Netherlands organization
for applied scientific
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The degree of a country's development is measured by the ratio of the price of an automobile to that of a haircut. The lower the ratio, the higher the degree of development.
(Samual Devons)

The perpetual tendency in the race of man to increase beyond the means of subsistence, is one of the general laws of animated nature, which we can have no reason to expect will change.
(Thomas Malthus in his 'Essay on the principle of population', 1798)

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Foreword

The TNO organization considers sustainable development to be an important concept. Research to promote sustainable development is an important part of TNO's activities, firstly, on account of TNO's independent position with regard to clients; secondly, on account of the bridging function which TNO is able to fulfil between government and industry; and thirdly, because TNO can cover a very large area of the entire field of economic, ecological, and technological development.
Naturally TNO has been involved in research which is particularly relevant to the concept of sustainable development for a considerable period of time - even before the term became universal after the publication of 'Our Common Future' the final report of the World Commission on Environment and Development. Examples are found in research concerning energy conservation, recycling materials (e.g. in the construction sector), sustainable application and management of natural resources, reduction of waste flows, etc.
Recently, the concept has become more structurally imbedded in the organization. Sustainable development is currently part of the mission of TNO Environmental and Energy Research. The response by the Dutch government to TNO's strategic plan for the coming period also reinforces TNO's decision to direct its policy towards conducting research on sustainable development.

To date, TNO has already embarked on various activities which are entirely oriented towards sustainable development:
a. During the first half of 1991, an initial study was carried out which dealt with the contribution by TNO's environmental research regarding sustainable development. The results of this study were published in July 1991 in the report 'Milieu-onderzoek en Duurzame Ontwikkeling' [Environmental Research and Sustainable Development] (De Walle et al., 1991).
b. In the period July 1991 - April 1992, three explorative studies were carried out on topics related to sustainable development which are of importance to TNO. The three topics were: Health, Infrastructure, and Material Cycles in Industrial Production. The results of the explorative studies include three published reports.
c. An internal TNO conference was held at the end of May 1992 concerning the economic and ecological aspects of sustainable development.
d. Sustainable development will be the main topic of TNO's 60th anniversary celebrations in October 1992. The activities will include the detailed analysis and explanation of four aspects of sustainable development. These aspects are ecological capacity, technology, economy, and behaviour that is related to sustainable development.

This publication is one of the reports on the results of the explorative studies as mentioned in b. The three main publications included in the results of b. are 'Sustainable Development and Mobility' (Ruygrok et al., 1992), 'Sustainable Development: Closing the Material Cycles in Industrial Production' (Cramer et al., 1992), and 'Sustainable Development and Health' (Schaapveld et al., 1992).

The explorative studies are based on the know-how and insights of many experts. Resource papers were initially compiled, based in part on interviews. In order to assess the tentative results, national and international workshops were subsequently held.

I would like to express my gratitude to Mr. F.C. Dufour and Mr. A.F.T. Luns, who dealt with all of the organizational aspects of the explorative studies.

Dr. H. Speelman

Project Coordinator Explorative Studies 'Sustainable Development'.

Summary

To solve the problems of today's non-sustainable economic, ecological, and demographic developments, the World Commission on Environment and Development proposed the strategy of 'sustainable development'. TNO, the Netherlands organization for applied scientific research, feels that it can contribute to some of the many research questions raised by such a global approach. For this reason, several areas were selected by TNO for preliminary exploration. One of these was 'Sustainable development and health'.

In our exploration, we discovered that it was possible to link the major components of sustainable development (the six 'key issues') to health and health policy. The relationships between these concepts are difficult to disentangle and little is known as yet about the impact of variables on one another. What this exploratory study has shown, among other things, is that much more research is needed to understand these relationships at the global level. In this report we chose to confine ourselves mainly to Europe, so that many problems of developing countries which deserve more research have not been analyzed here.

Health is influenced by a number of so-called 'determinants of health'. To a certain extent, the key issues of sustainable development can be considered as exogenous determinants of health. Health can be influenced by all six of them: population and human resources, food security, species and ecosystems, energy, industry, and the urban challenge. However, these key issues will play a greater role in improving health in developing countries than in industrialized countries in the foreseeable future. In the latter, variables that are more or less independent of the degree of sustainability (such as the ageing of society, some life styles, and social factors) will be more important for the - limited - opportunities for further health gains. The role of environmental pollution as a determinant of health in Europe is still little understood.

The implementation of complex strategies such as 'health policy' and especially sustainable development requires a major adaptation of societies all over the world. Policy research is therefore one of the research areas that will have to be intensified in the context of sustainable development and health policy.

Other research areas for the promotion of health on a sustainable basis are:
- the search for unknown causes of important health problems;
- the search for health effects of environmental factors;
- the development of effective and efficient new forms of preventive and curative health care;
- the economic aspects of health policy within the context of sustainable development;
- implementation of health policy on a sustainable basis.

Health policy and sustainable development are here to stay. TNO wants to be among the many actors that play a role in progressing towards a sustainable and healthy future.

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1. Introduction

(based on a paper by Frits Prakke, TNO Centre for Technology and Policy Studies)

1.1 Starting point

TNO is the Netherlands organization for applied scientific research, and conducts studies in many areas: the environment, energy, industry, health, food and nutrition, defence, and policy. Why has the TNO organization directed its attention to the subject of sustainable development? The answer lies, first and foremost, in the belief that in 1992 society's interest in this subject has become so intense that it seems inevitable that it will have important strategic consequences for such a major public organization as TNO. Sustainable development, however poorly defined up to now, will influence applied research in the Netherlands, and therefore TNO as well. This means new demands from the market - both public and private - which must be responded to in time. The consequences of sustainable development are, in fact, so broad and potentially so revolutionary that the whole process of society's decision-making in such areas as industrial development and infrastructure will face major changes at a more general level.

For these reasons a study was carried out to identify the consequences of sustainable development for the Dutch system of applied research in general, and for TNO in particular. Because there is considerable uncertainty in the area of sustainable development with respect to both the objectives to be achieved and the means to be used, the conclusions will inevitably be of a policy, and even a political nature, rather than of a strictly scientific nature.

On the brink of the twenty-first century, the industrialized world can be said to find itself at a turning point. We can look back on some remarkable successes, but we must also face a number of important new challenges. In the last 100 years, tremendous efforts have been made to provide solutions for a range of serious threats to our civilization. At the national level, democratization and the social problem - grinding poverty, degrading living standards, massive unemployment - and at the international level, the continuous threat of a nuclear holocaust, are examples of the problems that will have to be solved during this century. In 1992 many of these solutions have been found, probably to our own amazement. Trade policy, increased productivity, social legislation founded on democratic principles, health care, international economic integration (e.g. the European Community), science and technology, and arms control have all played an important role in this. It would, however, be grossly naive to speak of the 'end of history' in the light of the recent successes. Rather, the problem is that, as a society blinded by the present, we have a totally inadequate view of the nature and extent of the new challenges facing us. In this respect, we are the prisoners of our own successful strategic thinking in the past. However, the contours of new threats are already visible.

Just as, at the beginning of this century, the social problem was central to our thinking, today we seem to be faced with what could be termed the ecological problem. This is still inadequately defined, at least in the sense of a

societal consensus on the causes and possible solutions. There is still little doubt that this presents the major new challenge to civilization. The compelling nature of the ecological problem follows not only from the various measurements of the progressive damage to the soil, water, and the atmosphere that are regularly published. To an increasing extent it appears that, however limited the consensus, the public is prepared to make sacrifices for a cleaner environment, a trend which can be expected to continue.

A fundamental aspect of the ecological problem seems to be that the solutions are in conflict, to a not insignificant degree, with the direction we have taken to solve the social problem, that is, undifferentiated economic growth. This means that we cannot find a technical solution to the problem within the existing policy, economic, and political frameworks, linked as they are to undifferentiated economic growth. The ecological challenge requires considerable institutional restructuring.

The answers must be sought in part in the area of science and technology. Institutional restructuring will in fact also be necessary in this field. The rules currently applicable to the financing of applied research will change. It may be possible to give only a very limited indication of the type of research that will lead to a sustained reduction in the burden on the environment, but it can already be stated that institutional changes will have to be made in the allocation of research funds to achieve that goal. Within private firms, we can see that R&D policy is increasingly influenced by environmental management systems. The ecological problem, therefore, also affects TNO as a national organization for applied research. This involves not only TNO's research programme in the narrow sense, but also the institutional relations by which the demand for applied research in society is expressed. It is for this reason that TNO has become involved in the public debate by studying the need for, and the direction of, applied research into the ecological problem, in particular in the sense of sustainable development.

TNO has been greatly inspired by the report 'Our Common Future' (World Commission on Environment and Development, 1987). This report will be discussed in chapter 2. It contains two main elements which can be used as the starting point for environmental and economic policy.
In the first place, sustainable development, in terms of overcoming the present acute threat to the environment in an absolute sense, is possible in the medium term. This will demand tight steering.
Secondly, economic growth to meet the wishes of, in particular, the large majority of the world's poor population is possible, and is not in conflict with the objective of sustainability, if economic growth takes a different form, both culturally and technologically, from the economic development realized up to now in rich countries. This development has only benefitted a relatively small portion of the human population.

It is useful to realize that these two elements of 'Our Common Future' do not remain uncontested. On the one hand, some deny the absolute need for radical change. This is based partly on the scientific doubt which always remains with regard to the various ominous environmental scenarios, such as those concerning the holes in the ozone layer, damage to drinking water reservoirs, the 'greenhouse effect', the suffocation of metropolitan conglomerations, and the waste problem. However, we estimate that the risk of waiting for scientific certainty is irresponsibly high.
On the other hand, special interests and blind, atavistic behaviour - by policymakers as well - play a role in the refusal to face up to environmental effects. As an organization of scientific research, TNO should distance itself from this attitude.

Nor is the perspective of further economic growth offered by the World Commission without its opponents, albeit 'different' and as yet poorly defined. The Club of Rome, among others, has recently sounded a much more pessimistic note regarding future developments (King & Schneider, 1991). Economic reforms and technological development, it feels, could never provide the desired goal of sustainability.

Our starting point is that, through major restructuring processes, it will be possible to bring about ecologization, to make production and consumption more environment-friendly. Such a development requires a long-term mobilization of social forces. The fact that radical restructuring of the economy is possible is illustrated by the industrial development of the last hundred years. While production processes were originally founded on very cheap (poorly-paid and even slave) labour, labour later became steadily more expensive, but the Western economies adapted to the change. Economic theory teaches us that the technology of production develops in such a way as to make the greatest use of the cheapest means of production and the least possible use of the expensive ones. Through mechanization and automation, labour productivity has risen spectacularly. This was possible as a result of the application, over many decades, of science, technical ingenuity, and social organization. Why should it not be possible in the medium term to reduce environmental pollution by 70 to 95 percent, if many branches of industry have managed to increase labour productivity by similar percentages in a matter of a few decades? In the course of a long and difficult development, we have learned that human labour is not a disposable good. Why should a similar development with respect to the environment not be possible?

It is incumbent on an organization such as TNO, with its expertise in the field of technology and its ties with organizations that shape the processes of production and consumption in a broad sense, to choose an approach which takes as its starting point the opportunities that science and technology offer. Therefore, the decision was taken to carry out three studies which could contribute to strategic thinking on sustainable

development. Where possible, we will discuss the significance of the identified problems for the role of science and technology.

1.2 The choice of three main themes

In order to study sustainable development in society, it is necessary, first and foremost, to provide some degree of disaggregation into broad sub-systems. It is remarkable how little this has been done in the discussion to date. All too often the leap is made directly from ecological responsibility in general to very specific problems, such as deposits of cadmium in river deltas. Some possible approaches, such as by branch of industry, are more suited to a socio-economic problem than to the new ecological challenge. We have chosen to divide the subject into three main themes, or sub-systems, which are considered of social, economic, and ecological importance:

- the material cycle in industrial production;
- the infrastructure (transport and telecommunications);
- the individual and his health.

