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# INTRODUCTION

Population, energy and environment are complex interrelated issues. Our understanding of the causal relationships between these issues is not complete but it is apparent that:

- While human skill and talent are natural and valuable resources, high levels of population and rapid population growth constrain human development. Lower levels of population growth will contribute to increased social and economic growth and development.
- High levels of population are a driving force behind growth in global demand for energy as people seek the services which energy provides. However, the availability and use of affordable commercial energy contributes to the socio-economic changes which bring about reductions in the speed and level of population growth.

- A rapidly-growing world population places higher demands on the world's natural resources (land, water, atmosphere, forests) and on its physical space and ability to act as a sink for wastes. High population growth and high levels of consumption, including inefficient energy use, are among the factors which threaten the achievement of sustainable development.

Currently, 95% of the world's population growth occurs in developing countries. This SBS therefore focuses on the factors influencing population growth and demographic trends in the developing world, the consequent impact upon energy consumption, primarily fossil fuel energy, and the combined impact of population and energy on the environment.

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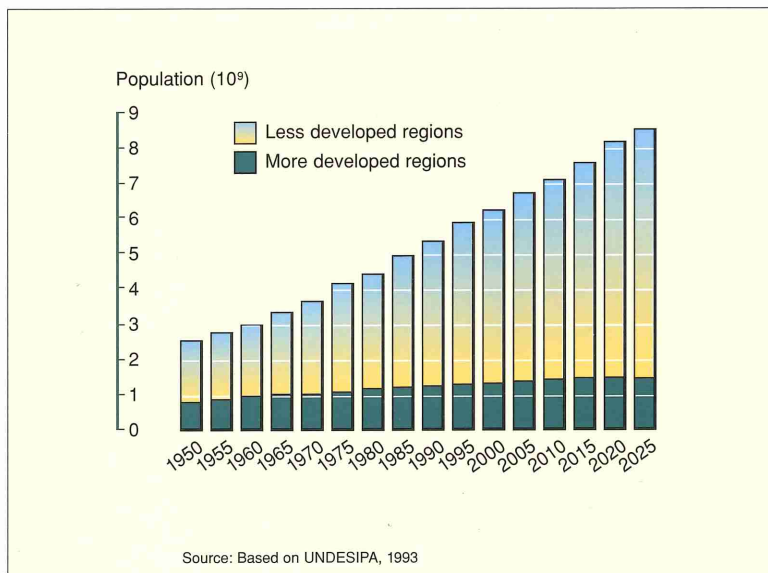
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# POPULATION

World population reached one billion in the middle of the last century. At the end of World War II, a second billion had been added. The last 45 years has witnessed the fastest growth rate ever, with population more than doubling to 5.6 billion in 1993, the last billion being added in just 12 years.

World population is growing at around 1.7% a year, equivalent to three people every second, down from a late 1960s peak of 2.1% a year. But world population dynamics mask increasingly wide regional variations: developed countries' population growth rate is 0.5% a year, compared with two per cent in developing countries (Figure 1). Around 95% of overall population growth occurs in developing countries which already house nearly 80% of the world's people.

Figure 1  
World  
population  
growth



Aggregated data for the developing world also mask variations in demographic trends. Countries in sub-Saharan Africa and parts of south Asia (excluding India) are characterised by: populations growing rapidly at two to three per cent a year, six to seven births per woman, stable or only slowly declining birth rates, and a fast decline in death rates throughout the 1950–1990 period. Elsewhere in the developing world, for example in south-east Asia and Latin America, population growth rates have declined since the

1960s to around two per cent a year and in east Asia they have reached 1.4% in the period 1985–1990.

Population growth is set to continue. The United Nations' (UN) median growth variant suggests a population of 6.2 billion by the end of this century and nearly 8.5 billion by 2025. This indicates that world population will be almost double today's level by the middle of the next century, before stabilising around 11.5 billion at the end of the next century.

