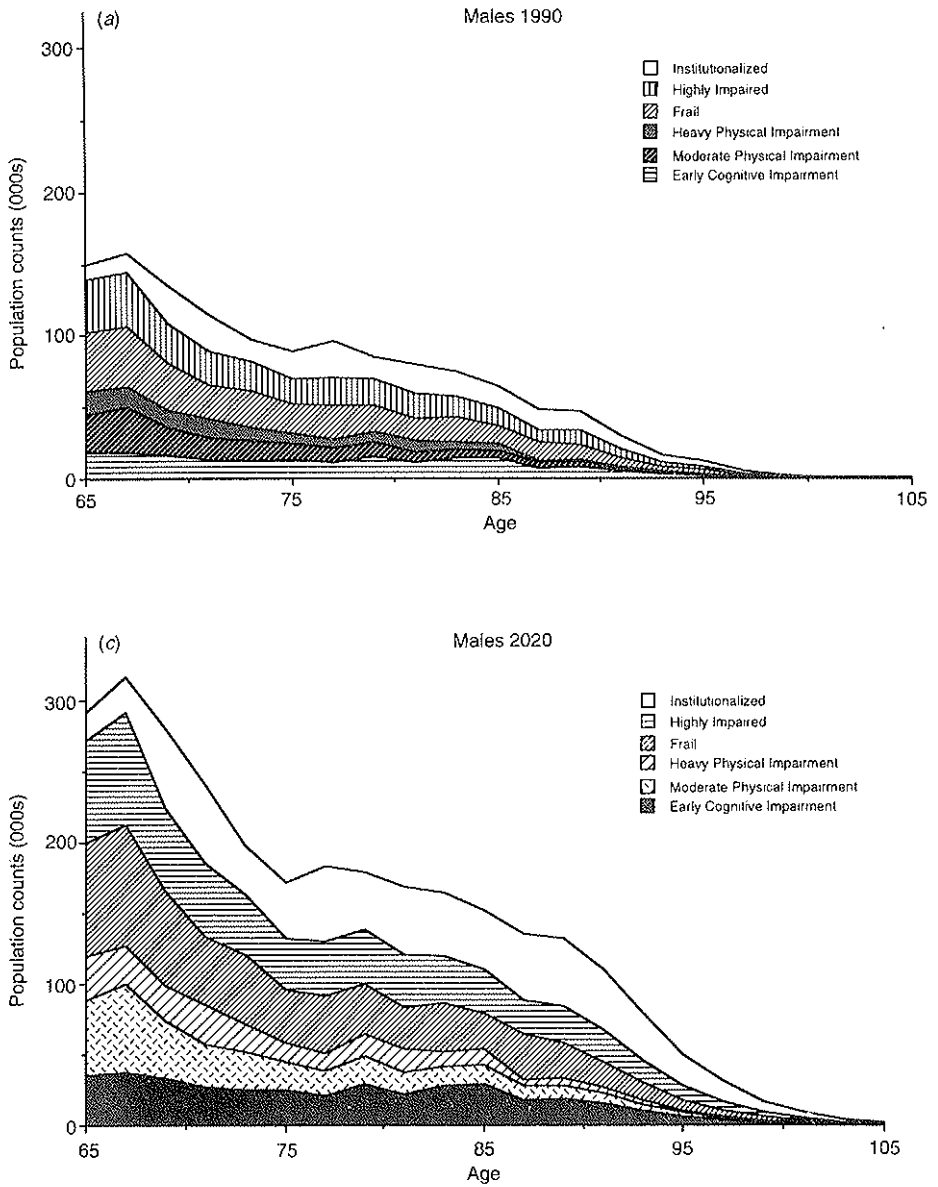
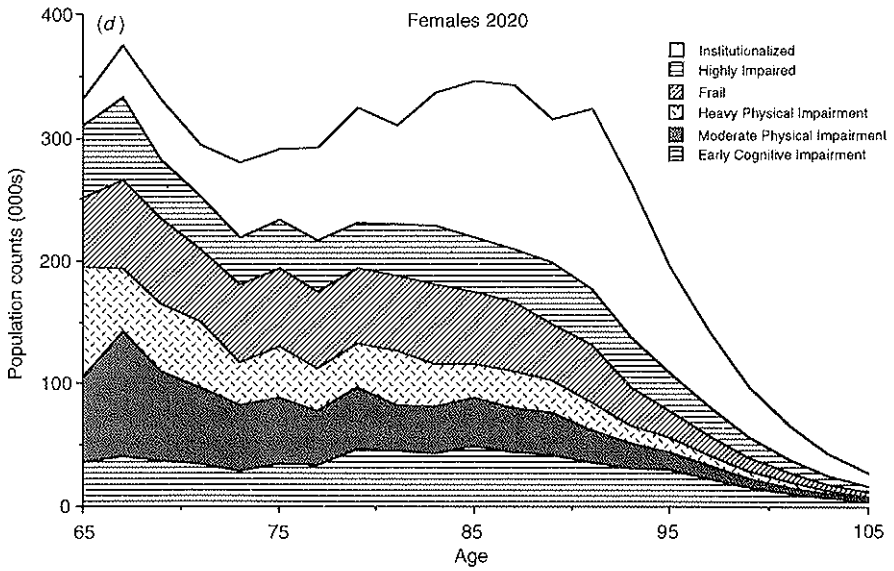
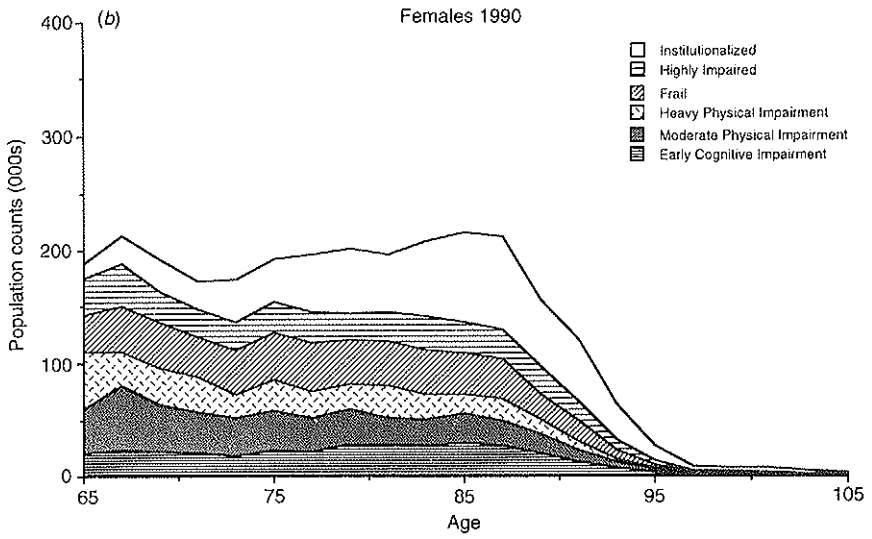


FIG. 17.3. *Distribution of population disability types (000s) by age and sex in 1990 and 2020*



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18 The State of Children's Health in the Developing World

LARS Å. HANSON

The differences between the so-called population pyramids in developing and developed worlds form a good basis for understanding the differences in disease patterns in the two types of societies. In industrialized countries the tall pyramid with a thin base, reflecting an increase in the aged population and a decrease in the young, is connected with the predominance of chronic conditions like cardiovascular diseases, tumors, diabetes, allergies, and arthritis. In contrast, the population pyramid of poor countries is typically broad-based because the majority of the population is young. The patterns here are dominated by the diseases of the young and poor: frequent infections caused by inadequate hygiene with lack of potable water and sewage control, aggravated by crowding; and undernutrition due to lack of sufficient nutrients and to infections. These infections initiate host defense factors, one effect of which is that the sufferer loses appetite; and common diarrheas cause poor uptake and loss of nutrients. Undernutrition impairs host defense mechanisms, although the clinical consequences are difficult to evaluate, but for vitamin A deficiency.

UNICEF reports that 13–14 million children under age 5 years die each year. The large majority of them live in developing countries and the main causes of death are infections and malnutrition. More than 60 percent of these deaths have infections as an immediate cause. Thus every year some 2.8 million children die from measles, whooping cough, and tetanus, diseases that can largely be prevented by available vaccines. Another 4 million die from diarrhea and more than 2 million from pneumonia. Many of these infections, too, can be prevented or successfully treated.

Even though frequent infections and undernutrition dominate the disease patterns in developing countries, chronic diseases certainly exist. They may be “masked” by infections and go unrecognized. Allergies used to be rare in developing countries, but are now becoming common. In Costa Rica about 23 percent of school children have asthma, the highest figure reported so far in the developing world (Soto-Quiros et al., unpublished data).

Much of the data presented in this review stemming from Pakistan come from an extensive field study performed together with my friends and colleagues, Drs. Fehmida Jalil, Bo S. Lindblad, Johan Karlberg, Shakila Zaman, and Rifat Ashraf. I thank them warmly for a most productive cooperation. Our studies were supported by the Swedish Agency for Research Cooperation with Developing Countries; the Ellen, Walter and Lennart Hesselman Foundation; and the H. Svensson Fund, Sweden.

Child Health and Population Increase

The high death rate of children in developing countries is seen in the same poor countries where the population increase is most rapid. Some thirty-five thousand children under age 5 years die every day. Forty-five percent of these deaths occur in India, Pakistan, and Bangladesh. Fifty percent of the world's children who live in absolute poverty are found in these three countries as well. High fertility and poor health with high death rates are part of the "pathology of poverty." Additionally, 35 percent of the children in the world who do not attend school are found in India, Pakistan, and Bangladesh (UNICEF, 1990).

Of around 1.5 billion children to be born during the 1990s, about 97 percent will be born in poverty. This population increase adds some 90-95 million people per year, more than the addition of another India during this decade.

In some areas the population increase may far surpass the carrying capacity of particular areas. It was rather drastically proposed that such public health measures as oral rehydration, saving the lives of many children with diarrhea, should not be made available in such areas because it would only "increase the man-years of misery" (King, 1990). This is not only unethical, it is also highly inefficient. An increased death rate would most likely lead to increased fertility. Furthermore, it would make little difference for the population increase. There may be as many as 1 million cases of AIDS among children in Africa as of 1992. Yet all the deaths from AIDS in Africa projected for the 1990s will have no discernible overall demographic consequence; these deaths will correspond to the population increase during one month on the continent (Potts and Rosenfield, 1990). To make a difference in population growth the fertility of the existing large young populations must be limited.

Child health has improved in many poor countries during the last few decades with expansion of vaccination coverage. UNICEF (1990) claims that, for example,

Table 18.1. *Effects of expanded vaccination programs on child health in developing countries*

Vaccinee	Vaccine	Percent coverage	Number of deaths or cases prevented
Infant	BCG	85	
Infant	Polio	78	1.5 m. cases
Infant	{ Diphtheria Tetanus Pertussis }	75	0.5 m. deaths
Infant	Measles	71	1.7 m. deaths
Mother	Tetanus	44	0.5 m. deaths

Source: Adapted from UNICEF, 1990

the expanding use of vaccines results in the yearly prevention of some 500,000 deaths from neonatal tetanus, 1.7 million deaths from measles, and 1.5 million cases of paralytic polio (see Table 18.1). However, 1.4 million deaths still occur every year from measles, a disease that could, like poliomyelitis, be exterminated from the world with the available vaccines. (It could be added that the economic gains from such campaigns against measles and poliomyelitis would be large.)

Infant mortality (deaths during the first year of life) has decreased in most countries; however, this decrease has stopped in as many as 21 developing countries and increases have even been seen lately in some countries (UNICEF, 1987).

Provision of safe water and sanitation has also spread, but more than 1.2 billion people still lack safe water and more than 1.7 billion people lack sanitation (UNICEF, 1990).

Diseases and Deaths among Children in a Developing Country: Pakistan

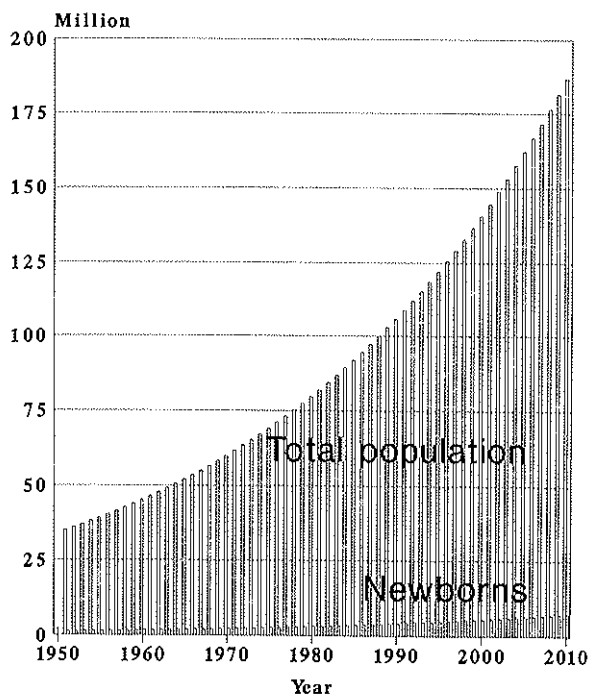


FIG. 18.1. *Total population and numbers of live births in Pakistan from 1950 projected through 2010 based on the Lahore study*

Source: Jalil et al. 1993b, Kahn et al. 1993

In 1950 the population of Pakistan was about 35 million. Today it is 122.6 million (UNDP, 1991), and it is projected to approach 200 million by 2010 (see Fig. 18.1). By that year 50 percent of the population is expected to be urban. As elsewhere, the urbanization process is accompanied by numerous problems of inadequate infrastructure to provide housing, sanitation, and primary health care. Results from a field study in and around Lahore, Pakistan (Jalil et al., 1993b) show that infant mortality of the order of 120 per thousand live births in a village increases to almost 140 per thousand when the villagers move to peri-urban slums. More established city-dwellers, living in the city slums, experience an infant mortality rate of about 90 per thousand, compared with only 16 per thousand among the upper middle class (Khan et al., 1993).

Newborns make up some 4 percent of the total population each year (Fig. 18.1). Ten percent of all newborns die before age 2 years (Fig. 18.2). Since 9.1 percent of the newborns die within 3 months of age, 84 percent of those who die before age 2 years die within the first 3 months of life.

Among the major causes of deaths during the first 24 months are respiratory infections, 13.5 percent; diarrhea, 36.5 percent; other infections, 23.5 percent; and noninfectious causes, 26.4 percent.

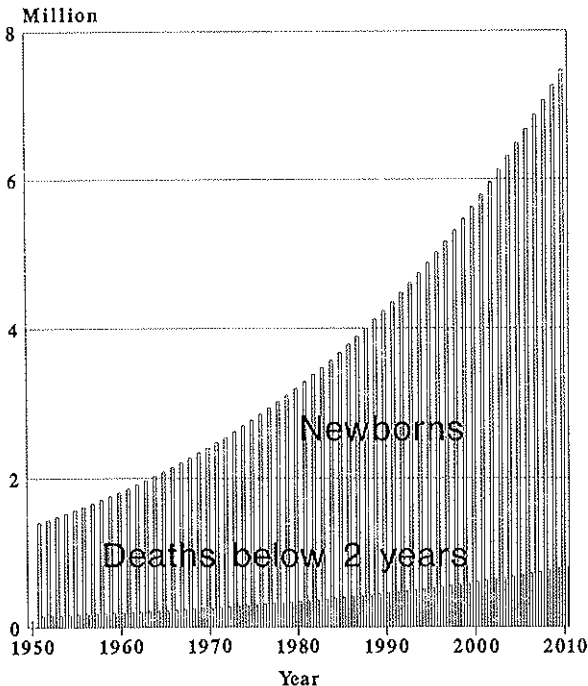


FIG. 18.2. Numbers of live births and numbers of deaths under age 2 years in Pakistan from 1950 to 2010 as calculated from the Lahore study

The Efficacy of Breastfeeding

The two major causes of death within the first three months of life are neonatal septicemia (bacterial infection in the blood of newborns) and diarrhea. Breastfeeding protects efficiently against neonatal septicemia. The risk of this often deadly disease is 18 times higher among infants who are not breastfed (Ashraf et al., 1990). Breastfeeding also protects against diarrhea with an efficiency of 70–80 percent compared to nonbreastfed children among those under age 2 years in the village and peri-urban slum in the Pakistani study (Jalil et al., 1993a). In Brazil infants who were not breastfed were 23 times more likely to die from diarrhea-related disease during the first two months of life than were exclusively breastfed infants (Victora et al., 1987). According to one review promotion of breastfeeding would reduce mortality from diarrhea by 24–27 percent in the age group 0–6 months, and by 8–9 percent in the age group 0–59 months (Feachem and Koblinski, 1984).

Human milk is very rich in a specially structured antibody (secretory IgA) that functions on mucous membranes (e.g., in the gut) by being unusually resistant to enzymic degradation and effects of acid pH (Hanson and Brandtzaeg, 1989). These milk IgA antibodies are produced in the mammary glands but are initiated mainly against the mother's intestinal flora; as a result the breastfed infant is provided daily with large amounts of antibodies against the microbial flora the infant is most likely to meet. A fully breastfed infant receives in grams of these antibodies 10–20 times the dose of gammaglobulin we inject to protect an individual lacking antibodies.

The milk antibodies are protective against e.g. cholera and against diarrhea caused by *Escherichia coli* and *Campylobacter* (Hanson and Brandtzaeg, 1989). Human milk also contains structures that function as analogs to receptors on mucosal epithelium for microbes, for instance the receptors for pneumococci and *Haemophilus influenzae* on epithelial cells from the throat (ibid.). This may be one explanation why breastfeeding protects against middle ear infections, which are often caused by such bacteria.

Analyses of the present modes of feeding in the Lahore study show that breastfeeding often does not begin in the first days of life and thereafter is combined with water and later other foods such as buffalo milk (Ashraf et al., 1993). These additional foods and fluids are given by bottle and are often contaminated with infectious agents. When early breastfeeding was promoted in the study area, the number of newborns given breastmilk within 24 hours of delivery increased from less than 10 to about 90 percent. Whereas almost no mothers exclusively breastfed before the promotion period, about 40 percent did so after and the rest were partially breastfeeding. Similar effects were obtained in the village and the urban populations (Hanson and Jalil, 1991; Ashraf et al., to be published).

Even if breastfeeding can prevent infections and death among young children, it is obvious that many other measures are needed for improving child health. Of the Pakistani population, 54.6 million still have no access to health services, 67.5 million have no access to safe water, and 97.6 million lack sanitation (UNDP, 1991). Among children of school age, 25.7 million are not attending school.

Breastfeeding not only protects against infections but also acts as a contraceptive. The present rapid population increase in many poor areas would have been impossible if breastfeeding were frequent and long-lasting. In the same manner the large number of children seen in many privileged families in previous centuries could only appear because their mothers were not themselves breastfeeding, but were using wet-nurses (Thapa, Short, and Potts, 1988; *Lancet*, 1991).

In nomadic populations, with the mother only able to carry one child while moving over large distances, a spacing between births of four years has been observed, mainly due to prolonged breastfeeding (Wood et al., 1985). Breastfeeding six times daily for two years has shown a contraceptive effectiveness of 90 percent and recently a contraceptive effect of partial breastfeeding was noted in Australian mothers amounting to 98.3 percent at six months, 93 percent at 12 months, and 87 percent at 24 months (Short et al., 1991). Although this may not provide adequate security for many couples, these are strong effects at the population level and useful for the 300 million couples in the world who do not wish any more children, but have no family planning services available. Actually, breastfeeding prevents more births than all family planning programs together in the developing world (Rosa, 1975; also today—R. Short, personal communication). Without breastfeeding, or other contraceptive measures, a mother could optimally deliver 17 children in her life-time (Jeliffe and Jeliffe, 1986).

It is not the volume of maternal milk produced that determines the contraceptive effect, but the number of suckings at the nipple each 24 hours. Stimulation of the nipple provides the necessary hormonal effects and therefore partial breastfeeding can also be efficient (Short et al., 1991). The fact that fertility is often high in traditional societies with a high prevalence of breastfeeding is probably a result of breastfeeding being incomplete (Ashraf et al., 1993) and infrequent. With the present breastfeeding pattern in Pakistan, the contraceptive effect is significant for the first six months of lactation. When the mother works away from home and cannot bring her breastfeeding infant with her, the contraceptive and also some of the anti-infectious effects of breastfeeding are lost.

The Link between Infant Mortality and Birth Rates

King (1990), among others, has questioned the link between infant mortality and birth rates, although other writers, including this author, have claimed a relationship. If declining infant mortality, at least under certain circumstances, can be linked to decreasing birth rates, health policies should make use of this relationship.

Breastfeeding can reduce both birth and infant mortality rates. Birth spacing of less than one year increases infant mortality two- to fourfold compared to a spacing of two years or more (Hanson and Bergström, 1990; Carlaw and Vaidya, 1983). If an infant dies, breastfeeding is interrupted and the mother is likely to conceive again soon, shortening the interval between births and increasing the risk that the next infant will die.

Another link between infant mortality and fertility is provided in a study of twentieth-century mortality decline in England and Wales. Reves (1985) theorizes that lower fertility with smaller sibships is followed by lower infant mortality because of less crowding and fewer infections within the family.

A review by the United Nations (1987), which demonstrates the complexity of the links and the different effects at different levels of development, concludes that infant mortality and birth rates are coupled via several mechanisms. For instance, parents in an area with high infant mortality will have a larger number of children than parents in an area with low infant mortality (the "insurance effect"). These links between infant mortality and birth rates provide a basis for efforts to improve child health.

Investments in Health and Education or in Weapons: Costa Rica

Child mortality has been decreasing in many countries as a result of vaccination programs, improved housing and sanitation, and other interventions. Providing safe water and sanitation costs circa US\$30 per capita. Yearly military expenditures worldwide exceed the income of the poorer 50 percent of the world population (Leger Sevard, 1991). Twenty-nine developing countries invest more in the military than in health and education combined. India expends US\$9,800 million yearly for "defense." In Pakistan 6.7–7.9 percent of gross national product goes for military expenditures, 0.2 percent for health, and 2.2 percent for education (UNDP, 1991; Leger Sevard, 1991). It is doubly dangerous to invest in arms: first, because such investment is a prerequisite for war; and second, because such investments leave less for child health.

Costa Rica abolished its army more than 40 years ago and consistently invests more than other poor countries in health and education (Leger Sevard, 1991; Mohs, 1991). Providing the majority of the population with primary health care, vaccination programs, potable water, and latrines has resulted in major improvements in health. Malaria, parasitic diseases, diphtheria, tetanus, measles, and polio have been largely eliminated. Stunted growth has decreased markedly, presumably mainly because undernutrition caused by frequent infections has been drastically reduced. A striking decrease in infant mortality as well as birth rates has followed. Fig. 18.3 provides another illustration that the decrease in these two parameters is often close temporally.

We have the knowledge required to vastly improve the situation of children in the third world, just as was done in industrialized countries long ago. Applying that knowledge would reduce infant mortality, which in all probability would further decrease birth rates.