The choice of these main themes is - by necessity - somewhat arbitrary. Because these are non-traditional cross-sections, they present an opportunity for acquiring new insights in thinking in terms of the impact of sustainable development on society. They bring together both a confrontation of traditional strategies in those areas with sustainable development and an insight to be gained into possible new policy options in the field of applied research. In this respect, the possibility was consciously left open that the choice of one or more of the sub-systems would fail to produce results, or would only lead to the conclusion that another definition of the sub-system would be desirable from the viewpoint of sustainable development. It is also possible to analyze the degree to which the objective of sustainable development is integrated with other, more traditional, objectives which are important to the three main themes.

That 'Sustainable development *and health*' was chosen among the themes for this TNO project is obvious. Although sustainable development is intended to safeguard the survival of all life on earth, mankind is the factor that will determine the sustainability or non-sustainability of society in the future, and *Homo sapiens* is the species that will reap the harvest, bitter or sweet.

It is obvious that sustainable development is a global strategy. For practical reasons, however, we have concentrated on the situation in Europe, with a distinction between Western Europe and Central/Eastern Europe. A few times, Dutch facts and figures will be given as examples.

1.3 The research method adopted

Given the uncertain and complex nature of the problem and the considerable diversity of the three main themes, the research method was more global than in most studies aimed at

technology forecasting or exploration. After all, the aim here is not to indicate the potential or impact of predetermined technologies within the existing economic structure.

Common to the studies was that groups of TNO experts formed a view of the relevant issues and the direction to look for solutions - both technological and policy - within the main themes. For each group, this view was tested by external experts and then modified. For each theme, finally, a workshop was held with international experts. In each case, the primary aim was to produce useful recommendations for applied research. The three studies differ, by necessity, in the degree to which this has been possible.

By the end of 1991, a working paper on 'Sustainable development and health' had been discussed with a number of experts in the Netherlands (see Appendix A). Their comments helped us to prepare a discussion paper that was used by the participants of an international workshop that was held in The Hague on 15-17 March 1992 (see Appendix B). The outcome of the discussions during this workshop was used to write this document. Comments from the Dutch experts and from abroad were very useful, and we want to thank those experts for their input. However, they bear no responsibility for our report; that responsibility is entirely ours.

2. Sustainable development

During our consultation with experts, including the workshop held in The Hague, we discovered that people held different subjective views about what was meant by 'sustainable development'. For this reason, we decided to clarify the concept by giving a short extract of 'Our Common Future' in this chapter. 'Our Common Future' (also known as the Brundtland Report) was published in 1987 by the World Commission on Environment and Development.
In discussing sustainable development in our report, we have tried to stick to the key issues of the Brundtland Report.

2.1 Sustainable development as defined by the World Commission on Environment and Development

In 'Our Common Future', a development strategy was presented in which development, environment, and population are seen as inseparable, both at the global and national level. Development is sustainable if it 'meets the needs of the present generations without compromising the ability of future generations to meet their own needs'.
Many of the development paths of industrialized and developing nations have become unsustainable. 'Environmental degradation, which was first seen as a problem of the rich nations and a side-effect of industrial wealth, has become a survival issue for developing nations. It is part of the downward spiral of linked ecological and economic decline in which many of the poorest nations are trapped'.

The economic gap between industrialized countries and many developing countries is widening due to the debt crisis, falling commodity prices, stagnating investments, and continued reduction and deterioration of the quality of the natural resource base in many developing countries (including the exhaustion, degradation, salinization of much of the soils, and the contamination and depletion of fresh groundwater supplies).
As a result, the majority of developing countries now have a lower per capita income than ten years ago. This problem is further perpetuated because management of the environment is particularly difficult in developing countries: many depend on agriculture, forestry, energy production, and mining for export, and this, together with high population growth rates, exerts additional pressure on overexploitation of the resource base. Environment, population, poverty, and development have become inextricably linked.
Industrial production, both in developing and industrialized nations, has become an important source of pollution of the biosphere. It is expected that, in the coming fifty years, production may increase by a factor of three to five, thus placing a huge burden on the environment at the world level. New technologies may mitigate this problem somewhat, yet many developing countries may not be able to afford them. It is clear that any solution to the environmental problem will have to be solved at the global level.
The World Commission on Environment and Development defines sustainable development as 'a process of change in which the exploitation

of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with future as well as present needs'. Present needs should not 'compromise the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can both be managed and improved to make way for a new era of economic growth... Sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations for a better life'.
The Commission admits that the path it recommends is a difficult one, involving many conflicts of interest and conscious choices. Any action towards sustainable development is therefore dependent on political will, and on both national and international cooperation, combined with institutional and legal reforms.

2.2 The key issues in sustainable development

The key issues to which the Commission addresses itself are presented in Table 1. They will be briefly discussed below in order to illustrate the interdependence between all these issues at the global level.

- ▷ population and human resources
- ▷ food security
- ▷ species and ecosystems
- ▷ energy
- ▷ industry
- ▷ the urban challenge

Table 1: The key issues in sustainable development according to the World Commission on Environment and Development

Population and human resources
The rates of world population growth have risen sharply in this century. Between 1900 to 1950, the world population increased at a rate of 0.8% per year, and between 1950 to 1985, at a rate of 1.9 % per year. In 1985, world population was nearly 5 billion with two-thirds living in developing countries.
By 2025 it is expected to reach 8 billion; 90% of this increase is expected in developing countries. This high rate of growth places a heavy burden on economic resources and on the environment.
Population and development are interrelated in a complex way. Economic development generates material resources which can be used to improve education and health and make better use of human resources available. With increased welfare and social development, fertility rates and mortality rates are dropping. This is a pattern which can be clearly seen in industrialized countries. In most developing countries, however, medical care and public health measures (e.g. the control of communicable diseases) have

led to declining mortality rates combined with fertility rates that remain high.
'The critical issues are the balance between population size and available resources and the rate of population growth in relation to the capacity of the economy to provide for the basic needs of the population, not just today but for future generations'. It is clear that population growth rates cannot continue as they have done in the past. It appears, however, that population policies to reduce fertility rates on their own are not enough, but should be combined with measures designed to improve social development as well, especially the education of women.

Food security

The next issue discussed by the Commission is the problem of food security. There has been a huge increase in food production due to modern agricultural technology in the last thirty years. Per capita consumption has increased globally, in spite of population growth and a decline in per capita cropped land available. Yet there are still more than 730 million people in the world with not enough to eat. The distribution of food where it is needed has been lacking in agricultural policies.
There are three broad types of food production systems. 'Industrial' agriculture, such as is found in North America, Western and Eastern Europe, and Australia, is characterized by high inputs of capital-intensive technology (advanced mechanical equipment, chemical fertilizers, pesticides, and high-yield seed varieties). 'Green Revolution' agriculture is usually found in fertile, irrigated areas of Asia, South America, and North Africa, and is also dependent on inputs from modern technology. 'Resource-poor' agriculture is found in developing regions that are difficult to farm (drylands, highlands, and forests in sub-Saharan Africa, Asia, and South America). This agriculture is dependent on rain, not irrigation, and has fragile soils.
All three types of agriculture have had a profound impact on their environment, due to agricultural policies emphasizing increased production rather than the conservation of the resource base. In industrial agriculture, the agricultural resource base has been increasingly degraded by acidification and water contamination. With Green Revolution agriculture, there has been a rapid growth in the use of fertilizers and pesticides, extensive cultivation of land, accompanied by de-forestation and soil erosion. Soil erosion reduces water storage capacity in natural and man-made reservoirs, and increases the incidence and severity of floods. Resource-poor agriculture, soil erosion, deforestation, desertification, droughts, and other processes are degrading the natural resource base. Agriculture can only remain sustainable if the resource base is not damaged. Overpopulation, poverty, and low agricultural commodity prices forcing countries to grow more crops have accelerated this process in developing countries.

Species and ecosystems

Species and natural ecosystems are much more important to mankind than had been thought up to now. Genetic variability of present species can be exploited to produce

new and improved foods, new drugs and medicines, and new raw materials in industry. New advances in genetic engineering are being made just when species are fast disappearing.

Moist tropical forests are the richest biological units in terms of genetic variability (totalling half of the world's species). Destruction of tropical forests has accelerated in the past twenty years to more than 10 million hectares per year, i.e. more than the size of a country like Hungary or Portugal. Over three decades this would amount to an area the size of India. Deforestation not only brings about a destruction of valuable species, but also contributes to the global warming problem, which in turn will place considerable stress on all surviving ecosystems.

Genetic variability represents a large untapped economic potential for the future. At present, the industrialized countries reap large financial profits from wild species because 'they have the scientific and industrial capacity to convert the wild material for industrial, agricultural, and medical use'. The genetic material of wild species not only contributes to the improvement of agricultural productivity, but also to the resistance of crops to insects, thus reducing the need for fertilizers and pesticides. Wild species also contribute to medicine. 'Half of all prescriptions dispensed have their origin in wild organisms. Materials derived from wild species contribute gums, resins, oils, dyes, tannins, vegetable fats and waxes, insecticides, and many other compounds'. Genetic engineering (or, the 'Gene' Revolution) of the future is also expected to enable crops to be grown in areas hitherto considered unsuitable for farming (such as seawater, deserts). Such developments depend, however, on a wide variety of renewable wild species.

Apart from the economic potential of genetic variability, there is also a moral argument against the disappearance of species through the destruction of their natural habitats.

Energy

Energy, economics, and the environment are closely interrelated. 'The growth of energy demand in response to industrialization, urbanization, and societal affluence has led to an extremely uneven global distribution of primary energy consumption'. Industrialized countries, representing about a quarter of the world's population, consume three-quarters of the world's primary energy derived from traditional non-renewable resources.

Energy can be derived from non-renewable resources (coal, gas, oil, peat, conventional nuclear power) and from renewable resources (wood, plants, dung, hydro- and geothermal sources, solar, tidal, wind and wave energy, nuclear breeder and fusion reactors). The combustion of traditional fossil fuels, used for heat, cooking, manufacture, and transport, is responsible for the 'greenhouse effect' (global warming), urban industrial air pollution, and acidification of the environment. The use of nuclear reactors represents risks of radioactive pollution because of possible reactor accidents and the problem of waste disposal.

Renewable energy sources provide 21% of all energy consumed globally: 15% is biomass (wood, charcoal, dung, crop residues) and 6% is hydropower. The consumption of solar,

wind, and geothermal energy is still insignificant in global terms. Because the technology required for producing renewable, clean, and cheap energy sources on a large scale is not yet available, energy conservation and energy-efficient technologies will have to be introduced in order to preserve non-renewable energy supplies for future generations and minimize the damage to the biosphere.

Since the oil price rises of the seventies, many industrialized countries have been able to make large reductions in their energy consumption. Further energy savings can be obtained through new technologies and further rises in the price of energy.

Industry

Industry (including mining and construction) has been historically both a necessary requirement for economic development and a threat to the environment. Many essential needs can be met only through goods and services provided by industry. It is said that industrialized countries are now in the post-industrial era, with manufacturing decreasing as a share of gross domestic product and with information-based services increasing. An efficient manufacturing base is indispensable, however, for meeting present and future needs.

The major polluters in industry are food processing, iron and steel, non-ferrous metals, automobiles, pulp and paper, chemicals, and electric power generation. In developing countries, these industries have been growing in relation to light industries, such as textiles and clothing.

Industry is responsible for pollution of air, soil, and water, and the depletion of resources through the 'entire cycle of raw materials exploration and extraction, transformation into products, energy consumption, waste generation, and the use and disposal of products by consumers'. Since the 1960s, public concern has led to action by governments and industry in both industrialized and developing countries. As a result, new technologies and industrial processes have been developed which reduced pollution and other environmental impacts. These achievements, however, are still limited and mainly confined to industrialized countries. 'Pollution problems which were once local have become regional or even global in scale. Contamination of soils, groundwater, and people by agrochemicals is widening and chemical pollution has spread to every corner of the planet'. Furthermore, industrialized countries generate about 90 percent of the world's hazardous wastes, including radioactive wastes, which are often transported for disposal in another country. At present, industrial development represents a serious threat to the natural resource base and to the future of the world's ecosystems. The challenge for industry in the future is to develop technologies that are more resource efficient and less environmentally polluting (including more recycling of materials), in both industrialized and developing countries.