Overall, the world's total fertility rate (TFR) – the number of live births a woman would be expected to have in her lifetime – is currently 3.5, down from five in 1950. In the developed world, TFR fell from 2.8 to 1.9 (below replacement level) in that period, while the developing world rate fell from 6.2 to 3.9. Within the developing world there are further marked divergences in the period: in Latin America and Asia, TFRs fell from 5.9 to 3.5 in the period, while in Africa as a whole there has been virtually no decline in a TFR above six, and with some parts of the continent even recording increases. Achieving the UN median population projections, will therefore require even further reductions in world TFR – to 3.1 by 2000 and 2.3 by 2025, before stabilising at the replacement level of 2.1.

## Demographic transition

It is generally accepted that demographic growth follows a four stage population cycle:

- In pre-industrial societies, a relatively stable population stage is maintained by a high birth rate, more or less equalled by a high death rate, mainly due to a high infant mortality rate.
- As society develops, simple advances in hygiene and health care reduce the death rate but do not influence birth rate, resulting in 'an early expanding population stage'. Many developing countries are currently at this stage of demographic development.
- More sophisticated health advances lead to a further decline in death rate and, at the same time, modern contraceptive methods lead to a substantial decline in birth rates. The society achieves a 'late expanding population stage'.



● The final stage of low, fluctuating population is one in which the demands of, and aspirations for, children in a much more affluent society impose financial constraints which in turn regulate family size.

The demographic transition is the ability of a society to move from high to low birth and death rates (from stage one to stage four). The speed with which a society moves through the transitional stages, is characterised by instability and influenced by a society's ability to accept changes in behaviour. It is interesting to note that it took 58 years for the USA to reduce its TFR from 6.5 to 3.5. Indonesia achieved the same level of reduction in 28 years and Colombia in 15.

While there is a correlation between these stages and the growth of per capita incomes, the relationship between population growth and economic development is far from clear. The experience of some countries suggests that a certain threshold of economic development is required before mortality rates begin to decline and couples begin to want to limit their family size. Evidence since the mid-1970s shows a tendency for income growth to be slower in countries with high population growth and those with slower rates of population growth have tended to show faster growth in per capita incomes. It would appear, however, that it is the level of income which contributes to the rate at which population grows, rather than the reverse. It is worth noting, however, that some countries have brought about unprecedented declines in mortality rates, despite low standards of living, for example, China, Sri Lanka, Mexico, Korea, Taiwan and Thailand, albeit for different reasons.

## ■ Factors influencing population growth

Conventional demographic thinking suggests that fertility has the greatest impact upon population growth, followed by mortality, with migration having the smallest effect. The reasons for high population growth and the paths to demographic transitions are found in the complex, interconnected social and economic factors which determine fertility and mortality rates.

### Mortality trends

During the last 40 years world mortality rates have fallen rapidly. Between 1950 and 1990, life expectancy in developing countries rose from 42 to 61 years, and in developed countries from 66 to 74 years. Infant mortality rates fell sharply in the developing world, albeit from a higher base, falling from 180 to 78 per 1000 live births,

compared with a decline from 56 to 15 in the developed world.

A number of interrelated factors have reduced mortality rates in the developing world, in particular, international efforts to control diseases such as smallpox, cholera, plague, malaria and tetanus. Other measures include government programmes to improve public health and social welfare, investment in education, and improvements in the status of women through education, employment, and involvement in decision-making. Reducing mortality rates is not hampered by cultural resistance to change since all societies welcome measures to reduce premature death and disease.

Health, measured by higher life expectancy, has improved more in the past 40 years than at any other time in history as a result of growing incomes, increased education, and governments' efforts to expand health services. Nonetheless, enormous problems remain: in the developing countries, child mortality is about 10 times higher than in developed countries and almost half of these preventable deaths result from diarrhoeal and respiratory illness, exacerbated by malnutrition. There is some evidence to suggest that child mortality relates more to parental education than to income or access to health care services.

For the developing world, there is a general rule that mortality decline precedes fertility decline. However, the relationship between mortality and fertility varies between different countries, affected by economics, politics, culture and the impact of population programmes. It is therefore misleading to suggest that mortality must fall to a certain level before fertility begins to decline.