Whereas many costly programs to provide potable water, sanitation, primary health care, better housing, and the like will be required to effect the improvement, there is one piece of information that can be implemented at once: breastfeeding properly done can forcefully prevent disease and death due to infection and can have

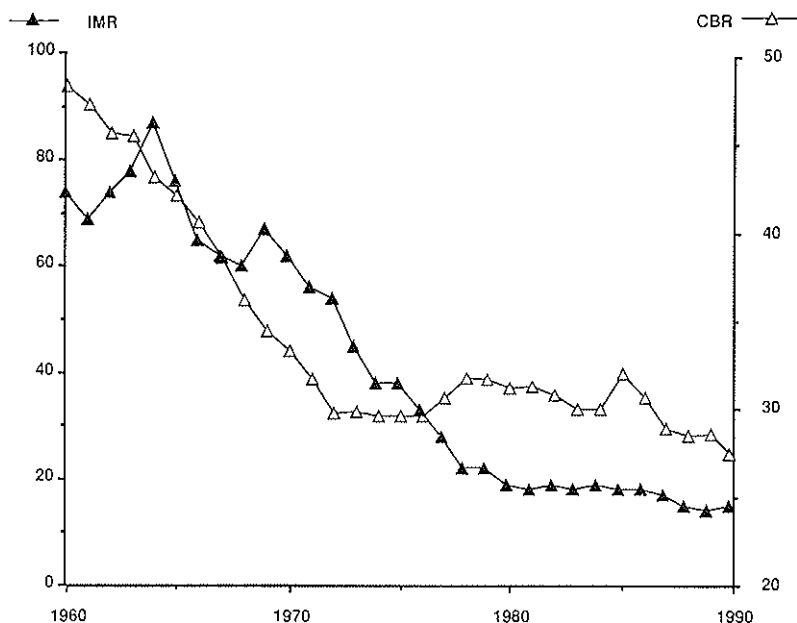


FIG. 18.3. Infant mortality rate and crude birth rate in Costa Rica, 1960–1990

Source: Dirección General de Estadística y Censos, Estadísticas Vitales, Costa Rica

a strong contraceptive effect. Campaigns to promote and teach breastfeeding are noncontroversial, breastfeeding is less expensive than other foods, and it is practicable in populations where modern family planning methods are not readily available. Promotion of breastfeeding provides a base for additional programs for maternal and child health.

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19 Malnutrition and Human Development

S. GRANTHAM-McGREGOR

The most important nutritional deficiencies that are known to affect child development are protein-energy malnutrition (PEM) and iron and iodine deficiency. PEM will be the main focus of this chapter; however, the importance of iron and iodine deficiency is increasingly being recognized and will be briefly discussed. Vitamin A deficiency will not be addressed, other than to point out that an estimated 500,000 new cases of eye lesions attributed to vitamin A deficiency occur annually (*FAO/WHO Expert Consultation*, 1988). The resulting reduced vision or blindness is likely to detrimentally affect the children's development and severely limit their educational opportunities.

Child development is extremely complex and is modified by many different psychosocial aspects of the environment as well as the biological condition of the child. Some aspects facilitate development and some hinder it (Horowitz, 1989). It is, therefore, important to consider the environmental context in which the nutritional deficiency occurs.

Nutritional deficiencies usually occur in situations of poverty that include low parental educational levels, large numbers of children, and lack of stimulation in the home (Grantham-McGregor, 1984*b*). In addition, iodine deficiency usually occurs in isolated rural communities (Hetzel, 1990). These conditions themselves detrimentally affect children's development. Therefore it is not possible to infer a causal relationship between a nutritional deficiency and poor development from the demonstration of an association, and experimental studies are necessary.

An added complication is that infections are also more prevalent in poor environments. Infections adversely affect nutritional status, at least in the short term (Rowland, Rowland, and Cole, 1988). Some, such as malaria and gastrointestinal helminths, also lead to iron deficiency. It is likely that infections per se affect child development but this has rarely been studied (Grantham-McGregor, 1990). There is limited evidence that frequent attacks of gastroenteritis and respiratory infections are associated with poor development in the first year of life (Pollitt, 1983). We have just completed a study in Jamaica in which the number of days young children were too ill to play was detrimentally associated with development (unpublished). Repeated attacks of ear infections are also associated with poor language development, especially in poor environments (Horowitz and Leake, 1980). More

Since the meeting, a well-designed study in Indonesia of anemic children age 12–18 months has been reported (Idjradinata and Pollitt, 1993). The treated children showed a significant benefit from iron treatment on their developmental level.

information is needed on the effects of other prevalent or serious diseases on children's development.

The quality of the environment, the presence of infections and other nutrient deficiencies, and the severity and duration of the deficiency would all modify the effects on development. Also the child's stage of development may be critical in determining the effect.

Iodine Deficiency

Iodine deficiency causes a range of disorders including cretinism, increased pre- and postnatal mortality, goiter, and neuromotor deficits. An estimated 800 million people are exposed to the deficiency, 190 million have goiter, and there are over 3 million cretins (Hetzl, 1990). Two types of cretinism occur, neurological and myxedematous, both associated with mental retardation. In several studies, children in iodine-deficient areas have been shown to have poorer motor, perceptual, and cognitive function than those living in nondeficient areas (Bleichrodt et al., 1987). However, these findings may have been confounded by poor social circumstances. In other studies women were treated in one village but not another (Fierro-Benitez et al., 1986). Children subsequently born in the treated village had better mental development than children in the control village; however, matching of villages is rarely exact. The most rigorous studies have been clinical trials in Papua, New Guinea (Pharoah and Connolly, 1987) and Zaire (Thilly et al., 1980). These have confirmed that iodine treatment of women before conception prevents cretinism and improves motor and cognitive skills in their offspring.

It is now well established that iodine deficiency in utero causes not only cretinism but a range of neuromotor and cognitive deficits. It is not yet clear whether this deficiency restricted to childhood affects mental function. The technology to treat iodine deficiency has been available for some years and the expense is not prohibitive. It is therefore distressing that children are still being exposed to iodine deficiency and that new casualties occur every year.

Iron Deficiency

Iron deficiency is the commonest cause of anemia, and estimates of the prevalence of anemia range from 51 percent in less developed regions to 10 percent in developed regions (DeMaeyer and Adiels-Tegman, 1985). A large number of observational studies have shown an association between iron deficiency anemia and poor mental development in children. Over the last ten years several clinical trials have been conducted in which iron treatment was given to children with iron deficiency anemia. In general, children over age 2 years improved in cognitive functions or school achievement with treatment, although these findings were not totally consistent (Pollitt, Haas, and Levitsky, 1989). Studies with children under 2 years have

often had negative findings except for those in which treatment began before anemia developed and continued throughout infancy. It is possible that the tests available for children of this age range are not sensitive to subtle changes in cognitive function (Simeon and Grantham-McGregor, 1990).

It is reasonably well established that iron deficiency anemia adversely affects concurrent cognitive function in older children. However, there are insufficient data on infancy and on long-term effects. It is likely that if anemia persists for long periods of time, then developmental deficits would develop that would be difficult to remove. This would be the case in most situations where anemia is caused by chronic infection with gastrointestinal helminths or poor levels of dietary iron intake.

Prenatal Malnutrition

The incidence of low birthweight in developing countries ranges from 39 percent in Laos to 7 percent in Chile. This contrasts with an incidence of 1–10 percent in developed countries (Grant, 1991). The excess in low birthweight in developing countries is largely attributed to babies born small for their gestational period (intra-uterine growth retardation, or IUGR) (Villar and Belizan, 1982). Poor nutrition during pregnancy is an important cause of IUGR. These children have higher morbidity and mortality and are more likely to develop postnatal protein-energy malnutrition (Fletcher and Grantham-McGregor, 1988). Studies in developed countries have often shown an association with poor development (Pollitt, 1988).

Few studies of IUGR have been conducted in developing countries. In Guatemala (Villar et al., 1984) children with IUGR showed poorer cognitive development at 3 years of age than children with normal birthweights. There is some suggestion that the effects of low birthweight on child development are more severe in poor social circumstances (Werner, 1986). If this is so then low birthweight is not only more prevalent in developing countries but also would have more serious consequences for child development.

The importance of nutrition in early development is illustrated by the findings of a recent English study (Lucas et al., 1990). In a clinical trial, preterm babies were given an enriched formula in the first few weeks of life. They showed marked benefits in developmental levels, especially in motor development, at 18 months of age.

Postnatal Protein-energy Malnutrition

PEM is associated with many nutrient deficiencies, not just protein and energy. The diagnosis is relatively crude and depends on anthropometric measurement. Originally children's weights were compared with international reference standards for their age and sex (Gomez et al., 1955; *Lancet*, 1970). It is now recommended that

deficits in height (stunting) and in weight-for-height (wasting) be used to diagnose PEM (Waterlow et al., 1977). The natural history (Waterlow, 1988) and geographic distribution (Keller, 1988) of wasting and stunting are different. Wasting reflects recent nutritional deficiencies or morbidity. Stunting takes longer to develop and thus represents poor dietary intakes for longer periods of time. It is unknown whether specific nutrient deficiencies play a role in stunting.

It is estimated that in developing countries 177 million children under age 5 years have weight-for-age below -2 standard deviations of the reference standards (moderate to severe PEM) (Grant, 1991). The geographic distribution of these children is indicated in Fig. 19.1. Moderate to severe stunting occurs in approximately 35 percent of children in developing countries aged 24-59 months, whereas wasting is less common. If PEM affects mental development, the implications of these figures are overwhelming.

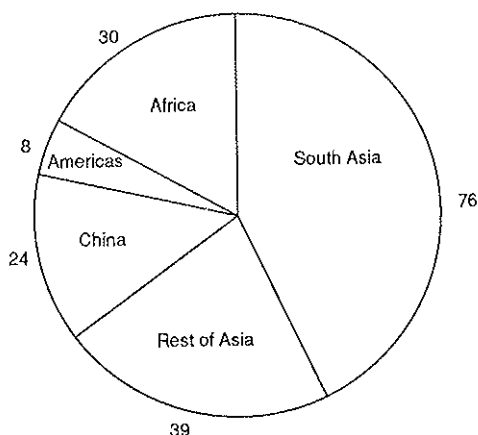


FIG. 19.1. *Absolute numbers of malnourished children, in millions, by region*

Source: Grant, 1991

Severe PEM

In most studies of PEM and mental development the term severe PEM included the syndromes of kwashiorkor, marasmus, and marasmic-kwashiorkor (*Lancet*, 1970). Unfortunately the definitions have not been used consistently, and there has been little attempt to look at stunting and wasting.

In 1956 Gerber and Dean reported that children with kwashiorkor had extremely low levels of development (DQs). It was subsequently shown that although malnourished children's DQs improved a little in hospital, they remained markedly behind those of adequately nourished children (Grantham-McGregor et al., 1982). In the acute stage of malnutrition children were also more apathetic and less active than the controls. In contrast to their DQs, these behaviors returned to normal on recovery

(Grantham-McGregor, Stewart, and Powell, 1991). This indicates that whereas some behavioral changes were transient, others were more difficult to reverse.

In the 1960s and 1970s many studies compared school-aged children who had survived severe PEM in early childhood with matched controls. As the importance of the effects of the environment on development was recognized, controls were more carefully matched for social background (e.g., Champakan, Srikantia, and Gopalan, 1968) or siblings were used for comparisons. These studies have been reviewed in detail elsewhere (Grantham-McGregor, 1989).

A study in Barbados had a particularly comprehensive range of measurements (Galler, 1984). Formerly malnourished children were examined at 5–11 years of age, then again four years later, and were compared with matched controls. They had lower IQs, poorer school grades, and fewer of them had passed the national exams for entry to secondary school (Galler et al., 1990). They also had poorer fine motor skills (Galler, Ramsey, and Solimano, 1985), more neurological "soft signs" (Galler et al., 1984), and lower scores on Piagetian tests of conservation (Galler and Ramsey, 1987). In addition the children had more behavior problems. They had poor attention, were easily distracted, and emotionally unstable, and had poorer social relationships. These children also tended to be sleepy in school and to be more aggressive than the controls (Galler and Ramsey, 1989).

Very few well-controlled studies have followed children into adulthood. In a South African study 16-year-old survivors of severe PEM were not different from their siblings in social adjustment and school achievement (Moodie et al., 1980). However, both groups had very low educational levels, and 25 percent were assessed as having serious antisocial behavior. Where educational opportunities are extremely limited, it is possible that differences will not be apparent in school achievement measures. In Jamaica, we followed a small group of severely malnourished children for 14 years after recovery (Grantham-McGregor, Schofield, and Powell, 1987). The children left hospital with DQs markedly lower than a control group of adequately nourished children who were in hospital with other diseases. Both groups were assessed regularly, first on infant developmental scales and then on IQ tests. The malnourished group's scores tracked below the control group throughout childhood, and there was no sign of improvement. The children also had poorer school achievement levels at age 15 (Fig. 19.2).

In general the findings of case-control studies of formerly severely malnourished children showed that such children had poorer levels of development than the controls. The differences between malnourished children and their siblings were somewhat less consistent and smaller than those between malnourished children and matched controls.

It is probably not possible to control for all factors that affect development (Richardson, 1974). The control groups frequently had more stimulating environments than the malnourished children in spite of the original matching strategy (Richardson, 1974; Cravioto and DeLicardie, 1972). On the other hand, siblings were likely to have been undernourished themselves and may only have differed in

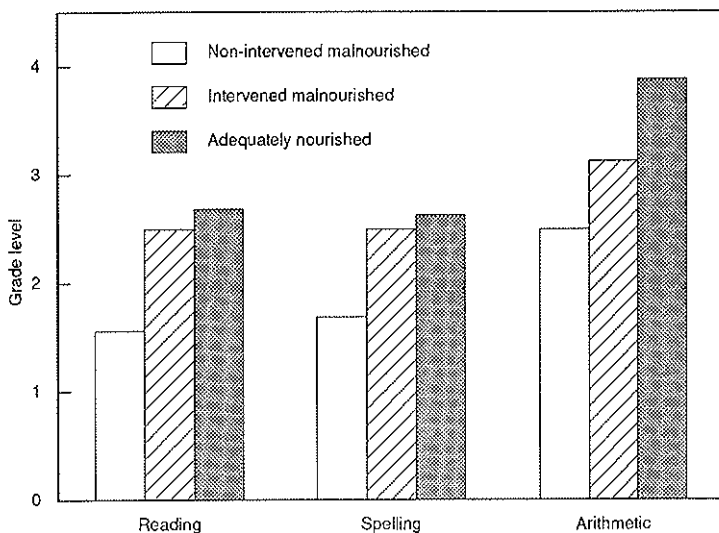


FIG. 19.2. Mean school grades, six years after intervention, in three groups: nonintervened malnourished ($N = 16$), intervened malnourished ($N = 17$), adequately nourished ($N = 20$)

not having suffered an acute episode of PEM. This would have minimized differences attributed to malnutrition.

In spite of the above problems, case-control studies are the best available design for examining the effects of severe malnutrition. From their findings it is not possible to prove conclusively that severe PEM causes poor mental development. The findings are reasonably consistent, however, across many countries. A temporal relationship in which PEM precedes poor mental development has been established in one study (Cravioto and DeLicardie, 1972). In addition, rats that were malnourished in the weaning period have persistent learning deficits on recovery (Smart, 1986). There are several plausible hypotheses as to the mechanism linking PEM to poor development. Therefore using basic epidemiological principles, it is reasonable to infer a causal relationship.

In general there are no consistent findings across studies of a specific cognitive deficit; rather the deficit appears to be global, involving most cognitive functions (Grantham-McGregor, 1984a). However, the children's behavior showed a consistent pattern of low attention levels, unsatisfactory social relationships, and emotional immaturity.

It is not clear to what extent continuing poor environments and poor nutrition, after the acute episode, contribute to the children's poor development or prevent recovery to normal levels.

Rehabilitation Studies

Studies in which children were adopted into much better environments suggest that marked benefits occur. In Chile a group of severely malnourished children were adopted and showed marked improvement by age 7 years; however, few details of this study have been published (Monkeberg, 1990). Malnourished Korean children who were adopted by US families were traced when they were between grades 1 and 8 in school (Winnick, Meyer, and Harris, 1975). Their IQ and school achievement scores were similar to North American norms on routine school testing. Although no early measures of development were available, a marked improvement almost certainly had occurred. However, the children's height, school grades, and IQs were still significantly correlated with their initial nutritional status. The severely malnourished group's IQs were 10 points lower than those of a group that was never malnourished but was adopted at the same time.

There have been few reports of providing malnourished children who return to their own homes with increased stimulation. Psychosocial stimulation programs restricted to the hospital stay have produced transient benefits only (Grantham-McGregor, 1984a). In Jamaica we conducted a three-year program of increased stimulation (Grantham-McGregor, Schofield, and Powell, 1987). Community health aides visited the homes and taught the mothers how to play with their children in such a way as to promote good development. The children showed a large improvement during the program, and some benefit was still apparent 11 years later.

The findings demonstrate that the quality of the environment modifies the eventual outcome of severe PEM. Marked improvement can occur but it is probable that the children do not reach their full potential. Most importantly, the majority of malnourished third world children will almost certainly continue to be exposed to poor nutrition and unstimulating environments. Their chances for rehabilitation under these circumstances are minimal.

Studies in developed countries

A few studies in developed countries have been carried out on children who were malnourished secondary to other diseases. Poor social background is not usually a confounding factor in these cases. The illness itself, however, may well provoke a variety of parental responses. Most studies have shown only small differences between malnourished children and controls or none at all (Rush, 1984), although a recent study in Portugal (Carmona da Mota et al., 1990) found large differences in IQs between a small number of children who were malnourished in the first 6 months of life due to intractable diarrhea and their siblings (mean IQ values 93 and 109). The findings from studies of the effect of malnutrition in developed countries therefore are inconsistent. An explanation may lie in the differences in the severity and duration of malnutrition, as well as the quality of the environment.

Mild to Moderate PEM

In several countries where malnutrition is endemic, young children's developmental levels are significantly related to their nutritional status, after controlling for several social background variables (Grantham-McGregor et al., 1990). The poor standard of school achievement in older children is a major problem in many developing countries (Pollitt, 1990). Several investigators have looked at an extensive number of variables that might affect school achievement. After controlling for many socioeconomic and sometimes education variables, they found that nutritional status still predicted school performance or enrollment. These studies were conducted in the Philippines (Florencio, 1988; Popkin and Lim-Ybanez, 1982), Nepal (Moock and Leslie, 1986), India (Agarwal et al., 1987), and Guatemala (Balderston, 1981).

In Jamaica we found that in poor urban schools, children's achievement levels were related to their degree of stunting and anemia, and to how often they had breakfast and how many days food was available in the home (Grantham-McGregor, Powell, Walker, and Hines, 1991).

Quasi-experimental studies provide stronger evidence than observational studies for inferring a causal relationship. In the 1970s, several preventive nutritional supplementation studies were conducted in countries where malnutrition was endemic. Supplementation was usually given to mothers during pregnancy and subsequently to their offspring, while other mothers served as controls. These studies were conducted in Guatemala (Freeman et al., 1980; Klein, 1979), Bogota, Colombia (Waber et al., 1981; Mora et al., 1979), Mexico (Chavez and Martinez, 1982), and Taiwan (Joos et al., 1983). In the last study, only the mothers were supplemented during pregnancy and lactation. In every study some improvement in children's growth and mental or motor development was found. Motor development was the first area of development to show improvement in two studies (Mora et al., 1979; Klein, 1979) and the only area in one (Joos et al., 1983). In the Bogota study stimulation was also given with or without supplementation, and this benefited mainly language development.

Fewer studies have been conducted in children already undernourished. In a study in Colombia (McKay et al., 1978), 3-year-old undernourished children were randomly assigned to supplementation with or without stimulation. Those receiving both treatments showed marked improvements, whereas children receiving supplement alone did not. In addition there was no association between nutritional status and cognitive development (Bejar, 1981).

Recently two studies have been conducted with undernourished children, in both cases using random assignment to treatment. In Indonesia undernourished children were given supplementation for three months and improvements in motor development only were found (Husaini et al., 1991). In Jamaica (Grantham-McGregor, Powell, Walker, and Hines, 1991), 129 stunted children from poor neighborhoods in Kingston were randomly assigned to four groups: control, supplemented, stimulated, and both treatments. The supplement was delivered to the homes, and the stimulation was a toy demonstration at home (Grantham-McGregor

et al., 1987). The treatments were given weekly for 24 months. The controls were also visited weekly in an attempt to control for any extra attention that the supplemented children might receive. A fifth group of matched nonstunted children was also studied. The stunted children initially had significantly lower DQs than the nonstunted group. The control stunted group's DQs declined further during the study and they substantially increased their deficit compared with the nonstunted group. Both stimulation and supplementation improved the children's development; however, only the group receiving both treatments caught up with the nonstunted group. The effects of stimulation and supplementation were additive (Fig. 19.3). The benefits of supplementation appeared slowly and steadily. Motor development was mainly affected in the first year and improvements occurred in other areas of development in the second year.

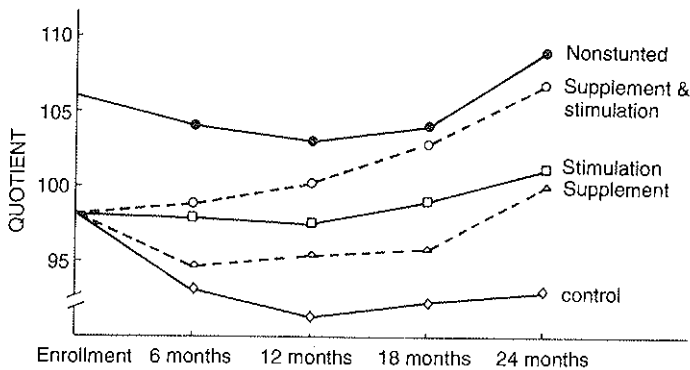


FIG. 19.3. Mean DQs of stunted groups adjusted for initial age and score, compared with a nonstunted group adjusted for age only

Follow-up data from the above studies have not been reported in detail. In the Bogota study (Herrera and Super, 1983) children who had received supplementation did better than nonsupplemented children on school readiness tests at age 7 years. In the Mexican study, supplemented children performed better than nonsupplemented ones in first grade and were more active and attentive in class (Chavez and Martinez, 1981). In the latter study, however, it is not clear how long the supplementation lasted. More recently, follow-up findings from the Guatemalan study have shown that children who received more supplementation in early childhood had better levels of cognitive function after adolescence than those who received less (IDECG, 1990).

The findings from the supplementation studies were consistent in that some benefit to motor or mental development was found. Only one study failed to find some improvement in development from supplementation alone (McKay et al., 1978). The findings from this study are difficult to interpret, because the dietary intakes and growth of the children were not reported.

Motor development consistently improved with short-term supplementation, whereas mental development took longer to improve. In most studies the benefits to development tended to be small; however, the actual increase in dietary intakes and growth was also small. Sharing the supplement with other household members and eating less of the usual diet almost certainly occurred. In all studies the supplemented children's growth failed to catch up to the reference values. Therefore supplementation studies do not permit us to evaluate the size of the effect of undernutrition on mental development, but only to detect the presence of an effect.

In general the early supplementation studies suffered from many design faults (Grantham-McGregor, 1987). These included lack of random assignment to groups, inadequate measurement of the total increase in dietary intake, and lack of a placebo. Random assignment was used in more recent studies (Lucas et al., 1990; Grantham-McGregor et al., 1991; Husaini et al., 1991). Most of the requirements of a clinical trial were fulfilled in these three studies, and it is reasonable to infer that the poor development found in undernourished children is at least partly due to poor nutrition.