The urban challenge

The last key issue discussed by the Commission is the urban challenge. By the year 2000, almost half the world's population will be

living in urban areas. The uncontrolled growth of urbanization represents a crisis for many developing countries, with cities such as Mexico City, Sao Paolo, and Bombay growing at a rate of 3 percent per year. Few cities faced with such rapid population increases can provide the basic facilities required for adequate human life: clean water, sanitation, decent housing, schools, electricity, roads, transport, medical care. As a result, a growing number of urban poor in developing countries suffer from a high incidence of diseases, mainly environmentally-based, as well as from malnutrition. The uncontrolled physical expansion of cities has a strong impact on the environment (destruction of the natural environment, air and water pollution) and on national economies that do not have the resources to provide the expensive infra-structure required to support such an expansion of the urban population. As for the cities of industrialized countries, they account for a large part of the world's resource use, energy consumption, and environmental pollution. This high level of industrialization not only has a large impact on their own ecosystems and those of developing countries, but also contribute to the global environmental issues (ozone layer, greenhouse effect).

2.3 Sustainable development as a global 'ideal' development process

As we saw in section 2.2, the development of industrialized and developing countries is closely interlinked. Actions will be required at the national and international level (e.g. agreements on the cessation of production of chlorofluorocarbons) and will involve legal and institutional reforms. Individual governments will have to view their own developments in a long-term, global perspective.

A development path is sustainable if growth of gross domestic product is optimized, given the constraints of limiting fertility rates, of producing enough food and industrial products without damaging the physical environment, of conserving energy and other non-renewable resources, of limiting uncontrolled urbanization, and of preserving the variety of species. These constraints can be alleviated by new technologies. Such a growth path implies a long-term strategy with sustainability as the ultimate goal. The message of the World Commission on Environment and Development is clear: take steps now in order to preserve the Earth for future generations. In other words, choose a development path that takes into account the impact of your choices on the welfare of future generations and on the international community.

In 'Our Common Future', the World Commission points to all these issues, but presents a much more optimistic view of how these issues might be resolved than the Club of Rome did (Meadows et al., 1972; King & Schneider, 1991).

How realistic is this view and how feasible is the strategy for sustainable development? Will sustainable development be considered a rather abstract guiding principle, or a blueprint for action, by governments, by organizations in their specific fields, and by individual citizens in their personal life? Will

some feel it to be a magic formula, a mere slogan, a squaring of the circle, and therefore something not to be taken too seriously?
It is our experience that the consequences of global sustainable development are still poorly understood. As stated in the introduction, we are only at the beginning of a discussion on a new course for society. In general, people have a tendency to focus on a specific target of sustainable development, such as environmental pollution, demographic growth, inequity within countries or between countries, life styles, and so on. Apparently the relations between the various components of sustainable development are to a large extent still unknown. Is there a hierarchy among the key issues of sustainable development? How much time is available to achieve our goals? Will the goals be acceptable to the population? We should probably start taking action now in a number of fields where we feel confident of the direction to be taken and of a chance for success, hoping to fill the gaps in our knowledge on the way.
The complexity of the concept of sustainable development makes it even more difficult to link this concept to health in simple 'cause-and-effect' relationships. The relevance of sustainable development for human health can be felt intuitively and is obvious in the long term, but this relevance proved difficult to describe explicitly during the international workshop that was organized by TNO in March 1992.
Health and health policy will be discussed in chapter 3. We will attempt to analyze the relations between sustainable development and health in chapter 4, and to describe the health effects of either a non-sustainable or a sustainable development in chapter 5.

3. Health and health policy

3.1 The concept of health

Health can be looked at in a broad or a narrow sense. In practice, the definition most commonly used is both limited and negative, though highly practical: health is the absence of disease. A large number of indicators can be used to measure morbidity and premature mortality in a population, and hence to obtain a measure of unhealthiness (Hansluwka, 1985). Various registration systems are applied to handle these health indicators. Morbidity can also be calculated indirectly, for example, by measuring consumption of medical services or sickness absenteeism, although these parameters are also influenced by factors other than (un)healthiness. Questionnaires can be used to probe the people's subjective judgement of their health. Life expectancy can be calculated from death rates. If life expectancy is corrected for the quality of the remaining years of life, one arrives at such important summary indicators as 'quality-adjusted life years' (La Puma & Lawlor, 1990; Anonymous, 1991) and 'healthy life expectancy' (Robine & Ritchie, 1991; see also section 5.3).
For a study of the impact of sustainable or non-sustainable development on health, one should use not only the 'classical' (and not so classical) health indicators that were just mentioned, but also, and especially, indicators of well-being, mental burden, and quality of life. A fully satisfactory and internationally accepted set of indicators in this field is not yet available.
The United Nations has devised the 'Human Development Index'. The American 'Index of Sustainable Economic Prosperity', which is much more complex than the UN index, has not been used outside the USA to date (Brown et al., 1991). The OECD is working on a set of environmental indicators, although aspects of health and well-being are not included (OECD, 1991b).
The Netherlands Central Bureau of Statistics (CBS) is developing indicators as well.
A number of the questions relating to living conditions, local environment, working conditions, health, and well-being in the CBS' Dutch Continuous Quality of Life Survey could be used for our purposes. Strikingly, the picture emerging from the answers to the question 'How do you view your own health?', included in the Dutch Health Interview Survey, has remained fairly constant over the past decades. When asking about subjective health, one should be aware that judgements are based on cultural determinants and may change over time.
The Dutch Social and Cultural Planning Bureau has developed an 'Index of Well-being'; the score for this index increased between 1974 and 1989.
Every three years, the Dutch Ministry of Welfare, Health and Cultural Affairs probes the progress made in reaching the 38 European health targets, some of which (19-24) depend on the relation between environment and health. Other European countries undertake similar activities within the framework of the 'Health for All' strategy (WHO, 1989a; Van Oyen, 1990).

A limited and negative definition of health does not suffice for the theme 'Sustainable

development and health'. This theme should rest upon a very broad definition encompassing all aspects of well-being, in particular those aspects which can be influenced by socio-economic and environmental factors. The definition of the World Health Organization (WHO) can serve as an example: *'Health is the state of full physical, mental, and social well-being, rather than merely the absence of disease and handicaps'*. Many scientists consider this definition unrealistic, and hence impractical, and prefer a more dynamic description of the concept of health, in which health is seen as a state of temporary equilibrium between opportunities and threats, both from within the organism and from the outside world (Illich, 1975; Ministry of Welfare, Health and Cultural Affairs, 1986). Another broad definition recently launched by a Dutch government committee commissioned to review and advise on choices in health care is *'Health is man's capacity to function normally in society'*. The problem of such broad definitions is that they do not match with existing registration systems, thus making the quantification of health difficult: comparisons between different countries, groups, and periods become complex, and this seriously impedes the preparation of trend and scenario analyses.

However, we need not choose one of the various definitions of health. We have already opted for the broadest approach possible: health must be more or less on the same footing as quality of life. The concept of 'sustainability' must be added to this broad definition. One could also say that 'health' should become an element of the concept of sustainable development. This idea of 'health on a sustainable basis' requires some power of imagination. It also places more emphasis on population health than on individual health. King (1990) defines the problem thus: 'health as a sustainable state implies a sustainable life style in a sustainable relationship to one's environment'. In poor countries, the goal of health on a sustainable basis may be incompatible with the aims of improvement of health and life expectancy in the short term.

3.2 Health policy

The factors that determine the degree to which individuals and populations are healthy are called 'determinants of health'. If seen as determinants of ill-health, they are also called 'risk factors' or 'risk indicators'.

The determinants of human health can be classified into five groups:

1. endogenous factors: characteristics of the human organism which are partly hereditary but can also change during life, such as immunological defence mechanisms;
2. physico-chemical exogenous factors: not only environmental factors, but also infectious diseases;
3. social and economic factors: e.g. education, personal relationships, societal influences, working conditions, management structures, income level;
4. life style and behaviour: e.g. dietary habits, use of stimulants, sexual behaviour, physical exercise, leisure activities;
5. health care.

This classification of determinants, according to the so-called Lalonde model (see Figure 1), has been widely accepted by national authorities and the WHO as a basis for 'health policy'. Health policy focuses on attempts to improve public health by influencing health determinants - in particular those in categories 2, 3, and 4 - rather than offering (curative) health care prompted by demand (Lalonde, 1974; Ministry of Welfare, Health and Cultural Affairs, 1986). The determinants can be defined both in a positive health-promoting sense and in a negative health-damaging sense. The interplay of forces between opportunities for and threats to health form the basis for the model's dynamic character.

The determinants responsible for the present inadequate state of public health and the lower quality of life in developing countries are easy to summarize: poverty, ignorance, violence, incompetent authorities, low standards of hygiene (e.g. contaminated water supplies), insufficient or poorly-balanced nutrition, too many births, and a lack of preventive health care (vaccinations, contraception, and so on). The relation between poverty in large parts of the world and prosperity in other parts is evident. However, a discussion of this relationship would be beyond the scope of this report.

The determinants of ill-health in the developing world also existed in the industrialized world until only a few generations ago. This should temper the nostalgia that some may feel for the simpler society of the past. Enormous progress has been made and is still being made in this century by socio-economic improvements, education, hygienic measures,

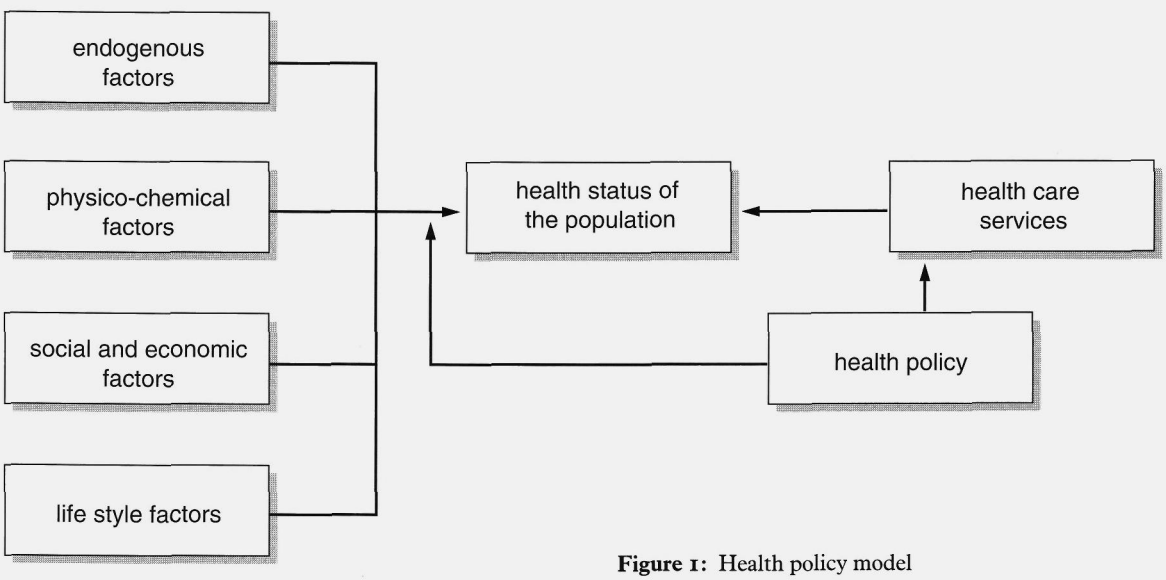


Figure 1: Health policy model

Region	1950-55	1980-85
World	49.9	64.6
Africa	37.5	49.7
Asia	41.2	57.9
South America	52.3	64.0
North America	64.4	71.1
Europe	65.3	73.2
USSR	61.7	70.9
Oceania	61.0	67.6

Source: World Commission on Environment and Development, based on data in World Resources Institute/International Institute for Environment and Development, World Resources 1986. (New York: Basic Books, 1986)

Table 2: Life expectancy at birth (years)

preventive and curative health care, and so on. An indication of this progress is the increase in life expectancy in both industrialized and developing countries (Table 2).

We do not mean to say that no attempt should be made at further progress, but we only want to point out that present endeavours to improve health should be seen in the context of a lengthy development.
The current disease pattern in affluent societies is predominantly determined by chronic-degenerative diseases of the elderly. For many of the diseases in the current Western disease pattern - cancer, cardiovascular diseases, musculoskeletal disorders, mental disorders, dementia, diabetes - the determinants (causes) are only partially known, if at all. To a large extent, the determinants of the disease burden in Europe cannot be quantified as yet. Another problem is that the average level of health in Western Europe is already very high (see section 5.3), with the possible exception of psychosocial health. The state of psychosocial health is far from easy to determine and depends on the indicators chosen, such as diagnoses for those unable to work, consumption of mental health care, answers to certain items in questionnaires, incidence of suicide, divorce rates, and registered aggression and criminal behaviour.