### Fertility trends

The motivations to have children are mixed, and influenced by a number of factors which determine fertility levels. These include: inadequate access to modern contraceptives; low social status of women; political, cultural and religious attitudes which raise the status of large families and oppose contraception; low life expectancy of children; and inadequate and insecure family income.

In cultures where women's social and economic status is determined by their child-bearing ability, girls marry young, start their families early and often continue childbearing throughout their reproductive years. Their choice of the size and timing of their families is limited, either through social expectation or inadequate access to family planning. In addition, where women have low social status and poor education, the use of modern contraception is lower and fertility higher.

In some societies, children are viewed as the means to gain security for their parents' old age, or to earn income for the family and carry out household duties, such as collecting water, firewood and grazing animals. Where such conditions prevail, a small family unit may not be viable. In addition, where infant mortality rates are high, parents have many children since they expect that several will die. As the survival rate of infants and children improves, this driving force is ameliorated but it takes time before parents' fatalistic attitudes erode and their increased confidence in the life expectancy of children leads to reduced fertility.

### Migration

Migration rarely increases overall population levels but has a significant local impact as large numbers of people move internally within countries, between neighbouring countries or across regions. It is usually motivated by the search for higher wages or for a political haven, but environmental pressures, such as drought, soil erosion, desertification, and other problems, have increased the numbers of environmental refugees, alongside the numbers of political, religious and ethnic refugees. In general, migration is

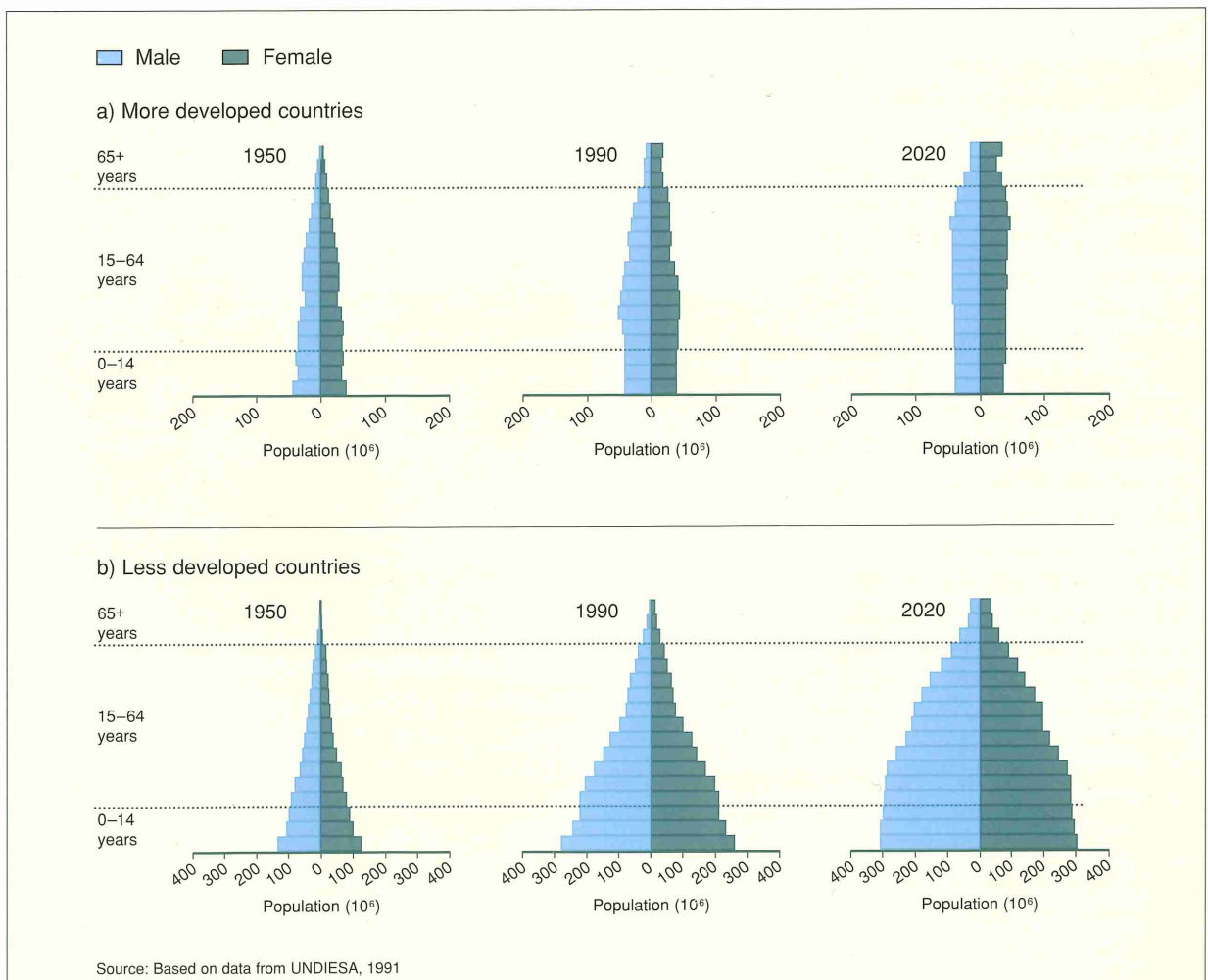
associated with the pressures of high levels of population: poverty, inadequate social development, and environmental degradation and in all cases, it increases existing pressures on the social, economic and environmental support systems of a nation or region.