Conclusions from studies of PEM

1. It is reasonably well established that severe protein-energy malnutrition detrimentally affects children's development, if they live in poor environments. This effect lasts at least until adolescence.
2. Children's development can improve following severe PEM, if they are exposed to both good nutrition and stimulation. It is unknown, however, whether they reach their full potential.
3. Mildly to moderately undernourished children usually have poor development.
4. Supplementation produces concurrent benefits to the development of children who are already undernourished. In children living in countries where undernutrition is endemic, and who are supplemented from before birth, it is highly likely that benefits occur.
5. It is less well established that supplementation in early childhood produces long-term benefits. More research is required on this topic.
6. Stimulation benefits the development of children living in poverty. It is unclear whether the effects are additive or interactive with nutrition.

Implications

The implications of these findings are sobering. Millions of children fail to reach their potential in mental development as a result of nutritional deficiencies. This is further compounded by psychosocial deprivation. They also fail to benefit optimally from education. Women with poor levels of education have higher fertility rates, and provide less adequate child care and stimulation than better-educated women. Their children subsequently have worse health, nutrition, and development (Grantham-

McGregor, 1984; Levine, 1980; Laos, 1978). Undernourished mothers are also more likely to have low birthweight children.

It is thus no surprise that nutritional deficiency and poor development beget nutritional deficiency and poor development.

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Part VI

Space and Settlement

20 Introduction

MASSIMO LIVI-BACCI

To consider the relationship of space and settlement is to assess the impact of population growth on environment. A thorny subject, as everybody knows; opinions (those of scientists as well as those of the general public) are polarized between two extreme positions.

The cornucopians assume that population growth plays only a minor role in the deterioration of the environment; what matters are the modes of development, the nature of the technologies used, and the regulations governing the use of resources. Population growth, if sustained by the development of adequate energy-saving and resource-saving technologies, and occurring in the framework of a system that internalizes the environmental cost of private and public activities and regulates access and use of primary resources, may be neutral in impact on the environment. Adherents of this position also state that a decline in the population—such as could occur during the next century in the rich countries should their current reproductive patterns remain unchanged—may ultimately result in a slowdown of economic growth, a decline of aggregate investment, and, consequently a decline in the pace of development of resource-saving, energy-saving technologies that minimize the negative environmental impact of human activities.

Seen in this light, it would be misleading to make population the scapegoat of our environmental problems, whose solution is better served by redirecting our priorities to other goals. Disarmament and the end of the build up of nuclear weapons—for instance—is a much more effective way to protect the environment than the slowdown of population growth.

The pessimists, meanwhile, hold that mankind, together with all living species, inhabits a finite world and that growth cannot proceed indefinitely. When growth will have to stop nobody knows, but never-ending growth is impossible. Energy-saving techniques and commodity substitution can accomplish a lot, but they are not a panacea. An increasing standard of living coupled with a growing population is an explosive mixture; consumption of goods increases as does appropriation of space for private and public use, thus consuming that certainly-not-substitutable resource called space.

We can devote great effort to trying to analyze the pros and cons of these polar positions or to seeking to reconcile them around an agreeable middle ground. This may not be the most useful way to deal with the problem, however.

A demographically flexible population is better equipped than others to meet the challenges of environmental constraints. But flexibility (or the ability to adjust the

population numbers to external and societal constraints) requires that warning signals be received by society on time, that the signals be intelligible, and that the corresponding steps be taken by the population. One could argue, for instance, that the present slowdown of the population growth of the West, and the ongoing decline in many areas of Europe, is a collective reaction to signals warning of the dangers of a saturated environment or to the stress induced by a society changing too fast. The collective unconscious asks for a break, and one way to get it is by reducing population numbers. Others will argue differently, but this interpretation, at a very high level of generalization, is not implausible. One of the major problems of the present time, however, is that the warning signals are distorted or weak, or come too late, or are misinterpreted, and that mankind may be facing constraints without the time to adjust to them. I will try to elaborate on this problem.

Let us consider a population, well settled in a given environment, that draws its livelihood from agriculture. Let us suppose that available land, agricultural techniques, and the population are in equilibrium. This population lives in a valley, the low part of it being cultivated; the intermediate land has been turned into pasture; the upper section is kept for wood, regularly harvested for firewood and building material. Suppose that, in a given period, there is an increase in population from some exogenous source (e.g., immigration of new households). Some of the new settlers can make their livelihood in cultivating areas formerly devoted to pasture; but as more families immigrate, it is necessary to cultivate less-productive areas and deforestation commences. It is very likely that the population soon perceives the consequences; the standard of living of the new families is lower because the land they occupy is less productive; deforestation leads to flooding, to erosion, and to a gradual impoverishment of the valley. A not too primitive population will perceive the early warning signals and attempt to regulate the situation. The system issues danger signals that are intelligible early enough for appropriate actions to be taken before the situation deteriorates.

The industrial revolution and the development of trade and transportation have severed the geographical link between production and consumption of resources. The meat we eat may come from Argentina, wood from Scandinavia, minerals employed in manufacturing from North America or Africa, wool from Australia. This is a wonderful thing, the very essence of modern development, but the historical geographical link between production, consumption, and environment is severed; the issuing of warning signals confused; their perception distorted. An increased level of human activity is responsible for the so-called greenhouse effect, but its adverse effects will become perceptible only after a very long delay and the first ones—a warming of the atmosphere—may even be mistaken (in certain climatic regions) for a positive development. Other examples of inefficient and distorted signals that endanger the ability of mankind to regulate its growth could be cited.

Constraints change in nature. Subsistence and energy may not be serious limits to growth, as they were at the time of Malthus, but space, water, and air are. Constraints tend to be more and more “global” in nature, but the warning signals are uncertain,

ambiguous, and tend to come late. The factors of choice and adaptation to external constraints also change. Biological adaptation may face new challenges; thousands of years have made mankind fit to withstand nutritional stress, or the variability of climate, or the physical fatigue of hard work. But the change of environment and the changing rhythm of life produce other types of constraints that require the development of other types of adaptations and reactions: we know little about their nature. In any case the global nature of problems generated by the increased interdependence of the world requires an increased degree of prudence. Control of population growth is one element in the strategy of global survival and therefore tends to be less and less a matter of calculation and more and more one of values.

21 The Impact of Population Change on Environment: An Overview

JOHN I. CLARKE

Rapid world population growth and global environmental change are two of the great concerns of our age, and for many people they are closely linked. In this chapter we examine those links.

Concern about world population growth spread after the mid-twentieth century, when it became apparent that rapid mortality declines in the developing countries were not accompanied by comparable fertility declines. Annual rates of natural increase in some developing countries rose as high as 3–4 percent, far in excess of those previously experienced by industrialized countries during their slower demographic transition in the nineteenth and early twentieth century.

Concern about global environmental change and environmental degradation in general is more recent, dating particularly from the 1970s. It is more a product of the space age, when satellite imagery has highlighted the global unity of the earth's ecosystem, the interdependence of environmental and human phenomena, and humanity's increasing ability to exploit resources and to wreak ever more drastic environmental damage (e.g., Davis, Bernstam, and Sellers, 1989). If anything, global environmental change currently attracts even more attention and alarm, in the West at least, than world population growth, not only because some of those living in the resource-exploiting industrialized countries feel more directly responsible, but also because of the unforeseen consequences of the phenomena of ozone depletion, the greenhouse effect, and climatic change, as well as the growing general awareness of the complexity of ecological interrelationships.

Here one should emphasize "interrelationships," for population and environment influence each other. In this two-way relationship, population growth not only affects the environment, but is affected by it. Among traditional rural societies of the past, the environment exerted greater influence upon populations; as societies have become less land-bounded, more urbanized, and more technological, they have exerted greater influence upon the environment. However, the influences are never all in one direction.

Correlations

Unfortunately, there has been widespread oversimplistic correlation between world

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population growth and global environmental change and degradation, the former being regarded as the main, even sole, determinant of the latter, sometimes without qualification. This attribution of blame must be partly because of their simultaneity at the global level—they have occurred together, therefore they must be related. Some very distinguished voices, many of them those of nonscientists, have been unequivocal in laying the blame on population growth. This to all intents and purposes places the blame undeservedly upon the poorest countries, which are currently experiencing the most rapid population growth, whereas the richest countries in fact use far more resources. In reality, the phenomena of population growth and environmental degradation are extremely complicated and are separated by many intervening and ultimate factors, some social and cultural such as types of settlements and religion, some economic such as the changing resource consumption and economic activities of populations, and the growth of technologies, trade, and use of energy.

Fig. 21.1 is a simplified depiction of population-environment relationships. It demonstrates the appropriateness of thinking of population as comprising the three dynamic elements of fertility, mortality, and migration, which interrelate with the three stock elements of size, distribution, and structure. The environment may also be conceived as comprising the four basic elements of air, water, energy, and materials, which interrelate with the extremely uneven human occupancy of the environment. This may be somewhat crudely divided between the built environment, the nonbuilt but occupied/utilized environment, and the uninhabited/unutilized

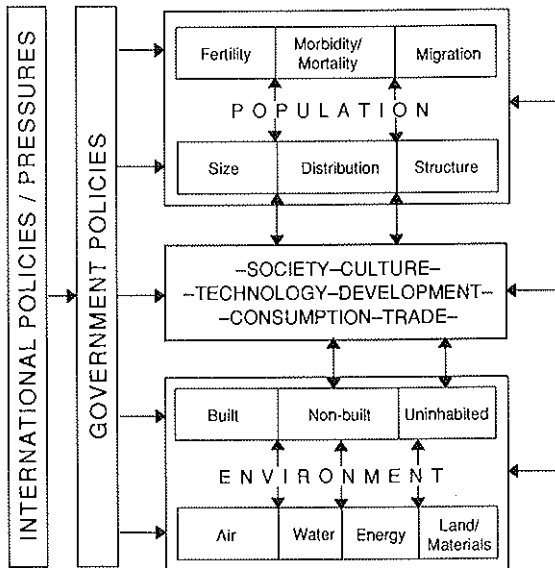


FIG. 21.1. *Interrelationships between population and environment and the intervening factors*

environment. Fig. 21.1 indicates that all these demographic and environmental factors, as well as the intervening factors, affect one another and are all increasingly affected by political decisions and events at national and international levels, such as the impact of warfare and of decisions concerning locations (e.g., of industries, towns, ports, communications) (Commoner, 1988, 1990).

The whole system is extremely dynamic, as all the elements are continually changing. Observers have emphasized the finite nature of resources, but resources become economically significant only with technological knowledge. Thus the variety of resources is constantly expanding, and in many developed countries raw materials are being used more efficiently and are being substituted for new materials (e.g., ceramics). Consequently, the gap in materials used by the more and the less developed countries is constantly growing.

The links between population growth and environment therefore tend to be more indirect than direct, more proximate than ultimate (Shaw, 1989; Keyfitz, 1991), and consequently they are not clearly understood. Certainly, world population growth has contributed greatly to global environmental change, but it alone is not responsible. In the same way, to advocate family planning or "population control" as the prime solution to global environmental change is an oversimplification. Other actors must play their part (Myers, 1991).

World population growth and global environmental change are, of course, aggregate phenomena, each comprising enormous diversity of local situations. Through the interplay of natural change and net migration, local populations may be growing or declining annually at rates in excess of 5 percent, and have very irregular population age pyramids. Similarly, the environmental impact of population densities may vary from vast urban agglomerations to wildernesses scarcely touched by humanity. Moreover, the extremes of population growth and density may not be closely correlated with environmental impact or degradation. The latter may be associated with high or low population growth and high or low population density. It may be caused by all manner of phenomena: the milling masses of a third world city, overpopulation of a steep mountain slope, overstocking of semi-arid pastures, rapacious deforestation of tropical rainforests, excessive tourist pressure along a coastal fringe, a chemical or nuclear disaster, the wreck of an oil tanker, inadequate disposal of sewage, abandonment of an environment by out-migrants, and so on.

Scales

Therefore the complex web of population–environment interrelationships may be examined at many spatial scales from the global to the local. On the one hand, studies may be concerned with such macro-issues as:

- the correlation of population data with environmental data derived from satellite imagery;

- the identification of population–environment crisis areas, present and future;
- the effect of population upon the disruption of ecosystems (e.g., by deforestation or desertification) and on the loss of biodiversity;
- environmental degradation and international migration;
- the relative impact upon environmental degradation of different sizes of settlements;
- the prevalence of environmental diseases like malaria, river blindness, and sleeping sickness;
- the potential health problems caused by the greenhouse effect, particularly the increase in carbon dioxide, and the effects of global warming upon disease vectors, heat stress, and food production.

On the other hand, there are many micro-issues to be examined, for example:

- the impact of outmigration or immigration upon the local environment;
- the effect of local populations upon specific environments, like a river estuary, a coastal zone, a mountain massif, a desert margin, or a small island;
- the decline in the quantity and quality of water;
- the disposal of industrial wastes;
- the relationships between local environments on the one hand and morbidity, mortality, and fertility on the other;
- the contrasting roles of women in environmental management and the control of resources;
- the influence of environmental variables upon the cost of childrearing;
- the ability of households and communities to respond to environmental change and protect themselves from it.

The spatial scale of analysis is inevitably influenced by the nature of environmental phenomena under consideration; hence, land use/cover and urban pollution necessitate a finer grain of analysis than climatic change or marine pollution.

Population–environment interrelationships may also be studied on different time scales, from the long-term environmental effects of increasing urbanization and migration, the effects of rising population on water management and availability, and the potential effects of rising sea-levels upon the population distribution of coastal lowlands, to the short-term catastrophic effects of many forms of sudden disasters: floods, typhoons, earthquakes, tidal waves. The insidiousness and lower visibility of the long-term events often mean that they attract less attention in the media than the more dramatic impact of disasters, which are now daily events in our livingrooms, thanks to the improvements in worldwide communications. It does not mean, however, that they are less important; indeed, disasters, at least those of environmental origin, do not have as much overall demographic effect as many long-term processes (Clarke et al., 1989).

The matter of scale of analysis is further complicated by the problem of linking explanations of demographic and environmental phenomena at different levels of scale (Clarke, 1976). Numerous examples might be cited. In the case of population distribution, the global pattern is greatly influenced by climate, a primary cause of

vast uninhabited areas such as Antarctica, tundras, deserts, and mountain massifs, whereas local patterns of population distribution are little influenced by climate. As for migration, international migration is motivated mainly by long-term economic opportunities, poverty, and political oppression, whereas intradistrict migration is motivated more by prospects for marriage, housing, and short-term economic opportunities. In the case of environmental phenomena, some localized events such as earthquakes and tidal waves may cause heavy loss of life, but generally such events are not major causes of world mortality. Other localized events, such as the ozone hole over Antarctica or a major volcanic or nuclear explosion, may have much more widespread, even global effects. Hence the problem of linking the explanations of diverse local events with global generalities, of linking the micro with the macro, is important and requires resolution. We must all become more aware of local actions having global effects (Gallopín, 1991).

Not surprisingly, studies of population–environment relationships tend to form a nested hierarchy, from the anthropological and sociological through the economic, political, and geographical, to remote sensing and geographical information systems.¹

Changes

One of the main complications in studies of population–environment relationships is the character of changes. While it is relatively easy to explain and predict long-term constants like the lack of population in certain uninhabited areas and long-term trends such as demographic transition, urbanization, and population concentration, it is much more difficult to handle fluctuations and cycles like those in fertility and counter-urbanization in industrialized countries, and the shifts and discontinuities that pose so many of the problems of today. Shifts and discontinuities may be

¹ The need for a more multi-disciplinary approach is now being stimulated and encouraged by international bodies such as the United Nations Environment Programme (UNEP), the United Nations Conference on Environment and Development (UNCED), the United Nations Development Programme (UNDP), UNESCO's Man and the Biosphere, other UN organizations like FAO, ILO, UNFPA, WHO, and UNICEF, the International Social Science Council's (ISSC) Human Dimensions of Global Environmental Change programme, the World Bank, the International Union for Conservation of Nature and Natural Resources (IUCN), the International Union for the Scientific Study of Population's (IUSSP) Committee on Population and Environment, the Committee for International Cooperation in National Research in Demography (CICRED), as well as international institutes like the International Institute for Applied Systems Analysis (IIASA), the International Institute for Environment and Development (IIED), and the World Resources Institute. In addition, national research councils such as the American Social Science Research Council (SSRC) and the British Economic and Social Research Council (ESRC) are promoting research, as have national governments (e.g., British Overseas Development Administration), research foundations (e.g., MacArthur, Menon; Jessie Smith Noyes), and many university research centres (e.g., Morrison Institute for Population and Resource Studies, Stanford, California; University of Michigan Population–Environment Dynamics Project; Carolina Population Center; Chr. Michelsen Institute of Bergen, Norway). In short, population–environment relationships have become a fashionable research field, particularly because it is of more than academic interest to geographers, demographers, and others, in assessing and overcoming some of the major problems facing the world.

instantaneous disasters or catastrophes, such as earthquakes and major accidents, or successes such as technological and medical breakthroughs. On the other hand, they may be more prolonged, like the recent political changes in Eastern Europe, the diffusion of AIDS, or the devastating drought in the Sahel. Demographers in particular have found it difficult to deal with such discontinuities in their long-term projections, most of which have been based upon the assumptions of continuity of existing trends. Yet demographic history is full of unexpected events, long and short, major and minor. No wonder that population projections are far from being an exact science: those for the year 2025, well within the lifespan of today's younger adults, give world totals of 7.6, 8.5, and 9.4 billion, a range of 1.8 billion, which inevitably means that the middle value is usually taken. We have a tendency to accept averages when ranges are wide.

Long-term Population Growth and Redistribution

When Malthus first wrote about population at the end of the eighteenth century, the world's population was about one billion, less than one-fifth of what it is today. Fertility and mortality were universally high, and abundant "natural checks" prevailed, so that population growth was restrained. At the same time, two-thirds of the world's population lived in three agricultural heartlands of the Old World, in China, India, and Europe. Elsewhere populations were generally scattered with low densities, except in a few localized peasant civilizations as along the Nile valley. Agriculture was the preponderant occupation of mankind, and only 2 percent of the world's population lived in towns.

The nineteenth and twentieth centuries have witnessed not only massive population growth, triggered by scientific and technological advances, but also a transformation of societies, economies, and politics, and of the patterns of population distribution and of population-environment relationships. The transformation was initiated in Europe, but diffused gradually around the world, and in many ways the changes in population distribution and concentration have been just as important to population-environment relationships as the mere growth in numbers.

At first, demographic growth was largely confined to Europe, which witnessed industrialization, urbanization, and concentration of population on coalfields and other mining and coastal areas. Populations became less land-bounded, more mobile, and less evenly distributed. As population growth increased, Europe opened a safety valve, facilitated by improvements in transportation, to the colonies of the new "Europes Overseas," thus initiating a massive change in distribution of world population. In the early nineteenth century more people lived in Britain than in North America and more lived in Europe than in all the New World and Africa put together. The "empty areas" of the Americas, southern Africa, Oceania, and Soviet Asia were sparsely inhabited (by European standards) by numerous indigenous peoples at lower levels of economic development. Consequently such areas were extensively settled by Europeans and indentured workers from Asia and Africa at

much lower densities than were normal in Europe, except in the peripheral core areas where ports and cities linked the colonial economies with the European homelands. These patterns of population distribution have persisted in the "Europes Overseas"; despite rapid population growth and coastal concentration, they remain less densely peopled and their population-environment relationships differ substantially from those of Europe itself, not least because the vast interiors of the Americas, Asia, Oceania, and Africa remain relatively sparsely occupied. However, they joined with Europe in developing modern industrialization and urbanization, becoming part of the developed world. Development elsewhere was much more restricted.

Indeed, by the middle of the twentieth century, when the world's population had reached about 2.5 billion, a strong demographic contrast had evolved between the developed and developing countries: between the low birth, death, and natural increase rates, low levels of agricultural employment, and high levels of industrialization and urbanization of the former and the high birth, death, and natural increase rates, high levels of agricultural employment, and low levels of industrialization and urbanization of the latter. The dichotomy was born, which later became a trichotomy between the first, second, and third worlds. While the dichotomy was never entirely clear cut, from a demographic viewpoint the contrast was never greater.

Since mid-century the world's population has soared to 5.4 billion today, and currently nearly 100 million are added each year. However, a number of processes have vitiated the oversimplified dichotomy between developed and developing countries, at least demographically, for while there has been convergence of vital rates in developed countries, joined by Japan, there has been divergence in developing countries. The developing countries now account for 77 percent of the world's population and the percentage is rising despite the fact that they dispose of only about 15 percent of the world's income. Demographic diversification among developing countries is not unrelated to their growing economic differentiation, with the emergence of oil-rich countries, newly industrialized and middle-income countries, as well as an excessive number of poor, least developed countries, which generally have experienced little decline in fertility, mortality, or population growth. The majority of this last group are located in sub-Saharan Africa, which with sustained high fertility and some lowering of mortality has become the most rapidly growing world region demographically and the focus of some of the worst problems of the developing world.

There has also been a growing social differentiation of populations, augmenting the plethora of cultural contrasts through diverse levels of social progress—in education, housing, social and health provision, and in the changing roles and status of women. Cultural specificities have gained importance in differentiating demographic characteristics, as for example between the Han population of China, which has undergone dramatic demographic transition, the Muslim populations of the Middle East and elsewhere who have enjoyed declines in mortality but much less decline in fertility, and many animistic populations of Central Africa who have

experienced little demographic transition. Cultural characteristics often offer better explanations of demographic difference than purely economic factors.

In addition, both the developing and latterly the developed world have undergone growing political fragmentation. The diffusion and proliferation of the European state model has meant that there are now more than 200 countries, of which more than 170 are independent (compared to 72 in 1945). The world is in such political flux that the number is growing annually. It has led to the nationalization of populations, affecting migration, vital rates, and population patterns. Government policies directly or indirectly exert widening influence upon the growth, movement, distribution, composition, and activities of populations, and hence upon population-environment relationships, though the emergence of supranational bodies such as the European Community is beginning to change the concept of the state.

Not surprisingly international inequalities are wide and increasing. The UNDP Human Development Index, which combines life expectancy and education levels as well as basic purchasing power, reveals huge contrasts between Japan and Canada at the top of the league and Gambia and Sierra Leone at the bottom. Although the index should certainly be handled with care (Kelley, 1991), it is a shattering reflection on "progress" in the modern world in which a billion people are estimated to live in absolute poverty, 1.5 billion without primary health care, and a billion adults unable to read or write.

These enormous inequalities are reflected in the demographic situations of countries and are having profound effects upon the changing balance of world population distribution. Since 1950, the continental leadership in population growth rates has passed from Latin America to Africa, where Kenya has had the unenviable reputation of the most rapid population growth rate. In consequence, Africa's population will rise from about 9 percent of the world total in 1950 to about 15 percent in 2000 and possibly 20 percent in 2030, when it may equal that of South Asia, be twice that of Latin America, and be more than the developed world or China. Similarly, because China has witnessed much greater demographic transition than India or South Asia as a whole, China will be overtaken by India as the world's largest population during the early part of the twenty-first century. The aging populations of the developed world, particularly of Europe, will be increasingly outnumbered. Moreover, not only will the balance of the continental population change on the basis of differential natural increase alone, but there will be a substantial alteration in the cultural balance, with the Muslim populations overtaking Christian populations through higher natural increase.