Environmental pollution is frequently mentioned as a determinant of unhealthiness. Among the specific forms of environmental pollution that can lead to demonstrable damage to physical or mental health are noise (Godlee, 1992a) and severe air pollution. The burden of such factors is obvious when they are intense. As in the case of most other forms of environmental pollution, much less is

known about the possible damage to human health of prolonged exposure to noise and air pollution of lower intensities (Kramers et al., 1989; Samet & Utell, 1991). Obviously, human adaptation is high. So far, environmental pollution has not had any effect on life expectancy in Western Europe since the latter continues to rise, not only in 'clean' areas, but also in more polluted regions. The contribution of environmental pollution to the total disease burden in West European communities is barely demonstrable, except in extreme cases such as with accidents in the chemical industry. The association between environmental pollution and food contamination, on the one hand, and the incidence of cancer, on the other, is weak - except in some specific sub-areas (Vessey & Gray, 1985; Forman, 1991). Thus, according to the current state of knowledge, the incidence of cancer can be attributed to only a minor degree (2 to 3%) to environmental pollution, and hence better pollution control is unlikely to result in a drastic decline in cancer incidence. (For a very readable state-of-the-art review of the relations between environment and human health, the reader is referred to the series of papers by Godlee & Walker (1991).) Unfavourable exogenous determinants during certain phases of pregnancy and immediately after birth have been reported by some to be associated with specific diseases in later stages of life: cardiovascular diseases and neurological, psychiatric, and immune syndromes (Bock & Whelan, 1991). Among the factors reported are maternal alcohol abuse, ill-balanced and inadequate nourishment of both mother and child, 'stress', and infectious diseases. Research into the possible effects of types of environmental pollution (e.g. via breast milk) is still in its infancy.

Obviously, more profit can be gained from preventive health care in Central and Eastern Europe through improvement of food supply and food variety, promotion of physical exercise, and the reduction of tobacco and alcohol abuse. Mortality in Central and Eastern Europe is much higher and life expectancy much lower than in Western Europe (Boys et al., 1991). The first reports on poor health due to severe environmental pollution in these regions are trickling in now, but serious investigations on this topic have yet to be published.

The key issues in sustainable development can also be considered as determinants of health in the sense of the health policy model. They fall in the categories of exogenous factors (both physico-chemical and social) and life style factors. This will be discussed further in chapter 4.

4. Sustainable development and health: a simple model

It is clear that there are relations between sustainable development and health. Development and health have always been related. Life expectancies have been rising globally as a result of development, as shown in Table 2. It is therefore understandable that public health experts want to play a role in the discussion on sustainable development from the point of view of health (WHO, 1989b). Health policy has been primarily directed at improving the present health status of the population. In the context of sustainable development, health policy will have to be concerned about the health of future generations as well, i.e. health on a sustainable basis. Quite recently, the World Health Organization published 'Our Planet, Our Health' as a contribution to the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992 (Commission on Health and the Environment, 1992).

Both health and especially sustainable development are already rather complex concepts in themselves, as was discussed in chapters 2 and 3. It is therefore not so easy to identify the interactions between them, let alone quantify them. Sometimes one does not even know if two variables are positively or negatively associated. A few examples of the complexity of the relations between some variables are given in chapter 6.

Let us briefly consider how the key issues of sustainable development are linked to health, whether directly or indirectly. These key issues, already mentioned in Table 1, are: population and human resources, food security, species and ecosystems, energy, industry, and the urban challenge.

Population and human resources
We are reaching a point where the high population growth in developing countries, due to better nutrition, improved health care, and prevention programmes, is threatening the natural resource base required for the survival of future generations. In the majority of developing countries, income per capita has already fallen in the past ten years. This means that improvements in health can no longer be seen in isolation of population growth and food production, with the concurrent environmental stress (King, 1990). In industrialized countries population growth is much less of an issue, but high population densities may be associated with psychosocial stress and other characteristics of further urbanization.

Food security
Food supply is threatened by ecological degradation in many areas of the world. In the recent past, food production increased faster than the size of the population; it is not so sure that this will continue in the future. In poor countries the problem is not only one of increased morbidity from inadequate nutrition, but one of plain survival. Biological and chemical contamination of food is another health risk, in both industrialized and developing countries. New technology should try to further increase food production, while proper agricultural practice should avoid damage to human health and the environment.

Species and ecosystems
Genetic diversity is necessary for exploiting the new potentials of genetic engineering (new drugs, foods, and raw materials for industry). Genetic engineering is still in its infancy and many of its potential applications are still unknown. Because its development potential is dependent on the genetic variability which is at present being destroyed (especially through the destruction of tropical rain forests), much of its potential may be lost for the future if deforestation is allowed to continue at the present rate.

Energy
Energy consumption in industrialized countries accounts for three-quarters of the total world energy consumption. There are as yet few clean, environmentally safe, renewable resources which can replace the traditional non-renewable resources, such as coal, gas, oil, responsible for air pollution, acid precipitation, and long-term global warming. The exact impact of these effects on health in the short-term are as yet unclear (see section 5.2). Accidents in nuclear power plants and the storage of nuclear waste are also hazards to health and to the environment. Energy conservation and anti-pollution measures have already reduced air pollution levels in many industrialized countries. Research on cleaner, renewable sources of energy will contribute to better health.
It should not be forgotten that energy is indispensable for health in the form of domestic heating, cooking, means of communication and transportation, replacement of manual labour by machines, etc.

Industry
Industry is and has been the mainstay of economic growth. Industrialization has made important contributions to health, such as greater wealth and technological innovations, also for health care. Industrial production is associated with local, regional, and global deterioration of the environment and biosphere. Working conditions and the pollution due to the production and disposal of wastes may have short- and long-term effects on the health of workers and of the public. New technologies can produce much more efficiently (fewer raw materials and energy required) and with less pollution than before. Sustainable development which encourages these new technologies will have positive effects on health.

Urban challenge
High population growth and the need for jobs has led to a huge wave of urbanization. By the turn of the century, half of mankind will be living in cities. Urbanization requires an extensive infrastructure of roads, shelter, and services (transport, energy supply, sewage, health services, education, etc). In many developing countries these facilities are often lacking, especially in the mushrooming illegal settlements: lack of sanitation, contaminated water supplies, overcrowding, diseases, violence, and poverty are serious threats to health. Improving health in urban areas requires management of the infrastructure, education, and reducing air and water pollution levels. Health risks of further urbanization in industrialized countries comprise psychosocial stress and the

deterioration of the social structure, leading to notorious inner-city problems. Measures to encourage the decentralization of the population will have to be taken in order to turn the tide.

We feel we can conclude that, especially in developing countries, relations between the key issues in sustainable development and health do exist. This means that in those countries health issues and health policies, much more so than in the past, will have to be integrated in the changes required to ensure a sustainable future. As is shown in 'Our Common Future', all the key issues affecting health and the components of these key issues are highly interrelated. It does not lie within our level of competence to try and unravel all of these relationships in our exploration.

We also conclude that these relations play a much smaller role in the European context,

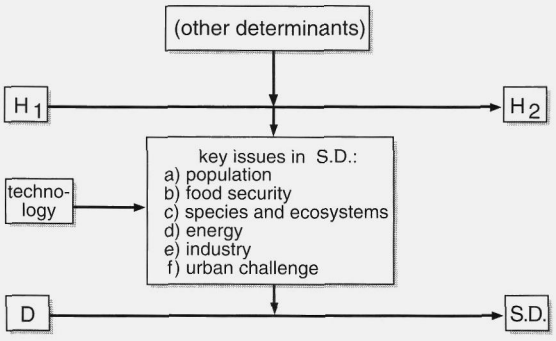


Figure 2: Relations between sustainable development and health

on which we concentrate in our report. However, it is clear that we cannot concern ourselves with the health of future generations in Europe without taking into account what is happening outside the health sector and in the world as a whole. Still, in Europe, health is much more determined by factors that are independent of sustainable development, such as the ageing of the population, life styles such as smoking and alcohol abuse, and epidemiological trends in disease categories. This will be discussed in section 5.1.

We have tried to sketch the possible relationships between sustainable development and health in a simple model (Figure 2).
We have two health states. One is the health of the population today (H_1) and the other is the health of future generations (H_2). The future health state will be affected to some extent by the development pattern and level (degree of sustainability, involving physico-chemical and societal exogenous factors and some types of life style), and to another extent by factors which are independent of sustainable development issues (endogenous factors such as ageing, some life style factors such as smoking).

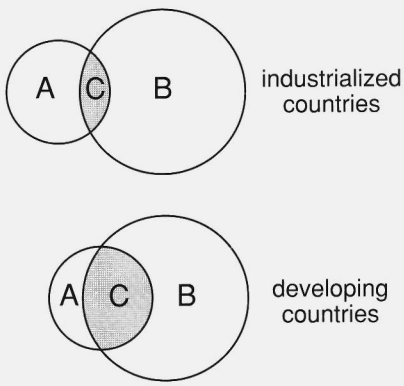
When the world economy moves from its present development pattern (D) to one of sustainable development (SD), it follows a growth path along which gross domestic product is optimized over time, given the constraints of the key issues in sustainable development. The more new technologies there are, the more these constraints to growth will be alleviated. Likewise, the key issues

in sustainable development can be seen as constraints on the road to better health.

It is possible to link the health policy model in Figure 1 to Figure 2. The key issues in sustainable development can be seen as determinants of health according to the health policy model: exogenous factors (both physico-chemical and social) and some life styles (such as food choice, recreational activities, and modes of transportation). Other determinants of the Lalonde model are not so clearly related to sustainable development: endogenous factors (age, gender, hereditary factors), other life style factors (such as smoking), and health care. The latter determinants act on health independently of the development path taken by society. The Lalonde model, as described in chapter 3, is not a submodel of the strategy for a sustainable development, although the key issues in sustainable development can be seen as determinants of health in the terminology of the Lalonde model.
In developing countries, the largest impact on health will come from determinants that coincide with the key issues in sustainable development; in industrialized countries, the health determinants that are independent of sustainable development will have a greater influence. This is shown in Figure 3.
In other words: in countries where the lack of sustainability presents the greatest threat to health, the influence of sustainable development on health will be the greatest. This influence may extend across national borders.

Health policy and sustainable development are strategies at different levels: health policy works well on a national and even an individual level; sustainable development has global implications. Combining the two policies means that (some) determinants of health acquire a global aspect.

The implementation of health policy and sustainable development will be influenced by social and political factors: political structure, equity, self-determination, regulations, taxation, cultural influences, some life styles (e.g. consumerism, nutrition, polluting behaviour), etc. This will be discussed in chapter 6.



A - determinants of the health policy model
B - key issues in sustainable development
C - factors common to both policies

Figure 3: The health policy model linked to the key issues in sustainable development

5. Impact on health of various factors in relation to sustainable development

It is essential to realize that health can be influenced by developments in society, whether sustainable or not, but that health policy is not explicitly mentioned as one of the key issues in the global strategy for sustainable development in the report 'Our Common Future'. A simple model of the relationships between sustainable development and health has been discussed in chapter 4.
In section 5.1, we intend to focus on health trends that are independent of sustainable development. As we showed in chapter 4, the influence of sustainable development on health will differ between countries. In Europe at the moment these independent trends influence health more than trends that depend on the degree of sustainability. Conceivable positive and negative health effects of a sustainable or non-sustainable development of society will be discussed in sections 5.2 and 5.3. We will use two approaches to describe health effects: one from the angle of sustainable development and another by exploring determinants of health according to the Lalonde model.

5.1 Factors that are independent of the degree of sustainability

The most important independent trend is the ageing of the population, with a peak in the second and third decades of the next century (De Jouvenel, 1989). A proportional increase in the ageing population and the concomitant increase in the prevalence of chronic-degenerative diseases such as dementia and osteoarthritis are inevitable, although the effects would be proportionally greater if the population were to stop growing.
Some epidemiological developments are also independent of the degree of sustainability. The replacement of cardiovascular disease by cancer as the number one cause of death is not linked to the implementation of sustainable development, nor is the course of the AIDS epidemic.
Likewise, the propagation of various forms of healthier life styles, such as promotion of physical exercise and discouragement of smoking and alcohol abuse, has little to do with sustainable development (Józan, 1991). Further individualization and emancipation will probably occur under any scenario, leading to more pluriform societies (Central Planning Bureau, 1992).