Given the rate of population growth in the developing world, and the static or decreasing populations in the developed world, increased migration from the former to the latter is likely, with many associated social and political issues.

### Age profiles

Lower fertility and higher life expectancies lead to populations with fewer young people and proportionally higher numbers of elderly. As countries move through demographic transition, their age profile rises. The effect is most noticeable in the developed countries, where the median age is about 33 years and people aged 65 or over make up about 12% of the population. By 2025, the median age may exceed 40 years and almost 20% of the population may be aged 65 and over (Figure 2).

Figure 2  
Population pyramids – developed and developing countries



Source: Based on data from UNDIESA, 1991



In contrast, the developing countries are characterised by large numbers of young people. However, declining fertility will reduce the proportion of children in the population and set the ageing process in motion. By the beginning of the next century, the proportion of those in developing countries aged 65 or over will rise slightly to five per cent and then increase more rapidly.

The age profile of a population has serious economic and social implications. For example, in the ageing developed world, increasingly large numbers of elderly people depend for their welfare upon a smaller group of working age people.

Differences in the developed and developing country age profiles help to explain the disparities in their projected population growth. The proportion of people in each age group in the developed world is roughly equal, with the exception of the post-war 'baby boom' bulge at the 30–45 age group. In the developing world there is a much larger proportion of people in the younger age groups, who will, as they reach their reproductive years, increase the number of children born each year. Thus the considerable momentum already built into the population system means that although total fertility rates may continue to decline and each woman will have fewer children, there will be many more women having children.

### ■ Keys to reducing fertility rates

Addressing the individual factors which influence people's decisions about fertility – family planning, education, health care and higher life expectancy, and improved economic opportunities – may bring about some fertility reductions, but the greatest effect will stem from policies which incorporate a wider developmental perspective. Most developing country governments accept the need to address population growth seriously. Some have introduced enlightened programmes to tackle the issue; others have pursued coercive measures which fail to recognise parental rights.

### Family planning programmes

Family planning is the most important element in fertility reduction: differences in the levels of contraceptive use explain 92% of the variation in fertility among 50 countries (Figure 3). It is estimated that in the 30 years to 1990, the use of contraception rose six-fold, the highest increase being in east Asia (from 17% to 70%) followed by Latin America (11% to 60%) and the lowest in sub-Saharan Africa (five per cent to nine per cent). On average, an increase of approximately 15 percentage points in contraceptive use has led to the TFR reducing by one birth.

### Demographics and population policy in China

China contains 20% of the world's population and is the most populous country with 1.2 billion people. This figure is expected to rise slowly to exceed 1.5 billion by 2025.