Concentration

Even more striking than the process of continental redistribution over the nineteenth and twentieth centuries has been the increasing concentration of population on a relatively small proportion of the Earth's surface, notably in economic core areas and cities. At the same time there has been relative abandonment of environments

that have proved hostile to dense human habitation—deserts, semi-deserts, mountain masses, and tundras—which cover between two-fifths and one-half of the Earth's surface, particularly in continental interiors. Unfortunately the limited amount of population data that is georeferenced makes it very time-consuming to attempt even rough assessments of the level and rate of population concentration (Clarke and Rhind, 1991). International estimates are made from a highly uneven mesh of political units that conduct censuses with varying frequency, comprehensiveness, accuracy, administrative subdivisions, and definitions of urban status. So general estimates of world population concentration should be taken with a pinch of salt, as considerable improvements are necessary in population enumeration.

Core areas incorporate a high proportion of the world's population growth through natural increase and net immigration. The growth of the world economy has influenced their location mainly in coastal zones, so that by the end of this century it is expected that two-thirds of the world's population will live within 60 km of the coast and as many as three-quarters will live within tropical developing countries (UNCED, 1991*b*). Inevitably, many of these coastal concentrations, especially the densely peopled deltas of Asia and low-lying islands, are acutely vulnerable to even moderate rises in sea level, as highlighted by the frequency of tidal waves and tropical storms devastating Bangladesh.

The march of urbanization, mostly within the core areas, proceeds so rapidly that today some 48 percent of the world's population live in towns, and the percentage could rise to 60 by the 2020s. While urban growth has now slowed to about 0.8 percent yearly in the developed world, it is about 3.6 percent on average in the developing world and has been at least as high as this since the early 1950s. Consequently, in 1990 61 percent of the world's 2.26 billion urban dwellers lived in the developing countries, and by 2025 nearly 80 percent of over 5 billion urban dwellers will reside in developing countries. Levels of urbanization in these countries range from less than one-tenth in parts of East Africa to over seven-tenths in parts of Latin America, levels comparable to those of developed countries. In previously sparsely urbanized parts of the world like sub-Saharan Africa the problems of adjustment to rapid urban growth in excess of 5 percent annually are particularly severe.

The growth of large cities is also remarkable. By the year 2000 half of the world's urban dwellers will be living within cities of a million or more inhabitants. In contrast to the deconcentration, counter-urbanization, and declining population taking place in many large cities within the developed world, the major cities of the developing world are growing rapidly; well over half of the 100 cities with 2 million or more inhabitants are in the developing world, which by the end of this century will probably comprise two-thirds of the 24 cities expected to have 10 million or more inhabitants. Some are very dominant primate cities far exceeding other cities within the urban hierarchies of their countries—Mexico City, Seoul, Buenos Aires, Cairo, Manila, Jakarta, and Tehran—despite a variety of government policies designed to slow excessive urban primacy (Oberai, 1988, 1989). Although some smaller countries with authoritarian policies have achieved decentralization, like Cuba and Sri Lanka, larger countries like China and Indonesia have not, though

Nigeria is an interesting example of how federalism has assisted decentralization. Obviously, rapid mega-city growth in developing countries creates numerous environmental problems, where slums, shantytowns, air and water pollution, and inadequate sewage disposal prevail. A recent survey (Population Crisis Committee, 1990) of the quality of life and environment in the 100 largest metropolitan areas of the world revealed that all of the 54 cities ranked "fair" or "poor" were in the third world except Naples, and only 4 of the 44 cities ranked "good" or "very good" were in the third world: Singapore ("very good") and Taipei, Hong Kong, and Ankara (all "good"). Unenviably at the bottom of the scale were Lagos and Kinshasa, which no doubt would have slumped even lower had the survey been taken after the disturbances of 1991.

Urban densities in Indian cities like Bombay, which has an average density exceeding 300,000 persons per square kilometer, cause special difficulties of pollution, environmental degradation, and health, especially when the urban structure forces the poor to live cheek by jowl with factories. The Bhopal disaster drew the world's attention to the vulnerability of the urban poor in congested environments; with inadequate housing, water, and sanitation, the poor are always the first to suffer from such calamities (UNCED, 1991a). Among them, women are often especially vulnerable.

Of course, cities concentrate the consumption of resources, the production of waste and pollution, and many of the environmental health problems, as is all too evident in Calcutta. They also compete for fuelwood and often, like Cairo, encroach upon some of the best agricultural land. Despite this, it is not always clear that population concentration increases aggregate environmental degradation within a country as a whole, because sometimes the concentration of political power within cities enables environmental problems to be more easily tackled.

Rural Poverty

Since mid-century, rural population growth in less developed countries has averaged about 1.5–2 percent per year, less than half that of urban growth but rapid enough to provoke major problems of adjustment. Increasing population pressures in marginal areas, especially semi-arid lands, inhabited mountains, and some humid tropical forests, have led to greater demands for food, fuel, and water. This in turn has led to changes in land use, agricultural systems, and production, sometimes accelerating environmental degradation of fragile ecosystems. However, it is not always excessive rural population growth or density that provokes degradation; sparsely inhabited rural areas suffering depopulation can also suffer from overexploitation by livestock-farming, bush fallowing, or forestry leading to deforestation, desertification, soil erosion or infertility, all problems that tax the ingenuity of the rural poor (UNCED, 1991a).

Environmental policies should endeavor to reconcile environmental conservation with the alleviation of poverty through more balanced and equitable economic

development. There should be harmony between the provision of sustainable livelihoods for all and the protection of the environment. The term "sustainable development," defined simply as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission, 1987), is capable of various interpretations and is not easily achieved. It is certain that population, environment, and development are an inseparable troika (Wahren, 1991).

Because the poor often live in ecologically fragile areas, UNFPA has elaborated an ecological approach to population and development planning that identifies critical concentrations of population within specific areas where carrying capacities are exceeded by existing agricultural practices. A methodology for identifying such areas is unlikely to be universally useful because geographical diversity is so great. However, the FAO studies (Higgins and Kassam, 1985) of potential population-supporting capacities of 117 developing countries have proved a valuable source for studies of specific unsustainable enclaves in a number of countries of eastern Africa: Kenya, Uganda, Sudan, Rwanda, Burundi, Ethiopia, Djibouti, and Somalia. Many of these countries also suffer severe political difficulties that exacerbate population-environment problems.

Population pressures and carrying capacities are not easy to quantify. They are greatly affected by such factors as ecological and land-use systems, conservation practices, the development of trade, circulatory movement of people, and remittances from migration, all of which vary greatly so that population pressure may bear little relation to population density. To answer some of these problems and relate carrying capacity to self-reliant development and sustainability, King and Slesser (1990) have developed a model called ECCO—Enhancement of Carrying Capacity Options—which offers a useful analytical method for looking more holistically at situations by examining energy transfers in the ecological systems. So far they have applied their model to Mauritius and Kenya, and in the latter country a substantial decline in the birth rate is seen to be necessary (Njoka, 1990).

Women and Children

In both urban and rural environments women play an important if rather neglected part in population-environment relationships. The varying roles of women around the world have led to considerable differences in their use and control of resources and their contribution to environmental management. Despite their greater vulnerability to pollutants of air, food, and water, especially as related to childbearing and childrearing, they have often been ignored in environment and development policies. Furthermore, despite their numerous agricultural tasks, especially for example in sub-Saharan Africa, they have little access to land ownership, credit facilities, and modern technologies. Too often they are not involved in decisionmaking about environmental issues, yet have to work harder in response to environmental degradation. Primary environmental care, like primary health care, is important and

women have a vital role to play in both, a role that is greatly enhanced by increased female education. The latter is undoubtedly a key to social and demographic transition and perhaps to greater environmental well-being.

Migration

This topic is not examined in detail, because it is addressed elsewhere in this volume. Migration is of course one response to both population growth and environmental degradation, but its direct and indirect causes and consequences at both source and destination are numerous. It is not always a relief to environmental degradation in rural areas or the prime cause of it in urban centers. The positive and negative effects of migration in the form of a balance sheet are rarely calculated in full, especially with the environment in mind.

Migrants move in millions over international boundaries, usually from poorer to richer countries, where population growth is slower, populations are aging, labor supplies are shorter, and employment opportunities are greater. Economic migrants are supplemented by refugees from political and environmental crises, as toward the coastal states of Africa, the oil-rich countries of the Middle East, and from North Africa to Europe. Their numbers may well increase, and since international migrants tend to localize in cities in the countries of destination, the problems of environmental degradation in those cities may also increase, with both local and global effects.

Perceptions

Population-environment relationships are perceived very differently by peoples around the world. For traditional societies in developing countries, population and environment are inseparable and symbiotic, to the extent that people are regarded as part of the environment. Peoples have had to remain in balance and equilibrium with the environment in order to survive. Forests, for example, have had to be maintained for hunting, collecting, and firewood. Population growth, along with modern economies in the form of commercial agriculture, manufacturing, the service sector, and urbanization, have greatly transformed traditional adaptations to the environment, causing much disequilibrium in population-environment relations. Often this expresses itself in the form of environmental disasters, which are most frequent in the poorest countries that are least able to cope with them. In some cases one poor country affects another; deforestation in Nepal is not only destructive there, it also affects India through greater run-off and is devastating downstream in Bangladesh, where rapid population growth leads to occupation of ever more physically vulnerable lands.

Generally, people in developing countries have more circumscribed views on environment than those in developed countries. They are more aware of rubbish in

the streets, air pollution over the city, or the quality of water in the local river than they are of global issues such as deforestation, desertification, loss of biodiversity or depletion of the ozone layer. Yet they often become adjusted to or even tolerant of deteriorating local conditions, though overcrowding in cities generally reduces attitudes of sharing and increases attitudes of competition and aggression. Inevitably desires for development outweigh expressions of concern about the environment.

In wealthy advanced countries there is an opposite trend, from dominant materialist values toward post-materialistic values, from individualistic toward more collective views, from blackness to greenness (Inglehart, 1991). In short, attitudes are tending to go full circle, at least among some of the younger populations of developed countries, brought up in an age of global awareness. In these countries pessimism about local environmental conditions is increasing rapidly, possibly because the inner cities are facing greater environmental problems, of water supply and of toxic and solid wastes (Milavsky, 1991).

Cross-cultural variations in perceptions of environmental degradation are highlighted where different populations live side by side, and are supplemented by variations between children, adults, and the elderly (Sinha, 1991), between residents, planners, and politicians, and between different periods of time. On the other hand, the growing influence of worldwide communications is creating awareness that the wealthy few are exploiting ever more resources from all over the world, while the growing numbers of poor are facing increasing local environmental problems from which there is no easy escape.

Conclusion

The relationships between population growth and environment are diverse and diversifying, as ever more complex population–environment situations evolve. Undoubtedly population growth has transformed humanity's impact upon the environment, and the continuing rapidity of growth is likely to have innumerable unforeseen effects. The most striking issues of current concern in population–environment relationships are the growth of mega-cities, the processes of deforestation and desertification, the occurrence of disasters, and the growing contrasts in human consumption patterns. A necessary reduction in these contrasts by raising the quality of life in developing countries will ironically increase global environmental pressures, suggesting that rapid population growth is undesirable. Reduction in population growth, especially in the poorer countries currently least able to cope with it, would improve population–environment relationships in the long run, but it cannot be the only panacea. Many other measures are also necessary to improve our complex relationships with the environment.

Too many theories of population–environment interaction have sought universal solutions. Suffice it to say here that the debate between the pessimists and optimists in itself has been beneficial in generating greater concern, which is manifesting itself in widespread international debate. It is to be hoped that the concern transforms

itself into action, particularly by the richer countries, in order to enable self-reliant and sustainable development in the poorer countries. Current inequalities in population-environment relationships and resource use are not acceptable and will be the cause of increasing frictions if they remain untreated.

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22 Internal Migration and Urbanization

NATHAN KEYFITZ

Civilization in its very etymology means urbanization, cities being the points of political and cultural progress through 6,000 years, the places where modern economies started to be built in the nineteenth century. One cannot imagine economic, political, or social development taking place over a countryside that has no cities.

Cities in the Industrializing West

Yet cities have also been seen as evil. They were the places, said Oliver Goldsmith in the eighteenth century, "Where wealth accumulates, and men decay" and Shelley in the nineteenth century, "Hell is a city much like London—A populous and smoky city," at a time when London was not yet a large city by modern standards. For Dickens the poverty of the city mass drove many to a nasty life of crime.¹ And yet notwithstanding Goldsmith, Shelley, Dickens, and many other critics, it was those cities that gave birth to the modern industrial achievements of the West.

Contemporary Third World Cities

Against this background it would seem normal both that industrialization in the third world is accompanied by urbanization, and that its cities possess some disagreeable features that have to be faced in the transition to modern economies. Yet third world cities have been criticized on matters even beyond the criticisms heard in nineteenth-century Europe. One view² is that they are far too big to accomplish their economic purpose, so all the visible misery in them cannot even be justified as necessary for development. The majority of their inhabitants are not building industries but gaining a precarious living in some quite different way. It is charged that they are nothing but overflow from an overpopulated countryside that should be controlling its growth.

Governments have repeatedly passed laws forbidding entry for residence in cities by people who did not have some legitimate business there,³ one of the less

¹ Elaborated and illustrated fictionally, especially in *Oliver Twist* and *Hard Times*.

² Expressed early by Hoselitz, 1953.

³ This was the case for instance in Jakarta during the regime of General Ali Sadikin, when many of those who were unable to prove they were in the city legally were trucked to some place sufficiently far

successful types of urban policy. Why less successful? That will become plain later as we see how official declarations extolling the countryside and laws inhibiting cityward migration were canceled out by other government policies that subsidized urban foodstuffs, built roads and even subways, and supported housing.

Definition of the Urban Population

It is in the nature of human settlements that their definition cannot easily be made uniform across countries. Cities, towns, and villages differ in many respects, including density, especially in the degree to which they are distinct from the surrounding countryside. The economic activities carried on by the urban inhabitants are not always clearly distinguishable from those of the surrounding rural inhabitants. Urban density may be much higher than rural, but the gradation from the center makes the boundary arbitrary. Even when the transition from rural to urban by occupation or density is sharp enough, there may be historical reasons why the distinction between them is not used for statistical purposes; the legal and hence statistical boundary may be defined by articles of incorporation that are unrelated to any currently observable criterion. National cultures and traditions differ in their determination of what places are urban for statistical purposes.

Our data in this chapter are those of the United Nations, which is unable to collect data independently of national statistical sources and so must accept national definitions. Below are five examples that will suffice to show their variety.

1. The Philippines includes as urban all administrative centers with a population of at least 2,500 inhabitants, along with those municipalities and cities with a density of at least 500 persons per square kilometer.
2. For Peru urban areas are all population centers with 100 or more occupied dwellings.
3. For Paraguay we are told only that urban includes all cities, towns, and administrative centers of departments and districts.
4. For Pakistan urban consists of municipalities plus all other continuous collections of houses inhabited by no fewer than 5,000 persons and having urban characteristics.
5. For Portugal agglomerations with 10,000 or more inhabitants are urban.

One can continue through the list—I have taken as examples only those countries starting with the letter P—and find definitions similarly combining in different proportions legal incorporation, number of inhabitants, density, continuousness of built-up area, and sometimes occupation.

away that it would take them a certain time to get back. And undesired migrants were even more sternly dealt with in China in various phases of its recent history.

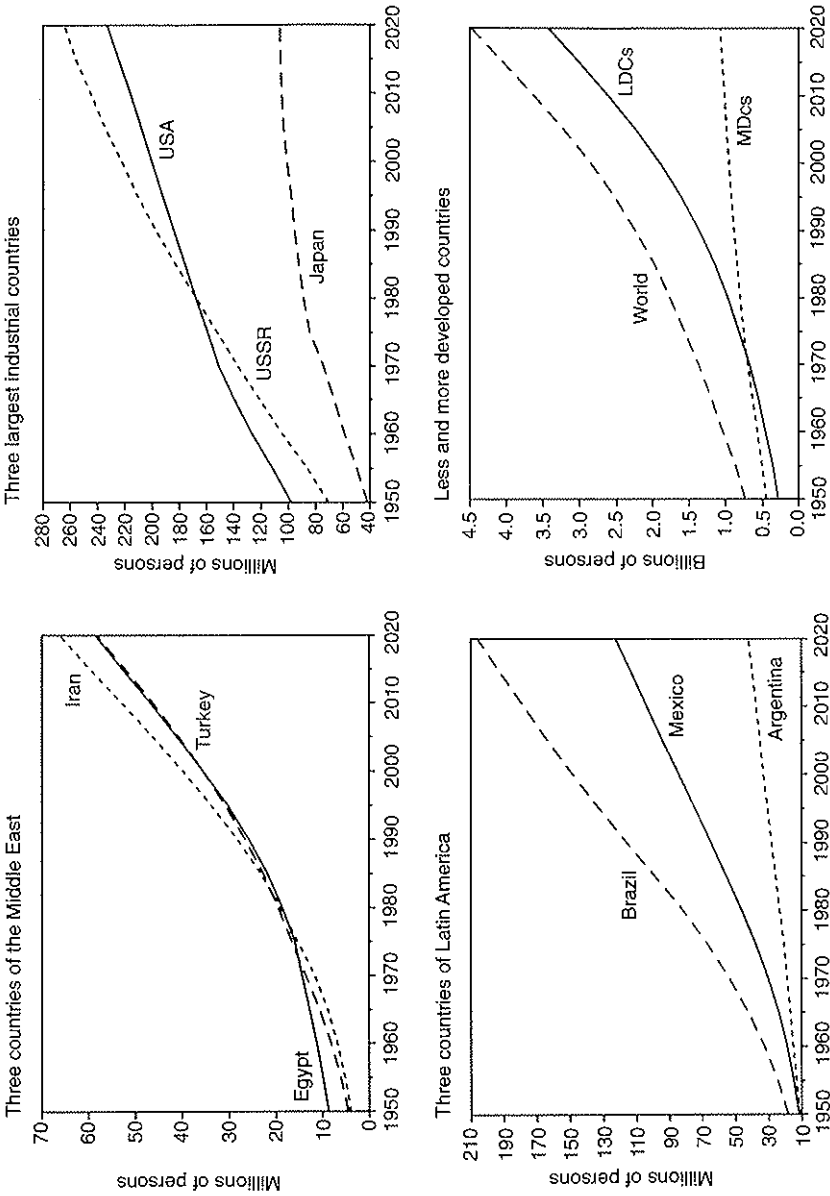


FIG. 22.1. Urban population in selected developing and industrial countries and in LDCs and MDCs
 Source: United Nations World Population Prospects, 1990: 226-228

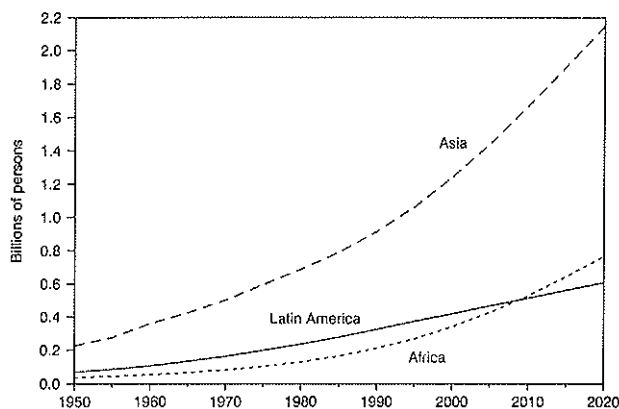


FIG. 22.2. *Urban population of Asia, Africa, and Latin America*

Source: see Fig. 22.1

TABLE 22.1. *Estimated and projected urban population of the more developed and the less developed countries (millions), 1950–2020*

Year	World	MDC	LDC	LDC/MDC ratio
1950	734	447	287	0.64
1980	1,764	798	966	1.21
2000	2,853	950	1,903	2.00
2020	4,488	1,063	3,425	3.22

Source: United Nations, *Estimates and Projections of Urban, Rural, and City Populations, the 1982 Assessment*

TABLE 22.2. *Estimated and projected urban population on three continents (millions), 1950–2020*

Year	Total	Africa	Asia	Latin America
1950	329	35	226	68
1980	1,054	129	688	236
2000	2,002	341	1,242	419
2020	3,526	767	2,150	609

Source: United Nations, *Estimates and Projections of Urban, Rural, and City Populations, the 1982 Assessment*

TABLE 22.3. *Estimated and projected share of the urban population in the more developed countries and in the less developed countries and regions, 1950–2020*

Year	World	MDC	LDC	Africa	Asia	Latin America
1950	29	54	17	16	16	41
1980	40	70	29	27	27	65
2000	47	74	39	39	35	77
2020	57	77	53	52	49	83

Source: United Nations, *Estimates and Projections of Urban, Rural, and City Populations, the 1982 Assessment*

With these cautions we present some of the UN figures on urban populations (see Tables 22.1 to 22.3 and Figs. 22.1 and 22.2). The most that can be said for their consistency (and UN statisticians would be the first to say that it is not much) is that they all take as urban what is so defined officially in individual countries. From having two-thirds as many people in urban areas as the more developed countries (MDCs in UN parlance) in 1950, the less developed countries (LDCs) are expected to have more than three times as many by 2020. In these 70 years, according to the standard forecast, the LDCs multiply nearly twelvefold (Table 22.1). For Africa they multiply by nearly 22; in Latin America, the slowest growing of the three geographical groupings shown, they multiply by 9 (Table 22.2).

In terms of percent urban (Table 22.3), the LDCs pass the point where they are half urban before the year 2020, while Latin America passed that point some years ago.

Requirements for Urbanization

In all times and places, cities have grown in accord with the production of surplus in some hinterland. What differs is the ways in which the city collected the surplus—classifiable as force and trade—and the size and productivity of the hinterland from which it could collect, which in turn has depended on means of transport (Keyfitz, 1965). The one million population that Rome had attained by the year AD 200 could be fed by sea transport of grain from North Africa and elsewhere, made possible by Roman legions in North Africa and Roman naval dominance of the Mediterranean. The trading city-states of seventeenth-century Europe drew the rural surplus with the attractiveness of their goods. And by the late eighteenth century, cities needed to grow to accommodate the manpower for their burgeoning industry. Urbanization increased *pari passu* with, usually well ahead of, the needs of industrialization. Old imperial centers persisted but industrial cities grew faster.

Thus nineteenth-century urbanization was mostly a feature of rich and powerful

countries. Until very recently towns depended on their domination, by trade or by force, of an accessible hinterland with a surplus of foodstuffs, as in Ibn Khaldun's famous model of preindustrial cities, based on his observation of the Maghreb but applicable far beyond North Africa.⁴

In modern times cities have grown rapidly with the increase of agricultural productivity, the simultaneous increase of urban goods and services, and the means of transport that would permit the exchange. The advent of the steamship in the nineteenth century helped create a single worldwide grain market. Ships carrying grain from peripheral areas, especially the Americas and Oceania, to the great cities of Europe passed other ships carrying manufactures outward from Europe.

All this has been changed by further recent technical progress in agriculture, which has made grain much cheaper in real terms. Now there are European, American, and other grain surpluses, so that the link between the size of the city, on the one side, and its ability to dominate or to serve an immediately accessible hinterland, on the other, has greatly weakened. Cities have become larger than ever in the past, and they are released from dependence on a surrounding countryside. Moreover, the increases in size are no longer to be found only, or even principally, in countries that are rich and powerful.