Apart from the question of whether the development of society will be sustainable, some believe that the society of tomorrow will most probably be even more complex than present-day society, and will put the coping capacity of the population to the test.
A small proportion of the population will benefit from the blessings of continuing advances in information technology and technology as a whole, but increasing numbers of Europeans will not be able to keep up with the demands of society. Others, however, believe that such statements are gratuitous and that comparable pronouncements were also heard in bygone ages. They contend that mankind will adapt and that new technologies will, in fact, add zest and comfort to life for most of us.

5.2 Factors that are the consequence of a non-sustainable development

As was pointed out in section 3.1, it is simpler to measure ill-health than health. It is therefore easier (but still difficult enough) to give an indication of health damage in a non-sustainable society than health gains in a society with a sustainable development. According to most experts, the negative developments with the greatest potential to damage world health are environmental pollution, leading to changes in climate and destruction of the natural environment, and overpopulation, leading to food shortage and societal changes. They will be considered below. It should be realized that man is both the perpetrator and the victim of these developments. Except for food shortage and a few specific forms of environmental pollution, little is known about the specific long-term effects of such disturbances on human health and well-being (Kramers et al., 1989), although there are definitely relations between the key issues in sustainable development and health, as was discussed in chapter 4.

Although non-sustainability will supposedly have the most dramatic impact on developing countries, our report is mainly concerned with Europe - Central, East, and West - with the emphasis on Western Europe in this chapter. The effect of developments outside Europe on those within Europe can vary markedly. An example of a striking effect would be the total disruption of a number of developing countries due to ecological, demographic and/or economic factors, leading to a huge flood of immigrants. The effects of such a phenomenon would seriously disturb European developments in the areas of health and well-being. However, such hypothetical events will not be considered here.

In Europe, the main societal changes will (have to) be related to the management of raw materials, restoring the resource base, environmental control, energy supply, traffic, and the economy in general - fields not exactly within the competence of public health experts. Nonetheless, we shall try to make an inventory of possible threats to health if current trends continue. These threats are usually seen as coming from environmental pollution (both local and global) and from overpopulation (especially in developing countries). Therefore, we should ask ourselves two thorny questions:

- With respect to environmental pollution and climatic changes: to what extent are environmental factors such as an impaired ozone layer, a global rise in ambient temperatures, and increasing air pollution harmful to health?
- With respect to overpopulation and destruction of the natural environment: *ceteris paribus*, is life in large cities or in populous areas (e.g. Hong Kong, Java, the Netherlands) unhealthier than in less densely-populated areas with a predominantly virgin nature (e.g. Australia, Suriname, Iceland)?

As to the first question, we do not expect the above-mentioned climatic and environmental disturbances, resulting from non-sustainable development, to affect health in Europe

markedly within the foreseeable future. Even in the very long run, most of the - still hypothetical - threats to physical health in Europe are presumed to be soluble or curable. These threats are (Leaf,1989; Cook, 1991; Haines & Fuchs, 1991; Longstreth et al., 1991; Lush, 1991):

- increasing ultraviolet radiation caused by damage to the ozone layer and giving rise to an increased incidence of skin cancer and cataracts (and an impaired immune response?);
- introduction (and, sometimes, re-introduction), as a result of a rise in temperature ('greenhouse effect'), of certain vectors and parasites such as *Plasmodium* (malaria), hookworm, and *Bilharzia (Schistosoma);*
- also as a result of higher temperatures: flooding of low-lying coastal areas as a consequence of the raised levels of oceans;
- climatic changes induced by the greenhouse effect which, in combination with acid rain, could reduce the potential for food production;
- more frequent heat waves giving rise to excess mortality among the elderly;
- more symptoms of respiratory problems caused by air pollution;
- chemical contamination of drinking water supplies.

The second question about the possible - mostly psychosocial - consequences of crowding is equally hard to answer, at least in Europe. However, research in this field should be possible, for example by analyzing existing data from national health surveys in terms of the degree of urbanization. It makes sense to assume that life is more pleasant and healthier in the country than in the city, but it cannot be denied that many do not share this view. Therefore, this second question could be reformulated as follows: what are the intensities of population pressure and economic activities which are likely to cause damage to human health, probably preceded by disturbances of the ecosystem? The Netherlands is an interesting case in this respect because it is one of the few countries that combines a population density of nearly 500 per km^2 with a relatively high population growth (approximately 15% in the next 20 years) and a high level of economic activity (including agriculture).

Threats to a society which is growing in a non-sustainable way can also be described as developments in the four relevant groups of the determinants of health (see chapter 3): social environment, physical and chemical environment, life style, health care, and their effects on health. These undesirable developments are sketched below as a simple scenario. The possible consequences for the same categories of determinants during sustainable development of society are described in section 5.3.

Social environment

The future population of Europe will increase further, depending on: (1) immigration; (2) birth rates, especially in countries which now have excessive births (Albania, Ireland, the Netherlands, Poland, Portugal, Rumania, Spain, former Yugoslavia); (3) the weight given to countries with the most rapid growth (Turkey, the Asiatic countries of the

Commonwealth of Independent States); (4) mortality rates, particularly if they decrease further. If trends do not change and 'Siberia' and Turkey are excluded, the population of Europe will grow slightly but steadily, and the proportion of elderly will increase at the same time (Central Planning Bureau, 1992). The slow growth of the European population is not perceived by a majority as a negative development, except in areas that are already densely populated. However, for an increasing minority of the population, further urbanization and destruction of the natural environment will be a source of anxiety and discomfort.

It is assumed that purchasing power will not be affected by non-sustainability, so that political tension will remain under control. The diminishing quality of society and the environment (urbanization, ethnic tension, noise, individualization) could give rise to more psychosocial complaints than at present. Developments of this kind are, however, hard to predict.

Labour conditions will not change markedly; the present trend of growth of services will continue. Employment opportunities will probably increase due to demographic changes: a diminishing proportion of the population in the 18 to 65 year age group (Central Planning Bureau, 1992).

Physical and chemical factors

Growing urbanization in many areas in Europe will result in enhanced demands on the natural environment.

An example of this is the expected increase in the Dutch population by one million in the last decade of this century.

Nature conservation areas will be used more intensively for recreation. In recreation, amusement park-like activities will prevail over the search for peace and quiet.

Noise pollution will increase because of the increased traffic and more compact housing (highrise buildings). Agriculture will become even more industrial and productivity will grow even further because of higher global demand for food. This will lead to the increased risk of water contamination by pesticides and fertilizers.

Central and Eastern Europe will try to catch up with industrial output as compared to the West; environmental control will not have a high priority, leading to further ecological degradation.

Life style

In Western Europe, changes in life style (food patterns, use of stimulants and drugs, physical exercise, safety behaviour, etc.) will be modest.

Health care

New medical technology will improve the quality-of-life for an ever-increasing number of chronic patients. The number of hereditary diseases that can be prevented will increase appreciably. However, genuine breakthroughs in the prevention or treatment of chronic-degenerative diseases are not very likely.

The health effects of the above-mentioned developments in determinants can be summarized as follows. Life expectancy will increase slightly in Western Europe. In the

long run, the increase could be impressive in Central and Eastern Europe, provided that the inhabitants of these regions adapt some aspects of their life style to Western standards. Disease patterns will change somewhat (Schaapveld et al., 1990). Cancer will become the first cause of death in Western Europe, followed by cardiovascular diseases. Furthermore, the disease pattern will be dominated by chronic diseases in an ageing population. The effects of the deteriorating conditions of soil, water, and air on human health will be barely noticeable. Psychosocial complaints will increase in number (STG, 1992), particularly those due to noise (Godlee, 1992a), ethnic tensions, feelings of discomfort and unsafety in highrise flats, other manifestations of advancing urbanization, and fear of the effects of pollution.

5.3 Factors that are the consequence of a sustainable development

Which effects of sustainable development on health can be expected or hoped for? Two aspects must remain separate when looking for positive effects: the health gain expected from determinants which are independent of sustainable development (described in section 5.1), on the one hand, and the health gain provided by the better environment in a sustainable society, on the other.

Before we start looking for positive effects on health, we have to consider the following question: can the physical health of inhabitants of Western Europe still improve, for instance through continued reduction of known health risk factors? Later in 1992, the results of current research by the TNO Institute of Preventive Health Care into recent trends in 'healthy life expectancy' in the Netherlands may provide some clues to the answer. Healthy life expectancy is the average number of years man spends in good health; in other words, it is total life expectancy minus the period spent, irrespective of institutionalization, in poor physical or mental health (Robine & Ritchie, 1991). If we succeed - through better preventive and curative health care as well as other measures - in prolonging healthy life expectancy at a faster rate than total life expectancy, the total disease burden will decrease - a phenomenon known as 'compression of morbidity' (Fries et al., 1989). It is not clear whether a strategy of sustainable development would contribute to life expectancy or compression of morbidity.
In our pursuit of (even) better health, we must also take care that intensive efforts in preventive and curative health care do not result in an undesired shift in the causes of death and terminal morbidity - a phenomenon known as 'competing causes of death' (Schaapveld et al., 1990). The most important example of this phenomenon is the link between the decreasing age-adjusted incidence and mortality rates for cardiovascular diseases and the increasing chance of dying of cancer that is found in a number of countries nowadays, including the Netherlands (Muldoon et al., 1990; Oliver, 1991). Unfortunately, preliminary results of research into healthy life expectancy in a number of countries do not point to compression of

morbidity. Therefore, our goal for the future perhaps should be that healthy life expectancy does not decline.
In connection with this, it should be realized that any further improvement in physical health may require increasing amounts of money and effort; in this context, a Dutch parliamentary document speaks of the 'diminishing returns' of (both preventive and curative) health care (Ministry of Welfare, Health and Cultural Affairs, 1986). Moreover, nobody can gain full health and happiness; disease and discomfort will always be among us and, in the end, death will overtake all of us.

As in section 5.2, it may be useful to describe the possible trends in the relevant groups of determinants of health, but this time as the result of a strategy for sustainable development.

Social environment
The population of Europe will no longer increase, and may even decrease slightly as a result of a deliberate population policy: propagation of birth control in countries with excess births and termination of immigration. This will result in a greater proportional increase in the ageing population and an even higher inactives/actives ratio which will not be compensated by excess births or immigration. However, this effect will only be significant until the distribution of the population has reached a new equilibrium.
There may be some drastic changes in consumption patterns due to the higher costs of environmental pollution control, e.g. higher prices of packaging, energy, drinking water, transport, and many industrial and agricultural products. Purchasing power may decrease as a result of these price measures, leading to political tension. A decline in purchasing power need not necessarily imply a step backwards: a considerable proportion of consumption today is useless or even harmful. For some people, the fulfilment of emotional needs will compensate for the decrease in material pleasures. Others, however, deny that purchasing power will suffer as a result of sustainable development. Due to demographic changes (an ageing population and an increasing inactives/actives ratio), employment opportunities will become even greater than in a non-sustainable development. Furthermore, labour conditions will improve in order to entice people to continue working and to reduce sickness absenteeism. In order to provide for more old age pensions, the retirement age could be increased. New working patterns, such as telework at home, will be encouraged. The sustainable development of society implies that civilians will be subjected to more government regulations and self-discipline, which could be experienced as a burden.

Physical and chemical factors
The burden on the environment will be less than in a non-sustainable development because the population will remain stable and will behave in a more environmentally-conscious manner. Bio-technology will replace many traditional chemical processes in industry. There will be a shift to clean energy sources that will have become more economical because of the high price of

traditional sources. Natural areas can be enlarged. Noise pollution will diminish due to a shift in mobility patterns (fewer cars, etc.).

Life style
Some changes in life style will be modest but others will be more marked, such as an increase in physical exercise and changes in consumption patterns. Recreation will concentrate more on relaxation, rest, and nature than in a non-sustainable development. International mass tourism will decrease.