Part of what makes massive immigration to the city possible is the Green Revolution. It takes no elaborate model to see that if the same crop can be produced by half the labor force, then the other half can be released from agriculture, and foodstuffs will still be available for all. They do not have to leave, and indeed some are employed in village artisan work—building more-solid houses, making furniture and clothing, processing food. The release from agriculture follows from the physical fact of increased productivity—only so much wheat or rice is needed—while the departure from the village follows from administrative rules and practices. One of the key questions of development is why that released population moves to the city rather than finding livelihood where it has spent its childhood and youth.

The Urbanizing Bias of Government

What draws foodstuffs to these cities and especially to the capital cities of the new nations is not the mainly military domination of Ibn Khaldun's time, nor attractive goods for a world market such as come out of Osaka and Barcelona, nor services like

⁴ For Ibn Khaldun the city, especially the capital city, depended on the energy and fighting ability of its rulers to dominate a countryside and collect as taxes the foodstuffs surplus to the needs of the countryside. On the question whether the surplus is there as a technological fact that the ruling group discovers and collects, or whether the demands of the rulers bring a surplus into existence, examples of both can be adduced: the British administration of Burma brought into existence a surplus on the previously underpopulated delta of the Irrawaddy; on the other hand a surplus emerged out of the American Great Plains in the early part of this century without the stimulus of force personified by the tax collector.

those provided by New York and Frankfurt, but something different from all three: the support of a national territory that constitutes a hinterland, and for which the capital city can set the rules. Whether the LDC is a democracy or a dictatorship, it is ruled from a capital, often the largest city, usually located somewhere about the center of its territory. Calcutta, Rio de Janeiro, Karachi, and many other colonial cities were seaports, connecting the territory with the outside world, and in particular with the metropolitan power. These have been replaced by Delhi, Brasilia, and Islamabad, centrally located so as to dominate their respective nations.

The World Bank (1982), Ester Boserup (1981), Gale Johnson (1974, 1984), and many others describe the varied policies that have an effect on the rural-urban interplay. These include low investments in rural social overhead, export taxes on farm outputs, marketing boards that procure the harvest at less than the market price, exchange rates that encourage primary product imports and discourage exports. Fixing the price of grain at less than the market is a means of extraction⁵ of surplus that has a double (wholly unintended) effect on urbanization: it makes life easier in the city on the one hand, and on the other hand makes it more difficult for the marginal peasant to stay in business.

These policies apply widely, more in Africa than in Asia, where the Green Revolution has been spurred by considerable investment in irrigation works and communications. Capital-intensive production in cities is encouraged by easy import of advanced equipment that does not require abundant supplies of labor. Heavy expenditures are made in education, health, and transport services, all of them good, but tending to be centered on cities.

Why are the Same "Mistakes" Made in So Many Places?

Since the distorting effect of these urban-centered policies is so strong and visible, one asks why LDC governments, preoccupied by their urban growth, underestimate the advantage of letting prices go to equilibrium. Encouraging farmers with proper pricing would be more effective than attempting to prevent them from coming into the city after they have been reduced to poverty. Some movement toward freer prices has indeed been seen in recent years, and deregulation is nearly everywhere the watchword. But the deregulation is taking place with painful slowness. And disproportionate amounts of capital investment, both governmental and private, continue in cities, a point to be elaborated below.

Why then the wrong policies in the first place, and the slowness in getting rid of them now? The answer can only lie outside the economic system, and it must somehow lie in the political dynamics of the LDCs. The urban character of LDC governments, and their greater sensitivity to the welfare of urban citizens, must be involved. The dispersed rural populations contain relatively few of the elite at the

⁵ The point is elaborated in Keyfitz et al., 1989.

top end of the social scale, and at the lower end their poor do not so easily make their grievances known. Governments for their part are socially close to the urban elite, and have good reason to yield to the pressure of the masses in the capital city. They cannot improve the lot of these, through food subsidies, housing, and other means, without making the city more attractive to outsiders, and so drawing more people, in a never-ending cumulative flow, a typical positive feedback that has the negative effects we see.

The availability of cheap foodstuffs alone would support movement to the city. As the result of pressures exerted by city masses, governments pass legislation ensuring that grain is priced low. Yet price is not the only consideration; supply also is important. In hard times in the past, depressed conditions pushed people out of the cities onto the land; now it is the opposite: the city is where food is to be found. The international trade in cereals means that the city no longer has to be supplied from its own hinterland, its neighboring countryside. Foreign aid plus the sale of raw materials provides the needed foreign exchange. Governments persuade their farmers to produce peanuts or other export crops, whose sale price they can collect and then only partly funnel back to the peasant. Food policies alone would initiate a circuit with positive feedback and expand the cities without limit.

What makes this a systems issue is the reciprocal action: on the one hand masses of people close to the seat of government exercise pressure for various benefits; as these benefits are dispensed they make the city more attractive to other immigrants. There is no feasible way of making life better for those already in the city without attracting more people from the countryside. Thus it is political pressure that completes the positive feedback loop within which the economics operates.

Not all of the centralization occurs through administrative measures determined by the urban elite. The private sector, animated by the free market, also centralizes. Under the conditions of the LDCs, especially with uncertain legislation and unreliable courts, decentralized production is not so readily controllable. It could be highly profitable to have cotton weaving going on in 100 small establishments of five looms each, but how would the enterprise embracing these be managed so as to ensure that whoever advances the capital secures his return? The return on investment would be much easier to collect from one establishment of 500 looms. An entrepreneur can easily control the flow of funds through the big establishment in such fashion as to ensure getting his return, whereas controlling many small ones would involve more trouble and uncertainty.

I submit that however economically viable the decentralized arrangements may be, they do not spontaneously occur to those who make decisions, whether private entrepreneurs or government officials. This is aside from the foreign training in which everyone nowadays is taught the "right way" to do things, that is, the way that is right in the industrial countries. Ideologically also, decentralization is unattractive because it gives the appearance of depriving LDCs of the most modern technology. Yet those who argue like this should take heart from the way that Japan started on its post-World War II course. Its first aim was to get everyone working, necessarily at very modest technical levels, and no more in the towns than the scarce

capital then available permitted. The Japanese way is contrasted with the Philippine way below.

Overurbanization?

Thus, much current analysis (summarized by, e.g., Bairoch, 1988) points to the many kinds of diseconomies from overurbanization. The combination of labor-saving technologies, introduced into places where they are not appropriate, with rapid population growth is producing hopeless unemployment.

A summary of the economic literature on urbanization provided by Gavin Jones (1991) reviews many of these points. He speaks (p. 34) of the "striking disjuncture between what governments say they wish to achieve in urban growth and structures and the policies they put in place." The urban bias includes tariffs to stimulate "import-substituting" industry, multiple exchange rates for the encouragement of industry, subsidization of urban food prices, credit restrictions favoring urban dwellers, health and education services, and electricity and piped water. These are not thought of as urban policies, yet in fact they overwhelm the impact of any policies explicitly designed to slow the pace of urbanization.

Jones finds the basic dilemma faced by governments

in the wish to avoid excessive metropolitan growth and yet the reluctance to permit effective decentralization. Sacrifice of too much power from the center suits neither politicians nor bureaucrats, raising in some countries the specter of political instability and in all the delegation of regional planning to more poorly-trained technocrats in the regions, and loss of power and control over resources. (1991: 35)

A different viewpoint is expressed by Preston (1979). He finds that the LDCs are not seriously overurbanized. Which side one takes depends a good deal on how one evaluates the informal activities by which so many urbanites remain alive. The economic contribution of the people picking up cigarette stubs, selling hot meats, and pedalling bicycle rickshaws is undoubtedly positive, perhaps more than those same people would produce in the countryside. But to compare this product with what they would produce in the countryside under present investment policies is not good enough. We need to compare it with what they could produce under decentralized investment.

The matter is one that comes up in many contexts, and can be stated generally: individuals act rationally in terms of the context in which they find themselves. If the authorities arbitrarily set prices that favor the city, then people will move there in larger numbers than if prices are set by the market. We must insist on the fundamental distinction between what is rational for individuals given their context, and what is rational for the authorities who set the context. If the interests of the authorities coincided with those of their subjects, the world would be a much different place. Intervention of the authorities leaves without support or justification the argument that the cities of the third world are

optimum—that if they were not optimum they would not have grown that way in a free market.

How the Urban Bias can be Removed and the Dual Economy Integrated

The problem is to remove the urban bias that up to now has attached to investment, and beyond investment, to most government activity. This is not a proposal for more government expenditure, but for the same amount of expenditure for different purposes and in different places. It is based on a proposition that emerges from many studies, for example that of Gary Fields (1987)—essentially that the solution to urban unemployment is rural development.

It is easy to think of ways in which this can be implemented. (The hard part is to get people to accept the temporary inconveniences to which they will be put during the transition.) The purchasing power that is in any case distributed by government is one key. At present regulation is widespread, and it requires civil servants for its administration. Insofar as the regulation is unnecessary, one can regard the wages of those civil servants as transfer payments. They serve the purpose of increasing demand, but it is demand by people of relatively high income—certainly higher than the peasantry. These people are either from middle-class homes or they have been lifted out of the low side of the dual economy by their appointment. Their tastes and aspirations are such that they want television sets and other durables that are associated with middle-class urban living.

If the civil service were thinned down, and parastatals dissolved or sold (or even given) to their employees, considerable funds would be released. For countries with oil or natural resources in demand, the sums would be large indeed, but there is no country that does not have some receipts and some unnecessary urban expenditure. When those funds are used to support an unprofitable airline or telephone operation they tend to go to employees who are relatively well-off. The policy of giving a job to all who have graduated from college supports the existing middle class, and so widens the gap between the two halves of the dual economy.

Two Paths of Economic Development

But meanwhile populations are rapidly increasing, and the question is how to set an economic policy that will both aid development and, insofar as it does so, constrain population increase. Harry Oshima (1991) tells us how to do both at once. He contrasts two main routes of development.

One is the introduction by direct import from abroad of factories using the highest and most modern technology. That seems to have the advantage of leap-frogging all the painful intermediate steps, and jumping quickly to a modern economy.

The other route is first and foremost use whatever capital is to be had to get everyone working; in a poor country that will be in agriculture for most, and because capital is short it will unavoidably be at low levels of productivity.

Of the first route India and Indonesia are examples; of the second Japan and Korea. The latter made their greatest initial investments in agriculture—for example, dams that would permit work in the first six months of the year, otherwise too dry for useful work in the fields. One can think of innumerable other ways of getting people to work first, then gradually improving efficiency, for instance in cottage industry. Instead of importing ready-made factories for the extraction of coconut oil, one would devise improvements in the humble work of village pressers of coconuts. Subsequent progress in technology would take place at all levels, not only in foreign enclaves.

The Japanese–Korean way can be thought of as democratizing the allocation of capital—instead of buying an aircraft factory, improve the efficiency of thousands of artisan oil pressers and pottery makers. In a free market those artisans can be trusted to buy the best equipment and add their own ingenuity to the effect of adding capital.

The dazzling economic success of Japan and Korea needs no comment. But one can recommend this second route of development also from a purely demographic viewpoint. Having everyone working and making progress up the economic scale in proportion as new capital and on-the-spot inventiveness accumulates, the demographic transition pushes ahead, which means that low fertility follows fast after the drop in mortality. The multitudes who have a small gain in their standard of living with prospect of more develop the kind of social ambition that we know causes them to be prudent in their childbearing. On the other route the few people who have top salaries in modern factories cannot significantly change the overall birth rate.

Though evidence on other than economic differences between the two routes is harder to find, it seems likely that the Japanese–Korean route will be more egalitarian and hence more socially stable. That would not be regarded as an argument in its favor by all members of the elite. Aside from the personal economic gains to the elite of the first route, they do not naturally think of the humble pressers of coconut oil as following the path of modernity.

But above all we are interested in the second route here because it can slow the movement to the city. It is the concentration of capital that draws labor and hence concentrates population.

All this is argument for dispersal of capital investment, putting the money where the people are rather than putting it in the capital city and letting the people come to it. It still leaves open how much should go to the countryside, that is to say, the village, and how much to medium-sized towns. There are economies to be had in urban aggregations, but many of them will be had in places of 20,000 as well as in places of 20 million. Most kinds of service, from medical to waste disposal, must have a U-shaped curve of cost against size of place—dear both in the big city and in the village, lowest in medium-sized towns.

Unfortunately, medium-sized towns are not where the population is being drawn, as Table 22.4 shows. The cities of over 4 million in the LDCs, which had 13 percent of the urban population in 1970, were expected to be at 20 percent in 1990.

Steps have been taken in many countries to make the villages more livable, especially in the construction of schools and roads. But they are either too much or not enough. If the only aid to the villages is going to be schools and roads, then it is on the wrong track, because the schools give the idea of urban life to the young, and the roads make it convenient for them to leave for the city. I believe that roads and schools are inevitable, and in order to ensure that they are not merely conduits to the city something else has to be added; that something else is the opportunity to make a living.

TABLE 22.4. *Estimated and projected percent of urban population in cities and towns of various sizes, less developed and more developed countries*

Size	LDCs		MDCs	
	1970	1990	1970	1990
Under 1 million	69.0	55.8	67.5	66.7
1-4 million	17.8	19.6	18.3	19.3
Over 4 million	13.2	20.2	14.2	13.4

Source: United Nations, Estimates and Projections of Urban, Rural, and City Populations, the 1982 Assessment

Making the villages more attractive places in which to live—say with traveling banks (already being introduced), traveling libraries, and television (rapidly spreading in any case)—will all help to keep young people in the place where they were brought up, and where their knowledge and skills are much more badly needed than in the city to which they are now taking flight. Introduction of capital, management skills, industrial estates of a modest character, further spread of electricity, are some of what comes to mind for making rural and small-town industry more profitable, and that would exercise an effect in the same direction as improving cultural amenities. One has to stress that in a country like Indonesia such efforts are being undertaken for villages and small towns, and the question is whether the proportion could be increased with benefit to the rural-urban balance.

This shift of investment is no simple matter. Through the tax system or otherwise, funds would have to be moved from construction of shopping centers and high-technology factories to the design and marketing of efficient hand tools or simple electricity-driven processors. Wealthy people in Asia are not any more enamored of taxes than are wealthy Americans. The wealthy would not see the point of dispersing capital in a way that would bring the returns, but not returns collectible as dividends.

Environment in City and Countryside

Not only does the build-up of city populations go far beyond what their infrastructure was designed for, but it also has harsh effects on their environments. Environmental destruction takes different forms in more developed and in less developed countries; it is different in urban and in rural areas of each. For LDC urban areas we find today many of the evils of the industrial revolution of Europe. Some are described in a recent issue of *The Economist* (1990) under the heading "More people, bigger cities, greater wealth, worse filth":

Sulphurous coal smoke hides a Chinese city from satellite cameras; chemical waste makes Hongkong's shell-fish toxic, potentially lethal; the traffic fumes of Bangkok and Taipei make Los Angeles smell sweet by contrast; Manila's five main rivers, curiously described as "biologically dead", are in fact biologically teeming—and provide drinking water for hundreds of thousands. Asia has bought economic growth at the price of ecological devastation. (p. 25)

The same issue continues,

At least a third of the people in Dacca, Manila, Kuala Lumpur, Bangkok and Jakarta live in . . . slums, with little or no access to clean water, sewerage systems, roads, health care or education. Of Taiwan's 20 million people only 600 thousand are served by sewers. . . . Taiwan has one of the world's highest rates of hepatitis. [Chinese industry being above all based on coal,] because the coal is poor and China's industry inefficient, the air quality in nine Chinese cities out of ten is below the nation's minimum standard—which is itself the lowest level approved by the WHO. In July 1988 the air above Benxi, in northeast China, was so dirty that the city was invisible on satellite photographs.

Another witness is Dr. Layi Egunjobi, Director of Urban Planning at the University of Ibadan in Nigeria:

In the older "core areas" of city slums and in the relatively new built-up areas, the scene is one of overcrowding, lack of access roads, scarcity of drinking-water, ramshackle buildings, uncollected garbage, lack of sewers, inadequate air-space, and a housing environment littered with human faeces. All of these are conducive to the spread of tuberculosis, pneumonia, influenza, threadworm, cholera, dysentery and other diarrhoeal diseases. (1991: 14)

Wealth of Some Associated with Poverty of Others

In a curious way these evils are associated with the relative wealth of the cities. M. K. Tolba (1987) says that "the very prosperity of the cities is causing the terrible poverty found in the urban slums" (p. 24). How does wealth of some cause poverty and misery of others? Partly because the elite build factories that pollute, especially befouling the areas where poor people live. And, I would add with Pan Yotopoulos (1985), partly because those who attain affluence change their diet to favor meat, and so raise the price of cereals to the point where they are difficult for the poor to buy.

The countryside that constitutes the hinterland of those same cities is often desperately poor, and so has a different pattern of devastation:

The growth of the cities steals investment from the countryside, which becomes less fertile as impoverished farmers strip the forests and over-use the land—or as they give way before the encroachment of the factories, houses, and shanty-towns that surround most cities. Urban sprawl and rural blight thus increase in tandem. In India between the early 1970s and early 1980s the forested area within 100 kilometers of the country's 41 biggest cities shrank by a third. (*The Economist*, 1990: 25)

Striking a Balance in Kenya

In the following paragraphs we return to some of the economics, this time in terms of the problems that Kenya is now facing.⁶ Smoke and Wheeler (1990) tell us that

national economic policies with respect to industry, international trade and agriculture—via their influence on rural–urban terms of trade—exert a far more powerful impact on the spatial distribution of growth and patterns of rural–urban migration than do policies for the development of physical infrastructure or locational incentives aimed at particular areas and industries.

For example there is not much use building village roads if the price of the village product is held so low that few goods are available to be shipped out over those roads.

And the productivity of investment [in Kenya] entered a period of decline, largely due to rapid inflation of capital goods, high import tariffs that protect inefficient domestic producers, excess capacity due in part to the collapse of the East African Economic Community, and substantial Government investment in unproductive joint ventures with the private sector. (p. 4)

All this is in the context of very rapid population growth:

Much of the best arable land in the country is already under cultivation, and, while productivity may be expected to rise, there is some limit on the degree to which the agricultural sector can be expected to absorb the rapidly growing labor force. Given this reality and the fact that formal sector jobs are so expensive to create, there is a need to reinforce the expansion of small-scale enterprise and informal sector activities. . . . [T]he creation of these jobs can be greatly stimulated by increases in agricultural productivity and the expenditure of resulting rises in farm incomes in small towns and regional centers. (p. 5)

Kenya's Sixth Development Plan, 1989–93, says

it is necessary that small urban centers' growth throughout the country [be encouraged] in order to create a framework upon which rural-based production activity can stimulate growth

⁶ In addition to Smoke and Wheeler, 1990, recent materials on Kenya include: Evans, 1988; Gaile, 1988; and World Bank, 1989.

and provide markets and employment opportunities for the increasing number of job seekers (p. 45 of the Plan, cited by Smoke and Wheeler, 1990)

But Smoke and Wheeler comment that the strategy was intended to deconcentrate rather than devolve the functions of the central government, to disperse spatially rather than to yield autonomy to the local authorities.

According to Smoke (1989),

An important goal of the rural-urban balance strategy is to promote the development of a well-serviced urban system that facilitates the distribution of agricultural production, provides inputs and support services to both the agricultural and non-agricultural sectors, generates productive non-farm employment in urban centers and rural areas, and increases urbanization outside of the country's major cities. . . . The first policy innovation under the rural-urban balance strategy was the establishment of the Rural Trade and Production Centre programme, which concentrates infrastructural development resources in designated small urban centers in rural areas. . . . [T]he rationale . . . is that a set of basic interrelated infrastructure projects and services is required.

All this aims at an ideal that has been sought for some time. Thus back in 1978 the Government of Kenya said that "concentration of Government investment and industrial activity within certain growth poles will, in the long run, stimulate a higher level of industrial and economic development than had it been spread over a wider region." (Republic of Kenya, 1978: 65). Selecting the locations for those centers is a problem: "More emphasis should be placed on stimulating the areas that have high agricultural potential, but have lower yields and less productive crop mixes" (Smoke, 1989: 20).

All the points are well taken, and for the most part there is little disagreement between the Government of Kenya and its foreign advisors, in contrast to other development issues. Such differences as have arisen are on small matters. USAID, the initial and still major funder, has favored concentration on towns of over 5,000, while the Government of Kenya feels that the Centers would be more useful in smaller places. All seemed to agree that an objective index would be best for choosing the places, thus helping to avoid political influence, though real estate speculation would still be a problem.

Conclusion

The standard theory of migration to the city is in terms of the expected income over a period of years if the peasant stays in the countryside, compared with his expected income if he comes to the city (Harris and Todaro, 1970). Certainly there is much unemployment and underemployment in the city, but there is also the chance of a fortune, and the latter weighs heavily in the peasant's anticipation of the economic return to his migration.

This economic theory of internal migration, associated especially with the names of Harris and Todaro, is clearly valid, but one may doubt that it is the whole

explanation of a phenomenon as vast and as persistent as the rural exodus of the less developed countries. Mexico City, at 19.4 million, is followed by São Paulo at 17.2, Seoul at 15.8, Bombay at 12.9, Calcutta at 12.8, Cairo at 11.0, and many others.⁷ Governments strain to provide low-priced food, adequate schools and streets for the newcomers, not to mention houses and clean water and other privileges; they know the political pressure to provide these benefits that can be exerted by concentrated millions, and they fear above all the sanctions in the form of riots and strikes that such masses can exercise. These and other policies that are not intended to affect migration have a much stronger effect than internal migration policies as such. The United Nations (1986) gives other examples for Jakarta:

Of far greater importance than explicit spatial policies have been such factors as highly subsidized public services, which have created a bias in favor of the larger urban centers; the importance of physical proximity to central government officials for obtaining licenses and permits.

We can accept that the peasants are acting rationally in leaving the countryside, but it by no means follows that the result is optimal, unless we can also suppose that governments are acting rationally in setting the conditions on which the peasants make their calculations. In fact the solution to the city's problems lies in the countryside. Redistribution of investment from the cities, and especially from the capital city, to smaller places and to more labor-intensive projects, would in many instances produce a higher economic return, and in virtually all cases would lead to a more even distribution of income, and a more even distribution of population over the land.

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⁷ Numbers are estimated for 1989, Population Crisis Committee, poster "Cities."

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23 International Population Movements: Imbalances and Integration

ANTONIO GOLINI

Migration has played a fundamental role in the development of most contemporary Western populations and societies. Nevertheless, first-generation immigrants comprise a small fraction of the total population living in any one country. It may seem paradoxical that international migrations, which are the subject of growing concern, even fear, at least in the receiving countries and which, according to all experts, will acquire increasing importance, involve only a small fraction of the world's population (see Table 23.1). At the beginning of the 1980s the number of persons living in a country in which they were not born—who had therefore emigrated at least once—was on the order of 50 million, that is, one percent of the world's population (United Nations, 1989*b*). The overall stock of temporary immigrants must be added to this number. According to Appleyard (1989), this number stood at about 20 million worldwide at the beginning of the 1980s.¹

In the modern age, only in the new worlds have migrants constituted the population base. Nevertheless, even in these cases, the boost from immigration

TABLE 23.1. *The seven countries with the largest number of persons born abroad and the seven countries with the highest proportion of persons born abroad, early 1980s*

Country	Number of persons born abroad (thousands)	Country	Proportion of persons born abroad (percent)
United States	14,080	Israel	42.5
India	7,938	Kuwait	42.4
France	6,001	Singapore	21.8
West Germany	4,535	Ivory Coast	21.3
United Kingdom	4,211	Australia	20.6
Canada	3,867	Switzerland	16.7
Australia	3,004	Canada	16.1

Note: Excludes countries with fewer than 1 million inhabitants.