Health care
The marked proportional increase in the ageing population will prompt a greater increase in the demand for euthanasia. However, medical technology will progress, improving the quality of life for many, including chronic patients. Total expenditure on health care must now compete even more with expenditures in other sectors, such as environmental control. Therefore, not all technical 'tours de force' can be achieved - and may not even be desired - in all cases.
It may become increasingly difficult to find enough people willing and able to work in the health care sector, especially caring for old and handicapped patients. This is due to the fact that this kind of work is not very attractive in comparison to work in other sectors, that the demand for care is growing, and that the proportion of actives to inactives in the population is decreasing.

The health effects of the above-mentioned developments in determinants can be summarized as follows.

For quite some time, the population will age at a faster rate than in a non-sustainable development, because there will be fewer births and no immigration. Life expectancy will continue to increase, and physical morbidity and mortality patterns will shift in the same direction as during a non-sustainable development. The incidence of psychosocial complaints portrayed in section 5.2 will be lower, but the shift from prosperity to well-being, which will be imposed by more authoritarian governments, may not meet with general approval.

5.4 The contrast between sustainable and non-sustainable development

To some extent, sustainable development and non-sustainable development have different health outcomes, as was discussed in sections 5.2 and 5.3. This divergence is indicated - admittedly in a very simplistic way - by a few key words in Table 3. It has to be kept in mind that independent variables will have the greatest impact on health in Europe.

The health effects of sustainable development will usually, but not always, be of a more positive nature than the health effects of non-sustainable development.
However, there is much speculation here: there are important gaps in our knowledge that research will have to fill. These will be discussed in chapter 7.

key words	section 5.2	section 5.3
Size of population	increases slightly	remains constant
Life expectancy	increases further	increases further
Birth rate	remains constant	decreases
Immigration	remains constant	stops
Ageing population (%)	increases slightly	increases more
Purchasing power*	remains constant	may decrease
Consumption pattern	little change	great changes
Labour conditions	little change	improvement
Recreation	fun-fair type	bicycle ride type
Pollution	increases	decreases
Total disease burden*	remains constant	remains constant
Psychosocial problems*	increases	remains constant
Political tension	remains constant	increases

Table 3: Differences between the developments in sections 5.2 and 5.3 in a few key words (* = per 1000 inhabitants)

6. Implementation of sustainable development and health policy

6.1 Sustainable development and policy choices

As we have already pointed out, sustainable development implies a new long-term growth strategy for the world. Sustainable development has little chance of succeeding if only a few isolated countries alter their development plans without placing them in a global context. Implementing sustainable development will therefore depend on the political commitment of most nations, and on far greater international cooperation and international agreements than has been the case up to now. Many formal and informal structures and institutions in existence today will have to change. These include education, markets, accounting systems, governmental policies, regulations, and laws.

Such a strategy requires types of changes in social attitude which are difficult to imagine in our present consumption-oriented society. It also requires time. Some people say we do not have this time, that the ecological capacity of the Earth is under severe stress, and that, if we do not take immediate action, the survival of mankind will be at risk. Others take an opposite view: new technologies will be able to solve all our problems, what we lose in natural resources and ecosystems will be substituted in new ways. Our children's heritage will be new knowledge and technologies.

We tend to prefer a middle-of-the road approach. New technologies are certainly necessary in order to alleviate the constraints of sustainable development. If pricing policies were altered to take into account the real scarcity value of non-renewable resources and the negative effects of environmental damage (on the principle that the polluter pays), then industrial and agricultural production could adapt to the new set of prices through the working of the market system. New technologies for more efficient production would also be encouraged. We have already seen this happen in OECD countries after the oil price increases of the seventies: energy consumption has dropped by 20 to 25% since then. The price increases also stimulated the exploration of new sources of energy (Central Planning Bureau, 1992).

We also view sustainable development as something to be aimed at, but not to be achieved within one generation or at the cost of losing our democratic structures and personal freedom. We can incorporate many changes within our economic pricing system without changing our democratic structures. The most important structural change in our thinking will be that we will start making decisions on the basis of trade-offs between present and future returns, and will view national interests in a more global perspective.

6.2 Conditions for implementation of sustainable development and health policy

It does not lie within the scope of this report to analyze what policy changes are necessary to achieve sustainable development. What we can do, however, is to see how health policy might be implemented within the context of

sustainable development. For such a strategy to succeed, several conditions will have to be met. These are :

- a sufficiently large public support for the strategy;
- the strategy must be methodologically sound;
- sufficient insight must exist into the factors which lead to a change in social attitude and behaviour and into the (local) opportunities for change;
- defined targets must be set together with a clear (social) marketing strategy.

Public support seen in a global context can only be created when basic needs have been met and there is more equity between groups or countries. (We saw this in our workshop: the economic problems of Central and Eastern Europe are so pressing that health problems due to an unsustainable development are not a primary concern.) Giving broad publicity to the facts which make the proposed changes necessary can stimulate awareness of the problem. Public acceptance can be created by clearly stating the benefits which can be achieved with such a change of policy. Finally, only when a clear commitment on the part of both policymakers and the general public has been achieved, will the new strategy of health policy within the context of sustainable development have a chance of succeeding.

Directing the course of social changes within the context of a global vision represents a complex problem. The operational model required for this will need to combine an approach based on both the market mechanism and government intervention. Policies will therefore have to be based on both a top-down and bottom-up approach. Such a worldwide model will have to be adapted to the situation of individual countries and placed in the context of their own culture, level of development, political, and institutional structures.

How likely are these conditions to be met at the level of government and of the individual in the foreseeable future? Much more research is needed before these conditions can be satisfied. First of all, we need to be able to model health on a sustainable basis and try and quantify the complex relationships involved. Then we need to be able to disaggregate the global problem into segments corresponding to regional, national, and local situations. Scenarios will have to be developed for solving health problems with the highest priority in those segments. Suitable policies will have to be worked out. More research will also be needed to evolve new concepts and methodologies relating to structures and institutions (and their interactions) appropriate at the global scale (Jacobson & Price, 1990). Further multidisciplinary research is also required on how the individual can be motivated to change: social marketing, changes in life style and behaviour.

6.3 Examples of problems involved in the implementation of health policy

We shall give three examples that show how difficult it is to implement health policy in combination with other policies under present

circumstances. In the first example we will focus on the institutional problems arising from a multisectoral approach to health policy. In the second example we will look at policies that have failed because the approach to the problem (reduction in car use) was partial and did not integrate all conditions necessary for a successful policy. In the third example we will show how health policy measures taken in one sector may have repercussions on others.

1. As far as health policy in Europe is concerned, we already have some experience with a multisectoral approach - through the 'Healthy Cities' programme of the WHO, where all the determinants of health are considered together. In this programme, various departments at the local government level (e.g. public health, town planning, housing, employment, education) have had to work together for the first time. Due to the lack of commitment on the part of all departments and because the financing of the departments has remained unchanged, implementing coordinated action has been slow to get off the ground.
It is difficult to visualize how this multisectoral approach could be extended in the foreseeable future to cooperation between ministries at the national level, at present all fighting for their own budgets. The report 'Our Planet, Our Health' (Commission on Health and the Environment, 1992) suggests that Ministries of Health should be given a higher status than they get at present (they are often junior ministries). They could play a much more vital role in health policy if they were to compete for their budget on an equal footing with other ministries. It seems to us, however, that most of the conditions mentioned in section 6.2 will have to be met before the cooperation required between different institutions for multisectoral policy becomes an accepted procedure.

2. How will health policy on a sustainable basis affect the individual? Policies to encourage a change of life style will have to consist of a trade-off between the freedom of the individual and achieving the health objective in the context of other objectives related to sustainable development. Let us illustrate some of the issues that would be involved if health officials would like to limit the use of the privately-owned motor car so as to improve health. (For reasons of simplicity we will not go into the issue of commercial road transport.) Limiting the use of the car will reduce air and noise pollution and acid rain. Walking and cycling is also to be encouraged whenever possible in order to promote physical exercise.
How can the individual be convinced to change his habits and leave the car at home or do away with it altogether? In Athens the government instituted a new rule in order to curb the high levels of air pollution in the city. Car owners were forbidden to use their car on one day out of two: the number plate - with an even or uneven number - determined on which day the car could be used. The solution of many car owners was to buy a second car! The reason for this is that public transport in Athens is so bad that most motorists would not contemplate using it. In England there is a different

situation. Public transport is expensive and, in rural areas, scarce. Cycling, recommended by the British Medical Association for its many health benefits, is dangerous because there are no cycle paths. Little wonder that so many people still use their car (Godlee, 1992b). In the Netherlands, due to the high population density and past investments, there is a very good network of public transport, of cycle paths, and of facilities at railway stations to park cars or bicycles. Cycling is a common form of local transport. In some cities like Amsterdam, however, where cycles are stolen as a matter of course, many people refuse to go on using their bicycle. Although the price of petrol in the Netherlands is now one of the highest in the European Community, it has had little effect on car use. Far too many people still use their car because of its convenience. The main reason for this is that motor taxes and fuel prices are still relatively low in comparison to private incomes, and that the costs of using the car to go to work have been tax deductible until this year.

These three cases were presented in order to show that such a health policy is unlikely to succeed on its own unless many conditions are met. It shows how, in three countries, the government did not combine several policies (requiring the cooperation of such ministries as that of health, transport, environment, energy, and finance) in one coherent set of actions. If one is to reduce the use of the motor car, fuel prices will have to be raised and individual car owners highly taxed in order to compensate for the pollution they cause. There should be a good network of public transport. The difference between relative prices should be such that public transport becomes an attractive alternative, both in price and in convenience. There is no point in encouraging cycling if there are no safe cycle paths. Once the public becomes aware of the future benefits, then a promotional campaign on the merits of pollution control and cycling will have some effect. Individual responsibility will have to be stressed in order to enlarge the acceptance of such a change of life style. Economic incentives will have much more effect if combined with public acceptance. It is therefore important to find methods which can be used to help society adapt, a process which must take place as smoothly as possible in order to enlarge the chance of public acceptance of the many demands of health policy on a sustainable basis.

3. We shall now turn to our third example, that of changing food habits. Supposing the Ministry of Health in the Netherlands would like to convince people to eat less saturated animal fats (meat, dairy products) in order to reduce diseases of the circulatory system. An important drop in demand for such products would mean that farmers would have to limit their extensive use of land for grazing purposes and reduce their import of animal feed. The contamination of fresh groundwater supplies due to a surplus of manure would disappear in the long run. The government would have to weigh up the benefits of improved health due to a change in diet and of having access to clean groundwater supplies in the long term against the short-term loss of

incomes by farmers and the loss of exports of meat and dairy products. Some form of government intervention would be necessary (such as short-term subsidies to farmers in the adjustment period to other forms of agriculture) if the health policy is to succeed. If the health policy is not broadly supported at the government level, then the agricultural marketing boards could set up a large counter-offensive by promoting their products in such a way as to override the effects of the health promotion campaign. The health promotion campaign will then most likely have little effect. (This case may even be considered further to include the possible impact of such changes on the economies of developing countries. Developing countries, e.g. Thailand, are large exporters of animal feed to industrialized countries. This animal feed is grown in areas which have been cleared of forests. A drop in the import of animal feed by industrialized countries may therefore have a positive influence on the problem of defore-station in Thailand.)

With these examples we have tried to demonstrate the difficulties, but also the challenge of implementing health policy within the context of sustainable development. We will discuss the research implications involved in chapter 7.

7. Research requirements

Many areas require further research to solve problems connected with the implementation of a strategy of sustainable development. Obviously, we are talking in this chapter about health research in the framework of sustainable development, not about the many other research areas relevant to such a strategy, such as energy saving or waste recycling. Some of those issues will be discussed in the other two TNO publications mentioned in chapter 1. However, first we wish to address a more general research question before discussing specific health research requirements. In chapter 2 we concluded that sustainable development still awaits being put into practice: it may be clear what the key issues are, but it is not yet possible to foresee the consequences of proceeding on various fronts. Further conceptualization of the strategy of sustainable development and the quantified modelling of the numerous effects of its interdependent elements is a major research agenda item for which there is a real need. A start has already been made by several councils coordinating research efforts at the international level. These are the International Council of Scientific Unions (ICSU) in Paris, the International Geosphere-Biosphere Programme (IGBP) in Stockholm, the World Climate Research Programme (WCRP) in Geneva, and the International Social Science Council (ISSC) in Paris. Their members (National Academies, Research Institutes) are spread all over the world.

As we have shown in chapter 4, health is not linked as a matter of course to policies for sustainable development.

The relationshipbetween sustainable development and health is the strongest in developing countries (see Figure 3).
In Europe, health policy is to a large extent an independent variable. On the other hand, influencing environmental determinants for the purpose of improved health can indeed be part of the strategy for sustainable development. Even if the impact of various elements of sustainable development on health cannot yet be adequately described, it is possible to identify areas in health research that have a relation with sustainable development (or are at least not inconsistent with it). Each of these health research areas comprises a wide array of separate topics. To show the relations between them and to translate the results of research into a coherent health policy is also a whole area of research in itself.

The need for research in the field of 'sustainable development and health' emerges from the analysis in chapters 1 to 6. In chapter 7 we will concentrate on Europe, where priorities for health research are far less determined by sustainable development than in developing countries.

Research areas can be classified in a number of ways. We have chosen the classification given below:

7.1 the search for unknown causes of specific health problems;
7.2 the search for health effects of environmental factors;
7.3 development of new health care and prevention programmes;

7.4 economic aspects of 'health policy' in the context of sustainable development;
7.5 implementation of health policy on a sustainable basis.

This is of course not the complete research agenda for health research. We have limited ourselves to the formulation of research areas that *may* contribute to health within the context of sustainable development. Health research that has no relation to sustainable development will be mentioned in this chapter but not further elaborated on.
Even among these five areas, not all research topics will fall within our self-imposed limits, especially in areas 7.1 and 7.3. We will give two examples. Area 7.1: Although research into the unknown causes of chronic degenerative diseases may produce some hitherto unknown exogenous determinants, we would not be surprised if research results were to point more to endogenous determinants which have little to do with sustainable development. Area 7.3: The development of better prevention programmes against substance abuse or other unhealthy life styles and the discovery of new pharmaceuticals is essential for the further improvement of health in Europe, but it has little relevance for the sustainability of society.

For each of these five major health research areas, specific topics that require research are considered in the following sections of this chapter. These topics are to be considered as examples, since the list is far from complete.

7.1 The search for unknown causes of specific health problems

This involves research into unknown or insufficiently known causes of specific health problems, insofar as this is relevant to the sustainability of the development of society. Examples of important health problems of which the causes are insufficiently known are a number of chronic diseases and psychosocial problems. To what extent do pollution of air, water, and soil, social developments such as level of employment, labour conditions, forms of cohabitation, urbanization, and recreation, and specific life style variables play a causative role in the incidence of these disease categories?

An important specific area of research is concerned with the unknown determinants of chronic diseases which may be hereditary traits, life style characteristics and/or environmental factors. The proportional increase in the ageing population will be accompanied by a - relative as well as absolute - increase in the problems related to chronic, often disabling, diseases. For a number of chronic diseases these determinants have not yet been recognized or are insufficiently known to provide a solid basis for preventive measures. Some examples of these diseases are chronic non-specific (obstructive) respiratory disease, rheumatoid arthritis, diabetes mellitus, dementia, and schizophrenia. In contrast, the determinants of cardiovascular diseases and some forms of cancer are partly known, thus allowing primary or secondary prevention. The search for the causes of chronic diseases may be more fruitful in the discovery of

endogenous causes rather than environmental causes.

The causes of psychosocial illness are still largely unknown. Therefore, prevention programmes cannot be developed for one of the most important disease categories in the industrialized world. Research should play a role here.

7.2 The search for health effects of environmental factors

This area involves research into the nature and extent of the effects of sustainable versus non-sustainable development on health and the methods (indicators) which can be used to quantify these effects. These effects can relate to physical health and mortality, but also - and especially - to mental health and personal and social well-being. The health effects involved are those of known or suspected environmental determinants, as contrasted with the unknown determinants we wanted to elucidate in the research programme described in section 7.1.

The effects of various physical and chemical factors on health constitute an area in which research can fill the gaps in scientific knowledge. Some examples are: noise pollution, chemical pollution of air, soil, and water; and atmospheric changes such as the greenhouse effect. They have been linked to a number of health problems such as cancer, respiratory diseases, and mental disorders. What is the effect on human health of long-term exposure to low levels of these physical and chemical factors? It is often difficult to ascribe certain health effects to these environmental factors. An example in this respect is the relation between the presence of carcinogenic compounds in the environment and the occurrence of malignant neoplasms. Often intermediate end-points have to be used to provide insight into cause/effect relationships.

Such determinants as labour conditions, urbanization, and noise pollution can affect mental health, for example, through the development of 'stress', but the extent of the problem and various threshold values are difficult to quantify.

Nutrition is one of the life style variables. The composition of foodstuffs and our dietary habits are susceptible to change. Product innovation yields a variety of new foodstuffs ('novel foods'). Moreover, consumption patterns are affected by social and cultural changes in society. This continuous process is the basis of both opportunities and threats in the relation between nutrition and health. With respect to physical health, one could investigate the effects of a further improvement in our diet on the incidence of cardiovascular diseases, various forms of cancer, gastro-intestinal disease, diabetes mellitus, caries, and total morbidity and mortality.

Mortality is easy to measure. Assessment of physical morbidity already becomes more difficult. However, to enable us to measure mankind's well-being in a sustainably or non-sustainably developing society, a useful

set of indicators must be developed. The development of such a set of indicators necessitates a profound analysis of the vast pool of measuring instruments currently used for a broad variety of the aspects of health. The relevant sources of information are in the hands of many different bodies. For the sake of efficiency, the first step should be to investigate the extent to which combinations of existing indicators can be used in practice. The conclusion of such an inventory could be that indicators still have to be developed. Research into 'compression of morbidity' and 'competing causes of death' can be part of this field. How will they be influenced by environmental factors, by health care, by prevention? 'Compression of morbidity' and 'healthy life expectancy' - two closely connected themes - are now under investigation in a number of countries. 'Competing causes of death' is a topic that is much more complicated to investigate since it requires complex modelling techniques.

7.3 Development of new health care and prevention programmes

This area involves research into the potentials of health promotion and health care within the context of the sustainable development of society. That means manipulation of the determinants of health mentioned in chapter 3 by various intervention strategies.
It requires not only the input of existing knowledge, but also the results of research described in sections 7.1 and 7.2. As we already stated in the introduction to this chapter, however, most new health care and prevention programmes in Europe will have little relation with sustainable development.

Life styles that are detrimental to health could be targeted for preventive intervention. In industrialized countries, and especially in Central and Eastern Europe, this offers the greatest potential for further improvement of health. Topics are lack of physical exercise, smoking, substance abuse, and other types of risky behaviour. The risks are often well known, but it is difficult to change behaviour. Other life styles may benefit both health and the sustainability of society, such as food choice, physical activity, modes of transportation, and recreational activities. They should be promoted if proven to be effective. Much more research is needed on the process of influencing life styles.

Apart from changes in life style, research will have to focus on opportunities for the prevention of psychosocial problems. Due to the social developments expected, this deserves priority over the prevention of physical diseases. One should first reach consensus on definitions and demarcation of the problems. What do we consider to be psychosocial problems? What are the determinants of psychosocial problems (section 7.1)? How do these determinants relate to the key issues of sustainable development? What are the gaps in our knowledge about the magnitude of the problem today (section 7.2): prevalence, call on resources, direct and indirect costs? (There is already a fair amount of information on this subject. The magnitude

of the problem is huge.) Trend analyses could draw lines from the past to the present and from the present to the future. What do we know about the efficacy of preventive measures? Which target groups should be selected for the prevention of psychosocial problems? The best choice may be secondary school children. Another gap in our knowledge is the relation between work and mental disorders. Intervention projects should be carried out using a group of subjects and a group of controls. This type of research is expensive and time-consuming, but indispensable, and has rarely if ever been carried out in Europe. The final question is: how can the results of research be used to reduce the magnitude of psychosocial problems?

Other types of research are needed to mitigate the disease burden arising from the proportional increase in the ageing population. Where prevention is not a realistic option, sophisticated forms of care should be found for maintaining or improving the quality of life of the remaining years. Home care technology is an important field of research for those who want to postpone institutionalization as long as possible (Banta et al., 1988). There is also a need to prevent the problem of alienation.

7.4 Economic aspects of health policy in the context of sustainable development

Implementing a sustainable development strategy will require a change in relative prices, which will then influence consumption and production patterns. The first two areas of economic research described below deal with this question. The third area deals with health care and priority setting. The fourth area deals with the economic consequences of changes in health policy.

Research on a new set of prices and a new system of national accounting

Sustainable development represents a new development strategy in which the conservation of the environment and of non-renewable natural resources, the development of new production techniques, and new energy sources are integrated in the growth process. Up to now, the natural environment has been considered an unpriced scarcity in our economic system.

In order to implement sustainable development, a new set of prices and a new system of national accounting will have to be adopted, in which the 'true' costs (which reflect the scarcity of non-renewable resources and negative external social costs) are reflected in prices and in a new concept of gross national product (Hueting et al., 1991). Much more research is needed on finding the right set of shadow prices for the true costs of the depletion of non-renewable resources, the use of goods (e.g. air, water, soil) which had hitherto been considered 'free', internalizing

the costs of pollution and other negative external effects, so that the right signals will be used to influence the growth of the economy (Tinbergen & Hueting, 1991). Internalization of environmental costs is difficult to carry out, however, when the extent of the environmental damage is unknown, e.g. in the case of global warming or loss of biological diversity (Central Planning Bureau, 1992).

Research on changing consumption patterns as a result of price changes
The new set of prices will have a favourable effect on the environment and therefore on health in the long run. The change in relative prices will also have an impact on individual consumption patterns which may have a negative or positive effect on health. For example, negative effects may be noted in the health of people with a low income (e.g. old age pensioners) when energy prices are raised and they can no longer afford to heat their homes properly. Similarly, raising the price of such public services as water, waste disposal, etc. may affect consumption patterns. Many people tend to save on food first before they give up other pleasures. This may have a negative effect on health, especially for young children. The change in relative prices may also have a positive impact on health (e.g. higher fuel prices and road taxes will lead to fewer cars, more public transport, less pollution, and more physical exercise). More interdisciplinary research is needed at the level of consumer behaviour in response to changing relative prices. The behaviour will be determined by such factors as cultural background, income level, personal preferences, and the elasticity of demand for the goods or services of which the prices have been changed. This knowledge is also required if one wishes to change people's life styles for health reasons. Health promotion campaigns (e.g. to encourage people to stop smoking or drinking excessive amounts of alcohol) will have a greater impact if they are combined with prices that reflect the new norms (see also section 7.5).

Priorities in health care
If sustainable development would be introduced, expenditure on health care would then have to compete much more with expenditure on environmental control and conservation. The costs of health care in Europe have been rising steadily in the past decades. Cost containment will become an even more important issue than it is now. Setting priorities in the delivery and scope of the health care sector will become an important target for cost control. The choices will be based on the results of cost-benefit type analyses to ensure that scarce resources are efficiently allocated (Schaapveld et al., 1990). Health policy in the context of sustainable development means that the health of future generations will be given more weight in relation to present ones than was the case up to now. Our discounting rates in cost-benefit analyses may also change in order to reflect the new social rate of time preference (Central Planning Bureau, 1992).

The economic consequences of health policy
Finally something about the economic consequences of health policy. Changes in life

styles may also affect many aspects of economic life unrelated to the issue of sustainable development. Some examples: restricting of smoking and alcohol consumption leads to a reduction of the State's income from indirect taxes, may prolong life expectancy, and may consequently increase medical consumption; more physical exercise can give rise to more sport injuries, but at the same time lower sickness absenteeism among employees who are now healthier; decontaminating chicken farms from *Salmonella* will probably lead to a price increase of chicken meat and eggs; reducing the consumption of meat and dairy products will have repercussions on agricultures based on meat production and dairy farming (see also the third example in chapter 6).

7.5 Implementation of health policy on a sustainable basis

Modelling health policy on a sustainable basis
All the processes of change involved in implementing health policy on a sustainable basis should be embedded in a global vision. It is therefore important that the relations between sustainable development and health can be modelled and the variables within the relations identified. Some quantifying of the impact of variables on one another will also be necessary. This, in fact, implies a further exploration and development of the simple model presented in chapter 4.