Source: United Nations, 1989*b*

¹ This stock is concentrated particularly in the Middle East, where structural deficiencies in the labor supply and a consistently high demand for workers (at least until the Gulf War) produced a marked gap between demand and supply for labor.

only reaches high levels when we also take into account the descendants of first-generation immigrants. Even the United States—by definition a nation of immigrants—accepted “only” 53 million immigrants from independence in 1776 to the mid-1980s (Gardner and Bouvier, 1990). Evaluation of the overall demographic impact—both direct and indirect—of the international migrations from the period after World War II until the mid-1980s yields the following illustrative results: the effective population of Belgium is greater by 6.5 percent than it would have been without migration, the population of France is greater by 10.3 percent, and West Germany’s by 14.6 percent (Le Bras, 1991).

Similar observations can be made in relation to the migratory flows recorded over the years. The World Bank estimates the average annual migration balance for the period 1985–90 at one million persons (of whom about 580,000 relate to the United States alone and a little over 400,000 relate to all other countries of immigration—see Table 23.2). This balance is made up of people who move permanently, legally admitted refugees, and illegal immigrants. Again, we are talking about figures that are modest in relative numerical terms.

In recent times the general framework of migratory movements seems to be changing. Migratory flows have always been characterized by sudden and significant variations in trends; however, there have never before been so many rapid changes in the migratory flows in terms of volume, direction, and composition. These changes reflect the extraordinary political, social, and economic conditions in the world today and, in particular, the increasingly marked imbalances among the various areas of the world; growing economic integration and cultural standardization; and the growing availability, efficiency, and falling cost of the means of communication and transport.

Referring to these last factors, I shall attempt to place this chapter in a framework that relates international migration to underdevelopment, international imbalances, and the process of growing political and social integration.

TABLE 23.2. *The seven countries with the largest net immigration and the seven countries with the largest net emigration, 1985–1990 (estimated annual average balance in thousands of persons)*

Country	Net immigration	Country	Net emigration
United States	580	Mexico	150
Australia	122	Philippines	58
Canada	74	Lebanon	55
Saudi Arabia	65	China	55
Ivory Coast	59	Pakistan	51
France	21	India	50
United Arab Emirates	20	El Salvador	42

Source: World Bank, 1990

The Links between North and South: A Growing Integration

The expression "global village" is repeatedly used to characterize the process of increasingly tight integration in the modern world.

The boundaries that separate national markets for goods, capital, and labor have continued to be eroded. Worldwide trade has expanded by more than 6 per cent a year since 1950, which is more than 50 per cent faster than the growth of output. Global integration in trade, investment, factor flows, technology, and communication have been tying economies together. (World Bank, 1991: 2)

It is in the context of this integration and of a dynamic interactive process that the relationship between various stages of development and migration should be investigated.

The frequent political interventions by governments, international organizations, and multilateral agencies intended to maintain the existing balance or to create new ones also involve economic, technological, cultural, informational, and other interventions that both strengthen the case for the "global village" and often lessen the degree of national autonomy, particularly of many "Southern" countries. A significant example is the problem of the "debt" of developing countries (LDCs), as a result of which the industrialized countries (and thus their governments and their banks) and the large international agencies influence and in some cases direct the economic policies of the LDCs. These interventions are meant to have positive effects, since they push the debtor countries toward more rational administrative, financial, and productive behavior and, thus, toward economic recovery. But at least in the short term they often have negative effects especially when the imposed economic measures affect the social policies of the debtor countries—mainly in the fields of education and health—burdening the poorest strata of their population.

Trying to make an accounting at the macro level of this increasing integration, one may conclude that it seems to have harmed the countries of the developing world, whose role and weight in the international arena have lessened. That region's possibility of better estimating its own needs, even cultural ones, and the ability to have a more productive dialogue with the developed countries have been compromised. The annual summits of the so-called G7 countries (the "Great Seven" world economies) always have as explicit or implicit objectives the strengthening of the three current major poles of power: North America, Western Europe, and Japan. These meetings strengthen the political plan and numerous economic designs of the "Great Seven" and effectively cancel the North-South dialogue (Ravenhill, 1990). During the period of the internationally prominent leaders of the LDCs, such as Tito, Nasser, or Sadat, that dialogue was more intense, useful, and respectful of reciprocal interests. The current trend is accompanied by a lessening of the role of the Group of Non-aligned Nations (born as far back as the 1950s) and of Southern solidarity in general, which is countered by a substantial growth in Northern solidarity.

Only a new awareness of these trends on the part of the North can nourish the hope of rebalancing relations between North and South. The North should recognize that, with growing economic integration, a recession in the South can appreciably

damage the North. For example, according to Ravenhill (1990) the restriction of the markets of Latin America due to the unfavorable situation of the 1980s cost North America half a million jobs in the manufacturing sector. Increasing debt can cause a crisis not only among the debtor countries, but also in the banking system of the industrialized countries.

The revolutions of 1989 and the subsequent fall of communism in Eastern Europe and in the Soviet Union seem to confirm that the 1990s will witness, in international relations, a growing importance of economic and social problems in place of ideological and military problems. This upheaval should bring with it a further push toward economic integration.

If integration grows, the South's dependence on the North should deepen and strengthen. Under these conditions, the question is what attitude should the North have, and what attitude can be expected from the South in approaching the problem of inequalities between the two. Besides the moral imperative of facilitating development, the North has a direct interest in promoting economic growth in the South. And, under present conditions, the governments of the South can be expected to turn with increasing frequency and intensity toward the North, for development assistance.

Where, if not toward the North, should migration be directed if the population of the South wants to escape a life of material and moral privation or to run away from the lack of opportunities for social and occupational advancement? Between Eastern and Western Europe, following the fall of communism, integration—already advanced in the cultural and ideological realm—is becoming ever stronger. Viewed in the abstract, the development of the Southern countries and the reduction of the relative economic imbalances should be a high priority for the Northern countries. Particularly after the Gulf War and the international turbulence, world peace continues to be in peril; the number of countries dependent on external assistance is growing; and world powers such as the United States, the European Union and Japan cannot simply remain indifferent.

The Growing Imbalances between North and South and their Effect on International Migration

In the 1980s, the interests described above were not yet strongly felt by the Northern countries. Yet the imbalances between the two large parts of the world were increasingly accentuated. As depicted by such economic indicators as per capita gross domestic product (GDP), the imbalances are very evident and wider than those found in earlier historical periods. The proportional differences in per capita GDP (top rows in Table 23.3) are widening to the disadvantage of all regions of the South except for Asia.² The absolute differences are growing sharply (bottom rows of Table 23.3): GDP per capita (measured in 1989 dollars) in the whole South was

² This is true especially for East Asia, but not for South and West Asia.

TABLE 23.3. *Historical trends in gross domestic product per capita (measured in 1989 US\$)*

Region or group	1830	1913	1950	1973	1989
Regional GDP per capita as a percent of GDP in the OECD economies					
Asia	40	23	15	16	28
Latin America	—	49	52	40	31
Sub-Saharan Africa	—	—	11	8	5
Europe (non-OECD), Middle					
East, North Africa	—	—	29	27	26
Eastern Europe	64	57	65	63	56
Developing economies	—	32	25	22	28
OECD members	100	100	100	100	100
GDP per capita: OECD members and developing economies					
OECD members	935	2,220	3,298	7,396	10,104
Developing economies	—	701	839	1,599	2,796
Difference between OECD and developing economies	—	1,519	2,459	5,797	7,308

Source: *World Bank, 1991*

some US\$2,459 less than in the OECD countries in 1950; it was US\$7,308 less in 1989.

In 1950, the inhabitants of those countries classified today as more developed countries (MDCs) numbered 832 million and those of the LDCs numbered 1.7 billion; in 1989 they numbered 1.2 billion and 4.0 billion respectively. Never in recorded history have the imbalances in income been so marked in quantitative terms or involved such large numbers of people.

A simple exercise further demonstrates the magnitude of the imbalance. If per capita GDP between the South and the North were to be approximately equalized in 30 years and if, over that period, the per capita income of the North were to increase by 1.5 percent a year, then the per capita income of the South would have to grow at an annual rate of about 6 percent between 1990 and 2020. (Taking into account the expected increase in population size, this means that the aggregate GDP of the South would have to grow at an annual rate of 8–9 percent over 30 years.) In sub-Saharan Africa the growth of per capita GDP would have to be 12 percent a year.

Clearly, attainment of the desirable goal of economic equality between North and South will take much more than 30 years, even provided that no political, military, or economic crisis occurs in the foreseeable future. Even absent a crisis, the capital available to the South from domestic and international sources is likely to fall short of the massive investments needed for rapid development.³

³ As a matter of fact, "although concern over the willingness of capital markets to finance the U.S. current account deficit has eased, saving in the United States and other industrial countries remains low. As a result these economies continue to absorb a large share of the global supply of capital, and this in turn contributes to high world interest rates" (World Bank, 1990: 8).

TABLE 23.4. *Estimated size of the working age population (aged 15–64) and of the labor force in 1990 and projected change 1990–2010 (absolute figures in millions; annual growth rates in percent)*

Region or group	Working age population			Labor force		
	1990	1990–2010		1990	1990–2010	
		Absolute increase	Annual growth rate		Absolute increase	Annual growth rate
More developed regions	804	65	0.4	586	50	0.4
Less developed regions	2,450	1,298	2.1	1,778	733	1.7
World	3,254	1,363	1.8	2,364	783	1.4

Source: Working age population: United Nations, 1991; labor force: United Nations, 1988

The possible shortage of capital in the world markets, aggravated by the probable growth of investment flows directed to Eastern Europe and to the former Soviet Union (where it is in the political interest of the United States and especially Europe to invest), could worsen the situation in the Southern countries, where very rapid demographic increase will translate into rapid labor force growth. The quite reliable data on the working age population as well as the less reliable data on the labor force shown in Table 23.4 suggest the magnitude of the challenge the South faces in developing its own labor markets. The LDCs will have to create, in only 20 years, an additional number of new jobs (733 million) that is much greater than the 1990 size of the labor force in the entire developed world (586 million) (Golini, Gesano, and Heins, 1991).

International imbalances tend to decrease slowly, if at all, not only in the economic and demographic fields, but also in the social, scientific, and cultural fields. Indicators of such imbalances are elaborated in the reports of international organizations and in the scientific works of individual scholars.

In 1965, the recorded infant mortality rate in sub-Saharan Africa was seven times greater than that in the OECD countries. In 1989, the rate was 8 per thousand live births in the OECD and 107 in the African region: a figure 13 times greater. The ratio of per capita energy consumption in 1989 was about 35:1 between North America and the Indian subcontinent and 20:1 between Australia and Indonesia. In 1983 (the most recent year for which data can be found) 73 percent of the expenditure on research and development was concentrated in the industrial countries, 24 percent in the socialist European countries and the Soviet Union, and only 3 percent in the developing countries: this is one of the greatest (and most important) imbalances that can be observed. For every million inhabitants,

533 books are published in the North as compared to 67 in the South, giving a ratio of 8 : 1; the ratio between Europe plus the former Soviet Union and Africa is 23 : 1. In the field of mass communications the hegemony of the North is creating a new and important imbalance; it has been suggested that there is an "army of images and words" in the North that is moving Southward. With high technology satellites—a Northern monopoly—less developed countries can only accept or ban the images they receive; it is practically impossible for them to transmit their own programs to the North in order to give an idea of their own existence, ways of thinking, living, speaking, and artistic expression (Golini, Righi, and Bonifazi, 1991).

This international "image management" is also linked to migratory movements from the South and social integration in the North in ways that have both positive and negative aspects. On the one hand, the diffusion of Western television in the Southern countries, and also in the Eastern ones, helps alert people to their own condition but also encourages them to emigrate. On the other hand, the fact that the images are only one way, from North to South, means that Northern countries do not really know much about the others, which does not help them to get over the idea of "otherness."

However, full awareness of the current contrast between the privileged North and the economically backward South is still limited to relatively narrow segments of the population of both regions. As a result, migratory flows of population from the South to the North and capital moving from the North to the South fall far below what they could or even should be.

In developed countries, the middle class barely recognizes the privilege of living in a free, prosperous, protected, and cultured society in which labor, schools, houses, hospitals, laboratories, museums, theaters, libraries, free time, and opportunities for social and professional advancement guarantee a high and improving standard of living. The low industrial working class and the underproletariat—conditioned by their own growing marginalization—barely recognize the poverty, the demands, and the needs of LDCs. As a result only a few developed countries have populations and governments willing to accept significant numbers of immigrants and are committed to giving economic aid to developing countries.

Even in developing countries, perception and awareness provoke a relatively weak stimulus to emigrate. It is not necessary to ask why every year some 1,000,000 people emigrate from the South. Bearing in mind the marked imbalances between North and South and the enormous differences in life prospects, the question is really why so few emigrate. Quite likely, the most deprived segments of the backward countries do not fully understand their current situation, especially in comparative terms: ignorance, the lack of adequate economic resources, and the lack of psychophysical energy thwart them and discourage them from embarking on a migratory "adventure." Only when education and awareness of the real situation are generalized and the barriers begin to fall can one expect very large migration flows as have occurred, or are occurring, for example, between East and West Germany, Albania and Italy, and Mexico and the United States. Such migration takes place in

spite of the degrading jobs, low salaries, oppression, and intolerance that in many cases are the lot of the immigrants.

In general demographic, economic, and political analyses strongly suggest the conclusion that in the years to come, the high relative living standards in the developed world associated with its slow or even negative demographic growth and the lack or the slow speed of development associated with very rapid demographic growth of the less developed world (together with the expected increase in education and the increase in information from the Western hemisphere) will bring about a more or less strong increase in migratory flows from the world's economically backward areas toward the more developed ones.

Problems in Defining and Measuring Development and Migration

In order to analyze the relationship between development and international migration, we should be able to measure the level of development and the standard of living on the one hand, and the intensity of the migratory flows, the size of foreign population, and the level of socioeconomic integration on the other hand. In a world of nation-states in which migration at least in principle is regulated by the demands and the restrictions of the receiving countries, the definition and measurement of development and migration have been set predominately at the national level. There has been little technical work or political willingness to arrive at a global or even a regional approximation of standardized concepts and measurements; but the increasing integration of the world economy, the rising levels of international migration (propelled not only by economic factors, but also by political-social factors), and growing concerns about the global environment underline the need to better define and measure development and migration.

The markedly different definitions of development and underdevelopment, and the variation in the classification of specific countries even in a single organization's report between one year and the next,⁴ indicate that such classifications must be considered more as brave attempts than as reliable results of research. Classifications are more the fruit of the few statistics available than of essential and substantial theory or hypothesis. Moreover, there are serious deficiencies in social statistics, which rarely are adequate, complete, reliable, and timely. To remedy these deficiencies—so frequently underestimated—the scientific community and the national statistical offices should make every effort to collect and make available better statistics.

Under these conditions it is not easy to set up coherent and clear plans of assistance for development. For instance, it is difficult to understand how in 1989, from the funds for development assistance, Ethiopia received US\$702 million (\$14 per inhabitant) and Israel US\$1,192 million (\$264 per inhabitant, the highest figure in the world) (World Bank, 1991).

⁴ See, for instance, UNDP, 1990 and 1991.

In this chapter, I cannot discuss in detail this topic, which I raise only in the attempt to identify the links between development and migration more precisely. It is likely that in the future the “push” factors will increasingly determine international migratory flows. The problems and needs of the sending countries will dominate the needs and the restrictions imposed by the receiving countries which, up to now, have established the rules of the game. The outcome of these pressures, however, remains uncertain. It is not now possible to identify, with reasonable confidence, those countries in which rapid demographic growth, underdevelopment, and widespread human deprivation will combine to generate a very intensive migratory push.

All countries, North and South alike, are becoming aware of the deleterious effects that large-scale uncontrolled migration can have on political stability, on internal social cohesion, and on economic relations between sending and receiving countries. In spite of this awareness and the numerous technical and political interventions of experts and international organizations, discussions of migration continue to use definitions, typologies, classifications, and data with very different contents and sources. Therefore, it is difficult, if not impossible, to use methodological instruments to identify, monitor, and explain the migratory flows and the factors that contribute to population mobility.

Migration can evade control and restriction, becoming a “danger” to be faced and therefore to be known. Not surprisingly, methodologies for the collection of data on migratory flows and on immigrant populations have greatly improved in those countries where the need to control migration has grown. But also in less affected countries there is growing interest in achieving deeper knowledge of migratory phenomena.⁵

Prospective Links between Population Growth, Development, and Migration

A century ago, international migrations represented an important factor in the redistribution of populations between continents. Overseas colonies absorbed a substantial part of the strong demographic growth that took place in Europe. In contrast, in the final decade of the twentieth century migrations play only a very minor role in the demographic development of the Southern countries. Historical conditions have changed and options are fewer. Between 1845 and 1924, when about 50 million people (mainly Europeans) moved to the Western Hemisphere, the world population was on the average well below 2 billion. The present world population is about 5.5

⁵ Among the signs we can note the recent succession of international conferences—academic and governmental—addressed to the problems of international migration and to the action by organizations such as OECD, EUROSTAT and UN-ECE aimed at standardization of definitions and statistical procedures. According to press reports at the summit of the European Community, in June 1991, Germany proposed that the subjects of international migration and refugees be included among those dealt with by the Treaty of Rome. If such proposals are adopted, it will be necessary to set up new mechanisms of political coordination at the Community level, which will necessitate revision of all the rules (including statistical procedures) which govern this area.

billion and the possible receiving areas are fewer—there are no longer new worlds to populate. Will the developing countries be able to absorb the growing numbers they are experiencing during the course of their demographic transition or will the pressure cause massive outmigration from the South? During the opening ceremony of a recent International Organization for Migration (IOM) conference on international migration (Geneva, December 1990), the Minister of Emigration and Expatriate Affairs of Egypt asked: "Can we, South and North, East and West, or whoever we may be, cope with the current rapid changes?" The question is right, but then we must discover with which efforts, with which instruments, in how much time, and with which priorities the problem can be solved (Livi-Bacci, 1991).

In 1990 the population of developing countries represented about 77 percent of the world total. In ten years, this share is expected to increase to 80 percent and in the year 2025, to 85 percent. The rate of population growth in the developing world is decreasing, but in terms of absolute numbers growth is expected to continue to increase, reaching almost 5 billion inhabitants within ten years and more than 7 billion in 2025. The population of the Northern countries, in contrast, is likely to level off: their projected population size is 1,264 million in the year 2000 and 1,354 million in the year 2025. No less than 95 percent of total population growth in the next 30 years thus would be attributable to third world countries.

The Southern countries must face an especially stark demographic reality: the massive increase in their working age populations (aged from 15 to 64). That component of the population in the year 2025 is expected to include 4.7 billion people, or 93 percent greater than at present. The future of Southern countries will, in a major measure, depend on their ability to productively absorb this rapidly growing potential labor force. The North, too, has a vital interest in the success of that process.

In projecting or imagining future scenarios of migratory flows, we cannot consider the North and the South as two homogeneous geographic entities. We must take into account regional differences in order to identify those countries or regions that are at major "migratory risk."

A recent cluster analysis (Golini and Bisio, 1991) indicates that the Southern countries at highest risk (those of Central, Eastern, and Western Africa) will take much longer to complete the demographic transition than the others and thus will remain exposed to strong migratory pressure for longer periods. Thus, those are the regions that should receive high priority in international aid and development programs.⁶

The sub-Saharan African countries, unlike all other Southern countries, will experience high rates of natural increase and high urbanization rates for some decades to come.⁷ In this region—which includes 82 percent of the African population and

⁶ Clearly these evaluations reflect unexpected and emergency situations, such as, for instance, the 1990–91 crisis in the Persian Gulf and the demise of communism in Eastern Europe.

⁷ The UN projections predict, for sub-Saharan Africa, a total population growth rate of over 2 percent per annum until the year 2025 (close to 3 percent until the year 2005) and an urban population growth rate of over 4 percent per annum until 2005.

13 percent of the population of the South—currently about three-quarters of the population live in rural areas. Demographic growth and economic development have caused a substantial increase in internal mobility. Moreover, the available arable land is often shrinking and many people, mainly nonskilled laborers, are forced to migrate. In the cities, which are the destination of the majority of the migrants, the dramatic increase in the numbers searching for employment and the incapacity of the economy adequately to respond to the growing need for jobs have raised the rate of unemployment. In this context, emigration often becomes a strategy of survival—whether intranational rural–urban migration, or international intra-African migration, or international intercontinental migration (Cerpod, 1991).⁸

These few references have been given to indicate how intense, dynamic, and varied the mobility of the population is. We can expect a marked further growth in the decades to come in the regions that are the most vulnerable from a general point of view and the most at risk from a migratory point of view.

By contrast the data in Table 23.5 demonstrate that the extent to which governments perceive migration as an instrument of demographic policy is negligible. In the 1989 survey of official views on population policy carried out by the United Nations, 120 Southern countries out of 129 declared the level of emigration from their country to be satisfactory or too high. All the Northern countries declared immigration to be satisfactory or too high. Thus, almost all the countries, sending and receiving, consider that migration must be held at the present level or reduced.

Toward an Integration of Northern and Southern Interests

Among the causes and the consequences of migration, in addition to the demographic and socioeconomic factors which have long been considered relevant in the migratory mechanism, one should place an increasing emphasis on political factors. In the countries of origin, political factors with increasing frequency determine the decision to emigrate. Or, as exemplified in post-1989 Eastern Europe, new political conditions no longer prevent people from emigrating. In the countries of destination, migration is increasingly exploited as a political issue by leaders who take advantage of fear and hostility to immigration and immigrants.⁹

⁸ IRP (National Institute for Population Research of Rome, Italy) carried out a field survey in Ghana during July–August 1990 on a sample of 142 males, aged 18–50, living in the interior area of the Bolgetange region. It was found that the majority intend to seek employment outside their own region, even if the destination is often unclear. To the question on intent to seek employment in the capital, Accra, 73 percent answered positively, and on the intent to seek employment outside Africa 77 percent did so.

⁹ Looking only to some news releases of recent times, we see throughout Europe incidents that would have been considered “unrealistic” only a few years before. For example, in France the political handling of the intolerance toward foreigners is no longer associated only with the extreme political right wing; even politicians of prestige and of a democratic tradition show signs of intolerance. Even in the former East Germany, educated for over 40 years in an internationalist and proletarian vision of problems, as well as in West Germany, violent forms of intolerance toward foreigners are increasing. In Sweden, for the first time in its history, the new Speaker of the House was elected in 1991 thanks to the votes of a right-wing party that has a platform against immigrants and immigration.

TABLE 23.5. *Government views concerning the level of emigration and immigration in 1989*

	Number of governments considering emigration or immigration as			Total number of governments offering a view
	Too low	Satisfactory	Too high	
Views concerning emigration				
Eastern, Middle, and Western Africa	2	33	6	41
Northern Africa, Central America, Western Asia	2	18	9	29
Micronesia, South Africa	—	5	1	6
Caribbean, South America	2	13	9	24
Polynesia	—	3	—	3
Melanesia, Southeast Asia, Southern Asia	3	16	3	22
Eastern Asia	—	4	—	4
Total	9	92	28	129
Views concerning immigration				
Industrialized countries	—	26	8	34

Source: Based on United Nations data, 1989a

Also as a result of such political factors, the relationships between development, political-economic integration between North and South (and between East and West), demographic growth, and migration are becoming increasingly interwoven so that it is not easy to determine how to try to break the chain of some dangerous effects generated by these relationships. Accelerating the process of development seems to be the first and most promising approach. Parallel to this, efforts to reduce population growth in the less developed countries may be considered.