Developing a model for steering the processes of change
Steering the processes involved in the realization of major global changes is a complex problem, even when all the actors are convinced of the necessity and of their potential own interests. Making use of concepts from various disciplines (e.g. public, social and business administration, economics and other social sciences), a steering model will have to be developed that can provide direction to this worldwide innovation process.

Segmentation of problems
On the basis of the insights gained from the sustainable health model and the global steering model, choices will have to be made concerning priority problems in sub-parts of the model. The selection criteria used will depend, on the one hand, on the extent to which sustainable development is threatened by particular problems and, on the other hand, on the extent to which political institutions are able to tackle the problems.

Scenarios for priority problems
By working out scenarios for the priority problems, clarity and consensus can be reached about the targets to be achieved. These scenarios will have to concentrate on the important dilemmas and consequences of the different policy options (including the zero option) and result in concrete targets. Those scenarios which show that a lack of technological knowledge forms a bottleneck to change will be of particular interest to TNO.

Market segmentation for different policies
Policy options will have to be adapted to local situations and possibilities for change. From a global vision, policy options will have to be differentiated for different groups of actors, countries, cultures, political systems, particular health problems, etc. A basic condition is that the functioning of the local health care system in each case is well mapped out (who does what, who decides what, etc). The necessary local mix of steering via the market system and government intervention and of a top-down/bottom-up approach can then be established. The skills required by the people in charge of the process of change will then also become clear, so that a successful implementation becomes feasible.

Social marketing, life styles, and changes in behaviour
The policies leading to sustainable health must finally lead to changes in behaviour. The factors which stimulate or block changes in behaviour and life styles will have to be identified. Pricing, regulation, and technological development will have to be evaluated in the context of each particular setting.
The new policies will have to be brought to the general public. Concepts from social marketing can be used here: the right marketing mix will have to be used in order to reach and convince various groups in the community about the necessity of change.

7.6 Central and Eastern Europe

Central and Eastern Europe must be considered separately. The health research needed in these countries within the framework of sustainable development follows the same pattern as that identified for Western Europe. However, the priorities and emphasis are different, and the resources available for research in the various countries are scarce. The situation in Central and Eastern Europe is worse than in Western Europe in many respects: health, health care, some life styles, environmental pollution, food production, economic position, and political tension. West European research institutes could be of help here. One suggestion would be the analysis of existing sources of health statistics as well as sampling where statistical data are lacking (e.g. prevalence of risk factors according to age, gender, population group, district, profession, and other characteristics). In Central and Eastern Europe the emphasis is not only on mental and social well-being, but also on physical health (e.g. premature death due to cardiovascular diseases). Research efforts should focus on preventive rather than curative health care.

8. Conclusions

It is evident that the human environment and the Earth as a whole are suffering from today's non-sustainable economic, ecological, and demographic developments. The situation, therefore, cannot go on as before and new policies are essential. The global strategy of 'sustainable development' has been proposed by the World Commission on Environment and Development to ward off the peril of irreversible damage to the planet and its ecosystems, including mankind. 'Sustainable development' is an inspiring strategy, but it is also a very complex one with many components, mechanisms, and consequences that are as yet incompletely understood.

The World Commission has identified six key issues that have to be addressed: population and human resources, food security, species and ecosystems, energy, industry, and the urban challenge. It would be possible to make another classification or a more detailed one, but the present one works well for our purpose of exploring the position of health within the framework of sustainable development. Although health may not be a key issue in sustainable development, we conclude that it is certainly related to all the key issues.

There are many definitions of health. We have given health a very wide meaning, which includes physical, mental, and social aspects, and which more or less equals the 'quality of life'. There are numerous indicators for measuring health, but better ones may still be needed to measure changes connected with sustainable development. Health is influenced by so-called 'determinants of health': endogenous (mainly hereditary) factors, exogenous factors (both physico-chemical and social), life style factors, and health care. The endeavour to improve health by influencing these determinants is called 'health policy'.

We have tried to combine health policy with sustainable development and to identify some of the relations between the two. The key issues in sustainable development can be considered as exogenous determinants of health. The relations between both strategies appear to be stronger in developing countries than in industrialized ones. In many developing countries, sustainable development is indispensable for the very survival of people. In Western Europe, health would suffer from non-sustainable developments only to a limited extent, at least in the short and medium term, and further improvement in health should come mainly from factors that are independent of the degree of sustainability of society. Even in Central and Eastern Europe, where both the health and the ecological situation is worse than in Western Europe, health could improve more from changes in life style (smoking, alcohol, diet) and in the social fabric than from measures concerned with environmental protection. In Europe, therefore, arguments for sustainable development should be supplied more by other sectors than by public health.
The main problems surrounding the quality of life for Europeans in the near future will be the same as at present; they will differ in size only. These problems will be related to ageing, chronic morbidity, and psychosocial health, irrespective of the development

strategy chosen. The role of environmental pollution in determining health, now and in the future, is still little understood.

The implementation of complex strategies such as health policy and especially sustainable development is a tremendous task. It requires contributions from various sides: a sound scientific basis, political will, public acceptance, changes in social attitude and behaviour, institutional changes, and international cooperation. It also requires time. The possibility of achieving sustainable development is uncertain, but, for want of better alternatives, we have to proceed piecemeal and on various fronts in the hope of being right. It is inevitable that trade-offs will have to be made. It will be necessary to study the best ways of implementing health policy on a sustainable basis and of removing the many obstacles ahead.

A scientific basis is essential for proceeding on the way towards better health and a sustainable society. At present, our state of knowledge is still rather limited. Our first and foremost need is the major research agenda required for putting the still elusive strategy of sustainable development into practice and for modelling the complex relationships between sustainable development and health, so that the size of the impacts between various variables can be brought to light.
More specifically, research is needed in various areas:

1. the search for unknown causes of important health problems, such as chronic diseases and psychosocial problems;
2. the search for health effects of environmental factors, such as long-term exposure to low levels of chemical and physical pollution;
3. the development of effective and efficient new forms of preventive and curative health care, e.g. genetic testing and home care technology;
4. the economic aspects of health policy within the context of sustainable development, e.g. new sets of prices and national accounting, cost-benefit analyses of interventions that reflect the value placed on the health of future generations, and that include the costs and benefits of hitherto unconsidered environmental factors;
5. the modelling of health policy on a sustainable basis and the ways such a policy might be implemented.

It is not yet possible to work out consistent scenarios applicable to the broad field of 'sustainable development and health'. Such a model would have to consist of a large number of variables, many of which are hard to identify and/or quantify. We should focus on exploring and studying those topics which can reasonably be assumed to be part of the broad complex.

We have tried to achieve the aim of our project: to contribute to strategic thinking on sustainable development by exploring the relations between sustainable development and health, and by indicating important research questions pertaining to this field. We thereby attempted to identify the consequences of

sustainable development for health and any obstacles on the road to health on a sustainable basis. This is only the beginning of a new way of looking at health, health care, and health research. Health policy and sustainable development are here to stay. TNO wants to be among the many actors that can play a role in progressing towards a sustainable future.

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Appendix A

List of experts consulted by the authors before the international workshop on 'sustainable development and health'

- Prof.Dr. H.D. Banta, Consultant, World Health Organization, Regional Office for Europe, assigned to TNO, Leiden, the Netherlands
- Prof.Dr. C.F.J. Böttcher, Honorary Member of the Club of Rome, The Hague, the Netherlands
- Dr. C.L. Ekkers, Division Director TNO Policy Research, Delft, the Netherlands
- Prof.Dr. L. Ginjaar, Chairman, Health Council, The Hague, the Netherlands
- Prof.Dr. T.E.D. van der Grinten, Director, Netherlands Institute of Mental Health, Utrecht, the Netherlands
- Prof.Dr.Ir. R.J.J. Hermus, Director, TNO Toxicology and Nutrition Institute, Zeist, the Netherlands
- Prof.Dr. F. ten Hoor, Chairman, Nutrition Council, The Hague, the Netherlands
- Dr. R. Hueting, Head, Department for Environmental Statistics, Central Bureau of Statistics, Voorburg, the Netherlands
- Dr. J.A.M. Hulshof, Staff Bureau for Policy Development, Ministry of Welfare, Health and Cultural Affairs, Rijswijk, the Netherlands
- Prof.Dr. D.L. Knook, Director, TNO Institute of Ageing and Vascular Research, Leiden, the Netherlands
- Dr. P.G.N. Kramers, Head, Public Health Forecasting Bureau, National Institute of Public Health and Environmental Protection, Bilthoven, the Netherlands
- Dr. M. Mootz, Social and Cultural Planning Bureau, Rijswijk, the Netherlands
- Mr. R. Ritsema, Director Environment, Quality and Nutrition, Ministry of Agriculture, Nature Management and Fisheries, The Hague, the Netherlands
- Drs. R.J. Samsom, Chief Director Health Protection, Ministry of Welfare, Health and Cultural Affairs, Rijswijk, the Netherlands
- Dr. W.F. Stevens, Division Director TNO Health Research, Leiden, the Netherlands
- Prof.Dr.Ir. F.B. de Walle, Director, TNO Study Centre for Environmental Research, Delft, the Netherlands
- Ir. C.W. van der Wal, Division Director TNO Environmental and Energy Research, Delft, the Netherlands
- Drs. E.A.M. Wieberdink, Dutch Centre for Health Promotion and Health Education, Utrecht, the Netherlands
- Dr. J.A. van Zorge, Directorate for Chemical Safety and Radiation Protection, Risk Assessment and Environmental Quality Division, Ministry of Housing, Physical Planning and Environment, Leidschendam, the Netherlands

Appendix B

List of participants in the workshop on Sustainable Development and Health, The Hague, the Netherlands, 15-17 March 1992

- Prof.Dr. H. David Banta, Consultant, World Health Organization, Regional Office for Europe, assigned to TNO, Leiden, the Netherlands
- Ellen W. Bergsma MA, TNO Institute of Preventive Health Care, Leiden, the Netherlands
- Vera Boltho-Masarelli, Council of Europe, Strasbourg, France
- Dr. Kees L. Ekkers, Division Director TNO Policy Research, Delft, the Netherlands
- Prof.Dr. Gijs Elzinga, Director of Public Health, National Institute of Public Health and Environmental Protection, Bilthoven, the Netherlands
- Fiona Godlee MRCP, Assistant Editor, British Medical Journal, London, United Kingdom
- Prof.Dr. Tom E.D. van der Grinten, Director, Netherlands Institute of Mental Health, Utrecht, the Netherlands
- Drs. Paul M. Jongejan, TNO Technology Management Group, Delft, the Netherlands
- Dr. Péter Józan, Chief, Population and Health Statistics Department, Central Statistical Office, Budapest, Hungary
- Dr. Maurice King, Department of Public Health Medicine, University of Leeds, United Kingdom
- Dr. Jean-Pierre Poullier, Directorate for Social Affairs, Manpower and Education, Organisation for Economic Co-operation and Development, Paris, France
- Anna Ritsatakis Ph.D., Regional Advisor Country Health Policies, World Health Organization, Regional Office for Europe, Copenhagen, Denmark
- Prof.Dr.Ir. Arthur Rörsch, Member of the TNO Board of Management, Delft, the Netherlands
- Dr. Kees Schaapveld, TNO Institute of Preventive Health Care, Leiden, the Netherlands
- Jaroslav Volf M.D., Director of the Regional Institute of Hygiene, Ostrava, Czechoslovakia
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The TNO organization considers sustainable development to be an important concept. Research to promote sustainable development is an important part of TNO's activities, firstly, on account of TNO's independent position with regard to clients; secondly, on account of the bridging function which TNO is able to fulfil between government and industry; and thirdly, because TNO can cover a very large area of the entire field of economic, ecological, and technological development. Naturally TNO has been involved in research which is particularly relevant to the concept of sustainable development for a considerable period of time - even before the term became universal after the publication of 'Our Common Future' the final report of the World Commission on Environment and Development.
Examples are found in research concerning energy conservation, recycling materials (e.g. in the construction sector), sustainable application and management of natural resources, reduction of waste flows, etc.

In the period July 1991 - April 1992, three explorative studies were carried out on topics related to sustainable development which are of importance to TNO.
The results of the explorative studies include the following three reports:
'Sustainable development and health', 'Sustainable development and mobility', 'Sustainable development: closing the material cycles in industrial production'.