Under current conditions, however, there is the risk that development may remain only a remote possibility for many less developed countries. Observers often cite, to give encouragement, the case of the rapid economic development achieved by the four Asian "dragons" (South Korea, Hong Kong, Taiwan, and Singapore), even though their experience seems to be rather specific and cannot be simply extended. This is so not only for cultural reasons, but also for structural ones.¹⁰

It does not seem possible to generalize the dragons' successes for economic reasons as well. First, aside from the heavy debt burden carried by many less developed countries, particularly in Africa and Latin America, the economic aid given by

¹⁰ For Indonesia, with its 171 million inhabitants, to export goods valued at the same per capita amount as the exports of Singapore (US\$11,000 in 1987), that country would have to capture 75 percent of total world exports—prima facie an impossible task. Even lesser amounts of per capita exports would be incompatible with plausible changes in the structure of world trade. This point applies to a large number of the LDCs, especially the most populous (George, 1990).

the North to the South, as measured in relation to their income, tends to diminish over time. Official Development Assistance (ODA) as a share of the GNP of the OECD members dropped from 0.48 percent in 1965 to 0.33 percent in 1989. The ODA of the OPEC members dropped from 2.32 percent of GNP in 1976 to 0.45 percent in 1988 (World Bank, 1991). Second, because of the increased use of computers and robotics, the advantage of the abundant supply of low-cost labor in the less developed countries could diminish, reducing the attractiveness of these countries for investments by transnational corporations. Third, the funds available for the Southern countries have become sharply limited as the economies of Eastern Europe and the former Soviet Union have required massive and growing infusions of capital. Such international capital flows are also becoming less manageable as a consequence of decreased savings and of the growing indebtedness of some Western countries. Concerning this last point, one may hope that the enormous current military expenditure can be reduced and that the funds can be redirected toward more productive investments. In the late 1980s, the annual level of military expenditure was more than US\$1,000 billion, \$860 billion in high-income countries and \$170 billion in developing ones. In 36 countries, most of which are developing, military expenditure amounts to more than 5 percent of the GNP, thus absorbing a very high portion of the available resources (World Bank, 1991).

If these are reasons for pessimism with respect to the possibility of development, migration offers a partial solution to the problem of underdevelopment and excess labor supply in the less developed countries. But migration alone, important and necessary as it is, can solve neither the problem of rapid population growth nor the problem of underdevelopment.

A hundred years ago, migration was one of the principal factors in the redistribution of the population between continents. Between 1881 and 1910, the period of maximum immigration, America and, to a lesser extent, Australia absorbed about 20 percent of the population increase of Europe. Today, permanent annual emigration flows absorb only 2 to 3 percent of the population increase of Latin America and much less of the population increase of Asia and Africa. The options for large mass migration (involving tens of millions of people) toward new or old worlds no longer exist. On the other hand, the Southern countries themselves tend to be worried about the prospect of mass emigration either because the Western countries tend to absorb higher-educated immigrants, aggravating the brain drain, or because the European reaction to the oil shocks and to the crisis in the Persian Gulf has pointed up the vulnerability of some forms of labor migration such as the contract-worker system. But if mass migration alone is not a practicable instrument to break the links between underdevelopment, population growth, and present North-South relations, then there is no other recourse but to turn to the task of accelerating economic development in the South. In addition to promoting internal reforms, greater financial, economic, and technological North-to-South assistance can be an important instrument serving that goal.

In this case we must ask what would provide the impetus for the North to overcome its present-day egoism and to adjust market mechanisms in favor of the

South. Cultural change and fear could be the springboards in the North generating radical change in that direction. Greater cosmopolitanism and willingness to share better living conditions throughout the world, and the fear of environmental breakdowns, of a migratory "invasion," and of a continued increase of drug production and trafficking could prove to be the starting points. It would be desirable if cultural change played the main role, but probably fear will prevail. Already now, the fear of growing immigration (joined with the wish to expand export markets) pushes some countries, notably Japan, to adopt economic support programs aimed at accelerating development in Asian countries that have high potential outmigration. Similarly, transnational "Green coalitions" demonstrate that environmental questions giving rise to much fear can generate political action. The importance of such factors, in all probability, will grow with time.

The position of some Canadian and Australian lobbies in the field of population is shaped by domestic environmental concerns. These lobbies wish to limit their countries' population growth as far as possible, thus they are hostile to large-scale immigration. American opposition to immigration reflects ecological, social, racial, and economic concerns; some opponents propose a limit of half a million annual immigrants to the United States as against the near-million envisaged by the US government. Those seeking a lower immigration are motivated by ecological concerns (which would favor limiting the American population to 320–330 million inhabitants) and also by the wish to reduce racial conflicts and to stimulate greater levels of per capita domestic investment to modernize production (Bouvier, 1991).

The environmental question offers the South an important opportunity to realign its economic relations with the North. For the Southern countries, their acceptance of constraints to the exploitation of their natural resources and their willingness to adopt policies that would help ensure global long-run environmental well-being could provide the means to negotiate international agreements that would induce Northern countries to make environmental adjustments, but, above all, that convince them to transfer clean technologies at advantageous terms and to pay compensation for sacrifices involved.

The growing concern in the North regarding environmental issues might also serve as a means for the South to negotiate cancellation of the accumulated debt (or at least better conditions for its servicing and repayment) and to secure improved conditions in international trade, in particular greater access to the markets of the industrialized countries. The unfavorable international market conditions in which many Southern countries find themselves prevent them from fully exploiting the main potential strengths of their economies. Greater access to export markets would stimulate job creation and serve to moderate outmigration.

Such opportunities may not be fully taken advantage of by all Southern countries because they may lack the solidarity and the requisite strength to make a valid effective common effort. The long view required in addressing environmental questions may not prevail among policymakers attracted by the immediate appeal of short-term profits from the uncontrolled exploitation of natural resources (Ravenhill, 1990). To better negotiate with the leading industrialized countries—the "Great

Seven"—who already have extraordinary strength in the management of international economic affairs, the South would need to have greater political cohesion.

Greater political cooperation between the Southern countries should, however, include among its top priorities domestic political and economic reforms. Democratization is a prerequisite for modern industrial civilization. Democratic governments everywhere have proven to be the most conducive to successful economic and social development.

Even if the type of changes in international economic and political relations that I have just outlined were to be embraced and implemented with conviction and success in both North and South, two major obstacles to socioeconomic betterment would remain. First, the Southern countries—especially in Africa—lack the political, bureaucratic, infrastructural, and human resources that are prerequisites of highly successful international aid programs; second, they lack the time span necessary to create conditions for rapid development and to reduce internal imbalances and the political and social tensions in the Southern countries (which, I repeat, could also be potentially dangerous to the North).

Success in Southern development, however, would not quickly eliminate migratory pressures. Indeed with modernization, the impetus toward individual mobility as a means of occupational and social advancement would likely become stronger in the short-to-medium term. Waiting to see if and when the new culture will come about and if and when it can take root effectively, in the foreseeable future migration will continue to play an important role in the relations between the North and South. International migration can be helpful to correct the qualitative imbalances of the labor markets of the North, to lighten the demographic pressure of the South, to strengthen the economy of the South through emigrants' remittances, to promote development of human resources in the South, and to promote transfers of knowledge and technology.

The industrialized countries cannot ignore this situation and these prospects. It is likely that what will happen in the domain of international migration depends more on Western policies and popular attitudes than on any other factor. It seems preferable for the industrialized countries to aim at managing the modes, composition and intensity of the international migratory flows rather than to try to erect rigid barriers to such migration that would inevitably be overcome in a random and haphazard fashion.¹¹

What are the means necessary to manage immigration flows? A commonly used instrument is the establishment of numerical quotas for permanent immigrants. In Europe, according to Böhning (1991), this should be supplemented by two additional instruments: "project-tied migration" and "migration for training."¹²

Besides keeping the doors open to moderate levels of immigration, receiving

¹¹ In America, for example, severe laws, heavy fines for employers who hire illegal workers, and borders guarded day and night with the help of sophisticated instruments are not enough to make the Rio Grande uncrossable.

¹² The term "project-tied worker" refers to a temporary migrant worker admitted to a country to undertake a specific assignment or duty.

countries, especially in Europe, need to carry out a program facilitating the full integration of immigrants within the receiving society. Failing in this task, the democratic structure of these countries is endangered: the choice is either integration or conflict. If a society wants to remain democratic, it must treat immigrants in the same way as it treats its own citizens, giving them full civil and in due course full political rights. This is consistent with immigrants preserving their cultural identity yet ensures that immigrants are not pushed into the fringes of the receiving society. If the immigrants are left as "strangers on the fringes," the regression toward a weakened democracy would be inevitable as a result of the growing political-social tensions provoked by autochthonous citizens wanting to totally preserve their "rights" and the foreigners wanting to avoid a life of prolonged marginalization.

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Part VII

Summations and Recommendations of Participants in the Study Week on “Resources and Population”

Report of Group 1: Population Problems

In this report we review salient features of population growth, urbanization, and migration and outline policy options at country, regional, and international levels. We confine ourselves to the demographic dimension, leaving its interrelationship with resources to the reports that follow.

Population Growth: Past and Present

Following the period of mortality crises associated with epidemics of plague, a pattern of continuous if relatively slow demographic growth prevailed in Western Europe. The main lever to regulate growth was temporal adjustment in nuptiality. Western Europe was characterized by the unique features of late and less than universal marriage, and these features could be accentuated or reversed according to circumstances. With fertility within marriage generally uncontrolled, marriage behavior had an influence on population growth. Rather high general fertility and continuing high levels of mortality were, however, the rule.

This pattern of growth was eventually modified by a change of behavior with regard to fertility within marriage coupled with a marked decline in mortality. The causes of both these trends have long been a matter of debate. Both movements entered into shaping what has been called the demographic transition. Many theories have been proposed to explain what happened during a time stretching over almost two centuries throughout the region, with different starting and ending points in different countries. The transition occurred, with different timing and pace, in all industrialized countries, from Russia to North America, from Australia to Japan.

Within the less developed countries of today, a broadly similar dynamics assumes a different character. In these countries, new features have prevailed since the beginning, including a generally higher level of fertility, precocious and practically universal marriage, and the rapid spread and strong impact of modern methods of control of morbidity and mortality. Instead of a complex system of change born and gradually evolving within a society, these countries have experienced intensive exposure of their traditional cultures and ways of life to external forces, in a difficult and in some respects destabilizing interaction with internal social and economic realities.

From a demographic point of view, this resulted in unprecedentedly high rates of growth. For the whole world the population took a century to double—mainly in

This is a summary of the deliberations of a group convened on the final day of the Study Week consisting of Bernardo Colombo (Rapporteur), Axel Carlberg, Georges M. M. Cottier, Renato Dardozzi, Paul Demeny, Antonio Golini, Massimo Livi-Bacci, James McHugh, Christine Oppong, and Paul Trappe.

more developed areas—between 1850 and 1950. The next doubling took only 40 years, with most of the increase occurring in developing countries.

In the industrialized countries mortality and natality have leveled off downward, and the demographic expansion has virtually come to an end. An eventual decline in population—in the absence of migratory movements—is expected in many countries since fertility has steadily remained below replacement level. The rapid pace of aging of these populations sets the stage for significant problems in supporting the elderly and is likely to induce severe intergenerational tensions in the future.

In the developing countries several different patterns of demographic dynamics have been observed. Everywhere a reduction of mortality in general, and of infant mortality in particular, has been achieved, though with marked variation between countries and regions. Fertility has remained high up to 1990 in most of sub-Saharan Africa and in Islamic cultures, with a few exceptions such as secularized Turkey and Indonesia. Total fertility rates around 6 births per woman and population growth rates of 2 to 3 percent or more per annum are recorded for 1985–90. The most significant reduction of population growth, given the size of the country, has been in China. In the second largest country, India, the decline in the growth rate has been much less. Sooner or later in many other countries the birth rate declined measurably. For the world as a whole the United Nations estimates a 1990 average fertility of 3.35 children per woman.

The Current Situation and Population Prospects

Since the 1950s the Population Division of the United Nations has been publishing estimates for total population size and for various other demographic parameters. Their sources of information are of varying quality, but with consistent improvements over time they are now deemed to be of adequate reliability. Locally relevant margins of error may persist, but the global figures appear to be a satisfactory approximation to reality. Progress in methodological tools of analysis has aided in deriving coherent estimates in cases where available data are lacking or of poor quality. The estimate of 5.3 billion people on Earth in 1990, partly derived from extrapolating census figures, can be accepted with confidence.

Detailed data about fertility, mortality, age–sex structure, urbanization and rural–urban distribution are also widely available. More difficult and uncertain are statistics on employment and unemployment, particularly in situations in which the informal sector is a significant feature.

Since the early 1950s the Population Division has also issued projections of future population and its characteristics. Their reliability has improved over time particularly for regions of Africa, where few data were available until recently. But projections depend upon necessarily uncertain hypotheses about the dynamics of factors determining population growth. In particular, apart from migration, which is normally excluded from the calculations, these hypotheses try to capture differential dynamic patterns of mortality and fertility. The Population Division's estimates are

elaborated in high, medium, and low variants. A fourth calculation is also usually offered, based on the assumption that fertility remains constant at the level recorded at the starting point of the projection.

The evolution of mortality can be estimated with greater confidence than that of fertility because of the unidirectional tendency of mortality trends. In any case, assumed differences do not have an important long-term impact on population growth, at least as concerns ages beyond the reproductive period of women. Hypotheses concerning fertility are based on much more tenuous evidence and depend on tentative extrapolations, on analogies, on intentions of governments, and so on.

The assumption underlying the medium variant projections is that replacement-level fertility will obtain nearly everywhere by the year 2025. This stipulated homogenization of demographic behavior appears reasonable, but it is obviously surrounded by a large margin of uncertainty. According to the medium projection, the estimated population size for the world is 8.5 billion inhabitants for 2025, and approximately 10 billion in 2050.

Different paths of future demographic growth result from different assumed fertility levels. Calculations of the expected global population size can be based on hypotheses concerning the number of children per woman. The estimates thus obtained can differ very markedly over time. In any case, the growth in numbers, the reshaping of age structures, the prospects for further concentration in urban areas differ widely between the developed and less developed regions as well as between countries, ethnic and religious groups, and subpopulations defined by various other criteria.

Reaching a near-universal replacement level of fertility would entail a further large extension of today's practice of family limitation reflected in the quoted 3.35 total fertility rate of 1990. Extensions of the practice need not mean continued use of the same means as today. Apart from possible innovations deriving from a better knowledge of the physiology of human reproduction, this is suggested by the present variety of choices in different countries and social contexts.

Urbanization and Internal and International Migration

The urban population is increasing rapidly in the world, and particularly in the less developed countries. From having two-thirds as many people living in urban areas as the more developed countries in 1950, the urban population in the less developed countries will increase to more than three times the urban population of the more developed countries by 2020. In these 70 years, according to the standard forecast, while the urban population of the more developed countries multiplies by a factor of 2.5, that of the less developed countries will multiply more than twelvefold. For Africa the urban population will multiply by more than 22-fold over that same period.

Whereas in the more developed countries the process of urbanization and the growth of the largest cities occurred in parallel with the process of modernization and industrialization, in the less developed countries we can often observe an excess

of urban growth in relation to economic and social development. This has led to the creation of large urban slums. Nevertheless at present the rural-urban migration process continues because to migrants the cities represent a unique opportunity for economic and occupational advancement.

Cities concentrate the consumption of resources, the production of waste and pollution, and generate many health problems. Government policies should endeavor to reconcile environmental conservation with the alleviation of poverty through fostering more balanced and equitable economic development. A route to sustainable development is to encourage decentralization of economic activity, both public and private, in favor of rural areas.

Excess urbanization in the developing countries can also be viewed from a different perspective. Internal migration to the largest cities often represents the first step toward international migration, as migrants encounter a lack of jobs and unacceptable living conditions. In more general terms international migration is caused by the very large differences between countries with respect to population growth, economic development, and social and political conditions.

Until recently, migration flows were mainly determined by the rules and labor exigencies of destination countries (pull factors); at present, as is increasingly likely to be the case in the future, the push factors in the sending countries play a more important role. But migration alone, as important and necessary as it is, can solve neither the problem of excessive rates of population growth, nor the problem of underdevelopment. On the latter, it is commonly observed that migrants tend to be the more highly skilled members of a population—the “brain drain” effect.

If mass migration is not the right and practicable instrument to break the linkage “underdevelopment-rapid population growth-increasing North/South disparities,” then the solution must be the accelerated development of the South. This calls for adopting approaches more effective than those applied until now.

In the developed countries, besides the need to keep the doors open to moderate immigration, there is a need to adopt policies that guarantee full acceptance and integration of immigrants. Integration can alleviate social tensions and avoid the permanent marginalization of immigrants.

Some Correlates of Population Growth

Problems of adjustment of and to demographic dynamics appear very different for the less developed and more developed regions.

A general consensus was reached by members of the group on the desirability of slower population growth in many developing countries. The positive cultural and societal impact of lower fertility and lower mortality was noted. It was recognized that there are economic and social preconditions for achieving a suitable demographic development. The focus here is on a few pressing and immediate issues.

In some cases, achieving internal security and peace is necessary. This fosters a sense of community and strengthens expectations of future stability. Also important

is an effort to achieve social justice and equality, with a special concern, internationally, for the poor countries and, within countries, for the poorer sectors of the population. In particular, special attention should be given to:

- primary health care;
- educational opportunities for both sexes;
- employment;
- the responsibility of the privileged to assist the disadvantaged;
- supporting family and kin structures as natural and universal social entities and as basic units of social and individual security;
- fostering social groups and civic organizations—for social, economic, and political goals—for men and women;
- assisting basic social units to move toward self-reliance and market-orientation while also preserving traditional systems of cooperation;
- addressing the discrimination facing girls, teenagers, and young women, including unequal access to education, training, employment opportunities, and income;
- land reform under the rule of law with fixed private land tenure rights and respecting social and environmental values;
- efforts toward reversing the process of excessive urbanization;
- fostering formal and informal sector employment with special regard to the urban poor;
- fostering national self-reliance with respect to basic food requirements, including those for the urban masses.

International assistance to developing countries should be primarily directed at strengthening social and institutional infrastructure, transferring appropriate technology, and encouraging the adoption of sound development policies. There was consensus favoring a new commitment on the part of the developed countries to the solidarity with the less developed countries. At the same time, developed countries should be mindful of their own population problems. Some of these countries, as was noted above, face the problem of very low birth rates. This should be addressed by a national commitment to family policies that assist parents in responsibly planning and rearing the desired number of children.

Report of Group 2: Health Issues

Against the background of expanding population and increasing pressure on natural resources, we will describe briefly the health problems that we face at the present time. These problems will become worse if a balance between people and resources is not achieved.

Even now, large numbers of people live at marginal levels of food, sanitation, and health care. Their capacities for development and production are limited and a vicious cycle is set up.

We can make these statements as scientific facts, because we know, with reasonable accuracy, what the food needs of human beings are, both for bare maintenance and for a reasonable quality of life, although the latter implies some measure of value judgment. We know the prevalence and effects of infections in different groups; we know the handicap to human development produced by the concomitants of poverty. All these things are facts. However, there is and always will be a need for further research, both basic and operational, to provide a better understanding of these complex relations.

The purpose of this volume is to marshal the scientific evidence on different aspects of the problem of population and resources. In the sphere of medicine and health, however, we cannot make a rigid distinction between the process of diagnosis, based on facts, and deductions about treatment that follow from diagnosis. Therefore we have not hesitated to make some proposals in this report about what needs to be done, as we see it. We believe that the focal point for attacking and hopefully breaking the vicious cycle mentioned above is at the level of the family, the child, and the mother.

Children

The focus of this report is on children, because they represent the resource for the future.

Undernourished mothers produce children of low birth weight. The proportion of children with low birth weight approaches 50 percent in some third world populations, compared with about 5 percent in some richer countries. Low birth weight carries an increased risk of death or stunted development.

Partly because of this handicap, infant and child mortality rates in many less developed countries (LDCs) are still extremely high, in spite of substantial falls in

This is a summary of a group convened on the final day of the Study Week, consisting of J. C. Waterlow (Rapporteur), Lars Å. Hanson, Jerome Lejuene, Kenneth G. Manton, Giovanni Battista Marini-Bettòlo, and S. Grantham-McGregor.

the last two or three decades. Typical figures for the infant mortality rate (IMR) might be about 130 per 1,000 in rural areas and about 100 per 1,000 in cities. Although these rates are lower than in the past, the absolute number of deaths has continued to rise because of the increase in the child population. The main causes of death are respiratory infections in the first few weeks of life, and malnutrition and diarrheal disease from 6 months to 2 years of age.

Among those who do not die, growth begins to fall off at about 3 months. Deficits in weight reflect malnutrition, either primary or secondary to infections, usually a combination of the two, and are associated with increased risk of death. The continuing but less dramatic retardation in linear growth (stunting), which affects vast numbers of children, is accompanied by impairment of mental and behavioral development. It is probable that these handicaps persist into adult life. This represents an enormous and unacceptable loss of human capital. The exact causes are not fully understood, but it is clear that these handicaps result from the combination of physical and psychosocial deprivation that characterizes the life of impoverished families.

Concerning food, in addition to the consequences of inadequacy of energy and protein, specific deficiencies affect large numbers of women and children in less developed countries. The most widespread are deficiencies of iodine, iron, and vitamin A. Mothers who are severely iodine deficient produce children who are cretins. Less severe iodine deficiency in children impairs mental development. There is increasing evidence that iron deficiency in children results in poor cognitive function, at least as long as the deficiency persists. Severe vitamin A deficiency leads to some 300,000 cases of permanent blindness every year, with many more children having some degree of eye damage. There is evidence also that subclinical vitamin A deficiency decreases resistance to the respiratory infections that are a major cause of death. The technology exists for eliminating these deficiencies, but the coverage of the delivery programs is still too low.

In achieving the goal of a stable and sustainable world population, the nutrition and health of the young child plays an essential role. It follows that every effort has to be made to achieve conditions, both at home and in the workplace, that allow women to breastfeed their babies and to provide the stimulation that is so important for infants' psychological and physical health.

Adults

We are moving toward a better understanding of the minimum amounts of food that are needed to sustain the health and productivity of adults during the working period of their lives. Thus we are better able to set realistic targets for the production and distribution of food.

Whereas in industrialized countries large numbers of adults are overweight, with consequent hazards to health, in many parts of the third world a great many are maintaining existence at a level of body weight that is not compatible with optimum

productivity and an acceptable quality of life. Women are particularly at risk, not only because of the stress of childbearing and childrearing, but because of the enormous demands on their labor and time that are imposed in many societies.

Women hew wood and fetch water and often are responsible for a major part of agricultural activity. Biologically, females seem to be longer lived than males, but in many countries the life expectancy of women is actually less than that of men, indicating that they are exposed to greater disadvantages than men. Death in childbirth now seldom occurs in Western countries but remains an important cause of mortality in the third world.

There is an inverse relation between the education of women and the mortality rates of children. There may also be a direct effect of education on the birth rate, through wider birth spacing. It follows that the education of women plays a key role in the reduction of population growth. It follows also that there is danger of another vicious cycle: for the undernourished, overworked woman, education may be an unattainable goal, and so her state and that of her daughters becomes even worse.

Although in adult life the infectious diseases of childhood become of less importance, it is necessary to emphasize the continuing prevalence in less developed countries of infections and parasitic diseases and infestations as causes of death and of decreased productivity. AIDS, the latest addition to the category of major infectious diseases, is assuming epidemic proportions in some countries. We are beginning to see the tragic effects of this infection even in young children. The recrudescence of malaria, with organisms resistant to drugs and vectors resistant to insecticides, is of particular concern. The cost of producing new drugs is so high and the ability of the less developed countries to purchase them so low, that the development of new curative and preventive agents is held back, in spite of the efforts of WHO's Tropical Diseases Research Programme. Many valuable drugs have been derived from natural products; this emphasizes the importance of protecting the plant gene pool.

The Elderly

In most developing countries the expectation of life has increased substantially in the last generation, so that the numbers of elderly people are increasing. It is necessary to distinguish between conditions that are age-determined by the biological process of senescence, and those that are age-related, such as cardiovascular diseases and some cancers. Many of the latter are characterized as "diseases of affluence" and in principle can be prevented or treated. These diseases are becoming more common among the affluent groups of third world as well, and impose an increasing burden on the already hard-pressed medical services. It must also be remembered that many of these disease processes may be initiated earlier in life, so that a healthy lifestyle may have a protective effect.

Another group of age-related diseases that progress more slowly and cause much disability includes conditions such as osteoporosis, osteoarthritis, and Alzheimer's

disease. Here the causes and the preventive measures that might be taken are less clear.

Because of different nutritional patterns, different exposure to risk factors such as smoking and alcohol, differences in access to medical care and education, and differences in early health history, one may expect the various diseases that characterize old age to have different prevalences and natural histories in developed and developing countries. In fact, rather little is known about the disease patterns in the elderly poor in less developed countries. Much more research is needed on this subject. It is probably not the case that a lifetime of hard physical labor prevents the onset of degenerative disease. On the contrary, "wear and tear" of muscles and joints may lead to much pain and disability in the rural old.

Even in richer countries there are still inequalities in expenditure on health care, and these inequalities may be exaggerated in poor countries. Large sums of money are invested in high technology facilities for treatment of the affluent elderly, money that would be better spent if dispersed on primary health care. One aspect that has been neglected in less developed countries is the provision of simple measures to improve the quality of life of the disabled elderly.

In poor societies, the disability and dysfunction of old age mean that the elderly have to rely increasingly on the support of the family. This has the advantage of avoiding the isolation of old people that is so common in the Western world. Moreover, the elderly have a unique contribution to make from their own experience, as is well shown by the role of the grandmother in many societies. On the other hand, this extra demand on the family resources may be a stimulus to have many children, to ensure support for the aged.

Practical Recommendations

Measures to improve the quality of life in poor countries should be focused on the family, in which the mother plays the key role. Social and agricultural policy should give a high priority to reducing the burdens and constraints on women and the demands on their time. Lack of time limits their capacity to provide the psychological stimulation that is so important for children's mental development. The provision of sanitation and more accessible water supplies will reduce the prevalence of waterborne infections. Of perhaps overriding importance is better access to education and greater participation in community life and community decisions.

A healthy, well-nourished mother will produce a baby of satisfactory birth weight, which she should be able to feed from the breast alone for 4 months or more. Therefore, in all programs concerned with the provision of food, priority should be given to the mother, both for her own sake and for that of the rest of the family.

It is of great importance that breastfeeding be initiated immediately after birth. There is strong evidence that this will provide protection against a wide range of infections in the early months of life. Breastfeeding has other important effects, which will be considered below.

Toward the middle of the first year exclusive breastfeeding is no longer sufficient for the infant's needs and weaning foods have to be introduced, although this carries with it the risk of diarrheal disease, which is a major cause of death. Partial breastfeeding, for as long as possible, reduces this risk. In some societies it is continued for two years. Much attention needs to be given to the provision of facilities for breastfeeding for mothers who are working away from home.

An important question is the nature of the weaning foods that are used, which in many poor countries are inadequate in both quantity and quality. Simple village-level technologies are available for improving the quality and energy density of these foods and for reducing the level of bacterial contamination.

Hand in hand with nutritional measures go those for the prevention of infectious diseases: vaccination, sanitation, and the supply of potable water. WHO and UNICEF have active programs in these fields, which need to be strengthened.

Vaccines are available to provide effective protection against diphtheria, pertussis, tetanus, poliomyelitis, measles, and tuberculosis. WHO's Expanded Programme of Immunization has met with much success; for example, polio is on the verge of being eliminated from Latin America. However, in many parts of the third world vaccination coverage is still very incomplete and as populations increase even greater efforts will have to be made.

Unfortunately, no vaccines are available against the main killers of children—respiratory infections and diarrheal disease. Measures for the prevention of respiratory infections include a reduction of overcrowding, and perhaps in some areas the provision of vitamin A.

The prevalence and severity of the infections that result in diarrheal disease can be reduced by proper sanitation and the provision of adequate amounts of clean water. Unfortunately, these measures require massive inputs of resources. Better progress has been made in cities than in rural areas. Improvements of this kind in the quality of life in rural areas would help to reduce the massive migration to cities.

It must also not be forgotten that there is a synergism between malnutrition and infection. In an adverse environment even a well-nourished child will be susceptible to infections, but the episodes will be less severe and life-threatening.

Although not all mothers are able to breastfeed for prolonged periods, maintaining breastfeeding and ensuring good nutrition in the first two years of life are of importance not only for the individual child but also for the population as a whole, for three reasons.

First, through endocrine mechanisms that are fairly well understood, even partial breastfeeding greatly reduces the capacity for conception, provided that the baby suckles often enough. Breastfeeding thus provides a powerful mechanism for increasing the intervals between births and reducing the overall birth rate.

Second, although the relationship is not invariable, there is evidence from many studies that as infant and child mortalities fall, after a lag period the birth rate also begins to fall. The causal relationship is not well understood, but there is strong evidence that education of the mother plays an important role. Many studies have

shown that the higher the female literacy rate, the lower the infant mortality rate, after controlling for differences in economic status.

Third, the impairments in physical and mental development referred to above are usually initiated in the very early years of life. These effects are reversible if the child has the good fortune to move to an environment that provides adequate nutrition and social stimulation, but this is not easy and prevention is better than cure.

Conclusions

We repeat the point already made, that in order to break the vicious circle of poverty—ill health—functional disability—poverty, and to mitigate the effect of imbalance between population and resources, strategies should be focused on the family, and within the family on the mother and young child.

The following, therefore, are health priorities.

1. All actions must be focused on the family.
2. The first priority is a reduction in infant and child mortality rates. This in itself provides a stimulus for the reduction of birth rates.
3. The child who survives must be protected as far as possible against the handicaps imposed by a deprived environment, with its combination of malnutrition, infection, and lack of psychosocial stimulation. These impair physical, mental, and behavioral development, leading to an unacceptable loss of human resources.
4. Breastfeeding should be promoted for as long as is possible for the mother in her particular environment. This has two important effects—protection against infection and reduction in birth frequency—which both contribute to a decrease in mortality.
5. Proper birth spacing is important for the health of both mother and child. It is the duty of the health profession to promote this by means that are appropriate within the cultural and social context.
6. Better education of women is a key factor in achieving all these ends.
7. With longer life expectancy there will be an increasing number of elderly people. As far as possible they should remain integrated within the family, to which they can make an important contribution.

Report of Group 3: Resources

The report of this group considers issues relating to materials, energy, water, and agricultural resources.

Materials and Energy

Raw materials (including fossil fuels) are finite and nonrenewable, and increasing consumption rates will cause their depletion and eventual exhaustion. As yet, however, predictions of exhaustion of reserves have failed to materialize. Known resources of most raw materials, including oil and gas, are higher today than they were ten or twenty years ago, and international market prices (in real terms) generally have decreased.

In part, this is a consequence of findings of new reserves, or the re-evaluation of known reserves, connected with improved methods of prospecting and exploitation. But the substitution of new sources and new kinds of materials for traditional ones has been more important, as has the trend of reduction of the material and energy contents in advanced societies.

New energy sources include nuclear energy and new renewable energy technologies; perhaps more important is the development of technologies allowing the more efficient use of energy and the elimination of wastage. New classes of materials, such as advanced ceramics and composites, have been and are being developed based on greater scientific understanding.

Important contributions leading to decreased needs for raw materials derive from recycling, including the recovery of scrap metals such as iron and aluminum, steps that have important energy-saving consequences.

In the future, new options will become available as a result of scientific and technological breakthroughs. Expectations are high for better-performing solar cells; biomass for energy and industrial use could gain importance as an alternative to set-aside policies for agricultural land. Nuclear reactors with improved safety are under development, and progress is being made in nuclear fusion, although forty years will probably elapse before it becomes a new source of commercial energy. New or improved ways of transporting energy over long distances are also being developed; they include high temperature superconductivity, and the use of hydrogen as an energy vector.

Therefore, from a global standpoint, the availability of raw materials and of

This is a summary of a group convened on the final day of the Study Week, consisting of Leslie Fowden (Rapporteur), André Blanc-Lapierre, Umberto Colombo, Malin Falkenmark, Ugo Farinelli, Amir Muhammed, Alberto Vollmer, and Victor Weisskopf.

energy sources is not a limiting factor for population growth and development in the short and medium term, if the most advanced technologies were adopted universally. In the longer term, it is possible to conceive ways of producing, using and recycling energy and materials that are commensurate with sustainable development. This course of action will prove difficult for less developed countries, however. Many of them have seen their traditional activities, based on the extraction of raw materials and the first phases of processing, decrease in volume and value. The greater technological content of new materials, and the strict connection between material and product development, prevent these countries from extending material processing downstream. These countries currently need increasing quantities of energy and materials to build their infrastructures and to provide basic goods to growing populations. As yet they do not possess the advanced technologies needed for the fully effective use of materials and energy.

Transfer of advanced technologies from industrialized to developing countries has encountered many obstacles: the lack of basic infrastructures and of adequate scientific and technical know-how to adapt new technologies to the conditions of the receiving country; reluctance of donor countries to release state-of-the-art technologies for fear of competition; and lack of funds. The introduction of the most advanced technologies often requires a "quantum-leap" that abandons the traditional development model characterizing early industrialization. This transition is a formidable challenge requiring effort on an unprecedented scale by governments and international organizations.

Water

Human society depends upon the global water cycle. Water reaches the land surface as rainfall. A considerable fraction quickly returns to the atmosphere; the remainder either percolates to deep aquifers or enters streams, rivers, lakes, and eventually the sea. In turn water can become polluted or be an agent for soil erosion.

Rainfall is distributed very unevenly over the Earth's surface, and the poorest countries are located to a remarkable degree in areas with dry climates or recurrent droughts; they then form fragile environments based on a delicate balance of soil, water, and vegetation. With society depending on a regular supply of water (and food and fuelwood for which water is essential for production), hydroclimate acts as a strong influence on the development process.

Population growth poses environmental threats linked to water, for example through increased water scarcity, water pollution, and degradation of soil structure and fertility. Three measures are essential to limit water-related environmental damage in the poorest countries: to reduce the negative effects of drought on agricultural production in both low and high potential areas; to accelerate safe handling of wastes and to reduce pollution; and to integrate soil and water management on a watershed basis.

Even if these strategies are adopted successfully, the arid, populous parts of the

Middle East and Eastern Asia will still present a major problem because the available rain and irrigation water will not support any significant increase in crop growth and food production. Further increases in populations would necessitate massive (perhaps physically unattainable) food transportation or migration of peoples on a large scale. In areas with higher production potentials, barriers to improved water management must be surmounted by local research centers focusing on acceptable methods to mitigate the effects of drought.

Agriculture

Land and water are foremost resources for agricultural production, but combinations of good soils having adequate moisture and favorable climates are encountered on only a small fraction of the land surface. Food and fuelwood are already scarce in some less developed countries, a situation likely to be aggravated if present trends of population increase and soil and water degradation continue.

Existing and future developments in agricultural technologies, including those in biotechnology, provide the basis for production systems to meet the global needs of the present and the projected populations of the early twenty-first century if appropriate policies and management practices are adopted rapidly by governments and international organizations. Such policies should promote the economic growth of the less developed countries, which in turn will stimulate agriculture. Governments must also ensure greater economic equality between the urban and rural populations by increasing the returns on farm produce and by creating structures for better marketing, storage, processing, and distribution of produce and the provision of agricultural credit. National governments would be encouraged in such actions if the conditions of international trade were made more favorable to the poor countries.

Where soil and environmental conditions are suitable, increased agricultural production can be obtained by intensification of land use through wider application of fertilizers and crop protection chemicals, and greater reliance on machinery and improved seeds. Produce prices should reflect the cost of these inputs to ensure commercially viable agricultural enterprises, while agricultural research should aim to lower the use of these costly materials by increasing efficiency. In the longer term, efforts should be made to replace these inputs by indigenous materials.

National and international support for research is vital, and its financing must keep pace with the demands placed on agriculture by increasing populations. New knowledge is needed to develop agricultural technologies that make increasingly efficient use of the supporting resources. Research also should address the implications of global climate change for agriculture, seeking realistic projections for different regions of the world and the identification of appropriate practical responses.

Agriculture accounts for only a few percent of total energy consumption, even in intensive systems, so this resource should not be a constraint. Water availability is far more critical: reduction of water requirements could result from the wider

adoption of more efficient irrigation systems, and the selective breeding of crop varieties exhibiting greater efficiency in water use.

The opportunities associated with crop improvement via biotechnological methods raise problems of intellectual property rights. Less developed countries, which often are the sources of useful genes for crop plant transformations, are justifiably concerned that they may have to pay heavily to acquire improved seed materials containing these same genes.

Food and Nutrition

Individuals within the poorest section of society in some less developed countries, especially children of poor families, often suffer malnutrition reflected in a stunting of growth, lower activity, and lower IQs. The main cause is an inadequacy of food, particularly food energy. Hunger is estimated to have caused 200 million deaths between 1969 and 1989. Calculations suggest that this appalling figure could increase fivefold in the next 20 years, with the highest incidences of hunger-related deaths occurring in poor countries where the lack of water often poses a real constraint on food production and where the rates of population increase are highest. Food scarcity, short of a level resulting in death, imposes an unacceptable burden on human beings; the malnourished perform below normal and are more readily subject to infections and other diseases.

Conclusions

Many of the present important resources used by human society are finite; however, newer technologies can expand the resource base and offer alternative solutions for materials and energy. Newer and/or renewable materials and energy technologies will become progressively available, and many of these will be more environmentally friendly than conventional sources.

Scarcity of land, and especially of fresh water, is already limiting human livelihood, including the quality of life, in some regions; these resources will come under further unmanageable pressures as populations continue to increase. This situation is especially acute in arid regions of Africa, the Middle East, and East Asia where most of the poorest countries are located.

No realistic single answer to these resource problems is available, but there is a need to improve the economic conditions in these countries, to develop their agricultural technologies, and to quickly reduce the rate of childbirths. Governments and international organizations should make exceptional efforts to facilitate sustainable development in less developed countries by supporting research and technology transfer, and fostering international trade. The Church has an important role to play in generating the will to solve the interrelated problems of poverty and hunger, economic development, and population.

Report of Group 4: Economic Issues

There are four major groups of economic resources: natural (land, water, energy, minerals, environment, etc.); human (population, knowledge, science, solidarity, etc.); technical (productive innovation, production, manpower skill, etc.); and financial (saving, investment, etc.). These resources are partially complementary and partially substitutes for one another; it is impossible to discuss one without the others. Time is a fundamental resource. On another level institutions are resources: democracy, political structure, social framework are not only values in themselves but also powerful factors of development.

Let us consider briefly the function of these resources in the process of economic growth. Technology alters the economic significance of a society's resource base to such an extent that it is impossible to discuss the role of natural resources without specifying the level of technological capability of the society. The growth and spread of technological knowledge make possible the exploitation of resources previously totally neglected. Historically, these factors contributed heavily to the development of the industrialized countries of the "North," enabling regions with a poor natural resource endowment to enjoy rapid growth. Yet the experience of the North does not provide a ready model for the developing countries unless a large number of conditions are satisfied. First and foremost, the successful transfer of technologies to developing countries requires appropriate social, political, and economic arrangements, which brings us to consideration of human resources and institutions.

Practically every contribution to this volume has asserted the overriding importance of human resources. Knowledge is the most important resource; it is necessary to "invest in people" through health, primary education, and technical education but also through education to the values of democracy. For this reason the institutional framework is of great importance. Productive processes rely on technical conditions, but they succeed only where other conditions are satisfied—especially (1) a "civil" infrastructure (security, schools, transportation systems, etc.) and corresponding government policies; and (2) a market that allows families and firms to operate on the basis of a price system, which provides them with signals to allocate factors and resources in an efficient way.

Human resources, technology, markets, government, and institutions have complementary roles in promoting economic development. Markets are the best way to organize production and distribution, but they need frameworks (legal, regulatory, etc.) that only governments can provide. Moreover, markets alone are incapable of

This is a summary of group convened on the final day of the Study Week, consisting of Alberto Quadrio Curzio (Rapporteur), John I. Clarke, Diarmuid Martin, Govind Kumar Menon, Romano Prodi, and Nathan Rosenberg.

performing such tasks as developing a system of infrastructure or supplying essential goods and services to the poorest segment of the population. For markets to work, the distortions that are common in the developing countries must be removed, and the structure of economic systems must change. This leads us to some sectoral issues.

The first issue relates to agriculture. The problematic relationships between agricultural production, productivity, and population growth in less developed countries have been dealt with extensively in many contributions in this volume. Here we call attention to some aspects that have received little attention.

Highly productive agricultural technologies cannot be translated into productive activities where private incentives are lacking. Government policies that distort prices and excessive private property power of quasi-monopolistic landowners or illegitimate controlling groups are examples of conditions that suppress private incentives.

A second issue relates to food consumption. Food production today is adequate in most of the underdeveloped areas, but faulty systems of storage and distribution induce wastage, and the lack of purchasing power prevents part of the population from obtaining an adequate diet.

A third sectoral issue relates to industry and manufacturing. No process of economic growth can become self-sustained without an increasing role of the industrial-manufacturing sector. The structural shift from agriculture to manufacturing has deep consequences for levels of unemployment: hidden unemployment in subsistence rural areas becomes open unemployment and deprivation. But this path can be smoothed with measures to protect the poorest in the transition periods. In the recent past a number of developing countries have successfully exploited technical, social, and economic opportunities and undertaken very rapid structural change and growth, similar to, but much more accelerated than, the processes undertaken more than a century ago in the developed countries. The most interesting feature of the growth of the newly industrialized countries has been the combined exploitation of internal factors (cheap labor, social cohesion, education, etc.) and external factors (growth of world trade, reshaping of most developed countries toward the service sectors, etc.). The growth path followed has been extensive, with an increase of employment but also of competitive capacities of productive processes mainly financed by internal saving and trade balance surpluses.

All the problems of production have their counterpart in the availability of financial resources. The elementary, but often forgotten, fact is that saving is a choice for the future. Saving means postponing consumption to satisfy a basic condition for investments, which are of high interest also for future generations. Worldwide since 1970 the propensity to save has increased only slightly, while the ratio of investment to gross national product has been practically stationary.

A rapidly growing population requires more resources for immediate consumption. Moreover, the age structure and the very rapid growth of the proportion of the elderly in developed countries weaken the propensity to save. For this and other reasons, some major countries of the North are now net importers of saving.

As a result, financial resources for necessary investments are scarcer everywhere (North, South, East, West). This obliges us to consider new sources of funds and old problems.

The problem of military expenditure looms large. World military expenditure amounts to US\$1000 billion a year, 80 percent in developed countries and 20 percent in less developed countries, the latter including about US\$40 billion in imports. Military expenditure averages about 5 percent of gross national product in developed and underdeveloped countries alike. But while in developed countries the military expenditure is about half the combined spending on health and education, the two magnitudes are about the same in developing countries. Furthermore in some of these countries the military expenditure far exceeds health and education expenditures.

With the end of the cold war, military expenditure can be reduced everywhere. Admittedly defense policies must be handled astutely and the reduction of military expenditure raises important political issues relating to an effective system of international arms control and peaceful means of conflict resolution. But the present time offers a historic opportunity.

Another large problem is the external debt of the underdeveloped countries. It has reached US\$1.3 trillion (including the debt of eastern European countries). Many countries are unable to pay the interest on their debt with domestic savings. The causes of such debt are found in the 1970s and 1980s in the problems of primary commodity and energy price explosion, stabilization policies, and high real interest rates, neoprotectionism, and unsound economic policies. It seems obvious that not enough has been done yet from every side to solve the problems, which constrain needed investment in less developed countries.

At the beginning of this comment we also mentioned environmental resources. Many chapters in this volume have devoted attention to this subject, so we will not go into any detail here. But economists must issue a "mea culpa" for having long considered these resources as "free goods" for which no one has to pay. In the new approach to resource conservation, the problems of pricing and taxation have become fundamental.

This volume and the Study Week on which it is based have looked at questions of possible future disequilibrium between the growth of population and that of resources. From the point of view of economics and economic history a crucial issue is that the speed of change is increasing and this implies a need for increased attention in order not to lose the capacity to confront new developments.

As economists we have chosen in these comments to stress one of the many tasks of our social science: how to increase resources, how to utilize them in the most efficient way, how to distribute them more equitably without destroying human initiative and the will to work. We conclude with some comments on forecasts and policies.

On the former, the optimistic forecasts for the developed countries are for an annual rate of GDP growth for the 1990s near 3 percent and the pessimistic ones for a rate near 2 percent. Per capita rates of growth are expected to be a bit lower. For

the developing countries the optimistic forecast is near 5 percent and the pessimistic one near 4 percent. But, because of rapid population growth, the per capita rate of growth in LDCs is considerably lower, 2.9 percent and 2.2 percent in the two forecasts. Within the broad designation of developing countries are vast differences. At one extreme are the sub-Saharan African countries with an annual rate of per capita growth of 0.4 percent in the optimistic case and zero in the pessimistic one. Both cases will be disastrous. At the opposite extreme are the East Asian countries where rates of growth are expected to range between 5.2 percent and 4.2 percent, both very good. This strongly suggests a need to concentrate on the differences among developing countries, to elaborate and apply different policies for their differing institutional, social, and economic problems.

Nevertheless certain policies on a worldwide scale would be called for over the next decade to establish and maintain a reasonably strong economic growth path in the 1990s. International organizations could play a major role in this area. The main policies are:

- to abandon restrictions on trade and the various nontariff barriers that are detrimental to developing countries;
- to make world markets more integrated;
- to improve the conditions for free enterprise in less developed countries and to foster direct foreign investment;
- to increase sound financial support to developing countries but at the same time to push them to adopt sound macroeconomic policies;
- to invest more in education and in institutions that facilitate the working of markets and democratic governments.

These policies are rooted in the conviction that it is much better to move techniques, financial resources, entrepreneurship, and goods from "North" to "South" than to move young and productive people in the South from their homelands.

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