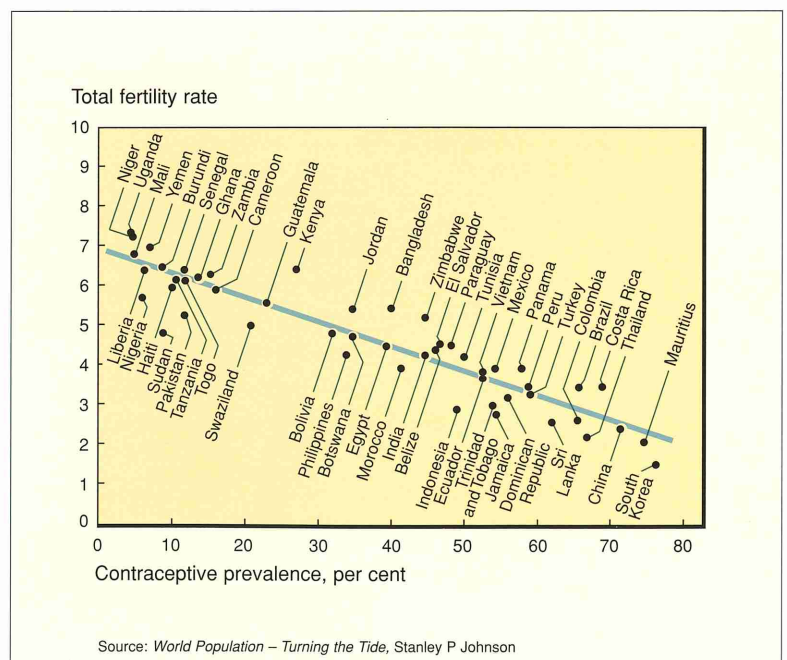
Population growth rates in China peaked at around 2.1% a year during 1965–1970. Thereafter growth rates fell sharply: TFRs fell from 6.4 in 1968 to 3.3 in 1980. The decline has stagnated since then around the level of 2.5 despite the introduction of the highly unpopular 'one-child' population policy in 1979.

The dramatic decline in fertility in the 1970s has been attributed to a combination of improved maternal and child health care, wider provision of family planning services, and a trend towards later marriages and longer spaces between births. Much of the decline came from fewer women having more than three births. The reduction in the number of women having second births only became apparent after the 'one-child' policy came into effect. This trend was reversed in 1985 as the policy was relaxed.

Without China's population policies and fertility declines of the last two decades, it is likely the country would now be inhabited by an extra 200 million people. Nonetheless, the population is still rising by 1.4%, largely as a result of the age profile: a rapid rise in the 1960s birth rate has sustained continuing population growth as women born in that decade reach their childbearing years.

Demographic, health and family planning surveys estimate that while nearly 400 million married women in developing countries use family planning, at least another 120 million who do not use contraception do not want more children. In virtually every country outside sub-Saharan Africa, women wanted fewer children than they were actually having.

Figure 3  
*Contraceptive prevalence and fertility, 1984–1992*



Source: *World Population – Turning the Tide*, Stanley P Johnson



A top priority for family planning programmes is therefore to meet this large potential demand for contraception but national surveys suggest that many programmes have a long way to go in making family planning widely available and known, particularly among women in rural areas.

Access by communities to effective contraception will help women to avoid unwanted pregnancies and the consequent need for abortions, although legal abortion services may still form an element in reproductive health care.

### **Economic development/poverty reduction**

In the developing world, already heavily burdened by under- and unemployment, nearly 40 million extra people enter the labour force each year. Job creation initiatives are essential, particularly in rural agricultural areas where poverty, unemployment and lack of land are high, but governments have limited options. Consequently, poverty continues to hinder the transition to slower population growth.

Historical analysis of economic growth shows that less than half the growth can be explained by inputs of labour and capital; the single largest contributor to growth is technological development.

Advances in science and technology are increasingly seen as crucial ingredients for international competitiveness.

The characteristics of traditional manufacturing will continue to shift from mechanisation, with few product variations, well-defined tasks and hierarchical organisations, towards greater flexibility, more product variety, more reliance on automation, computing and control technologies, and tailoring of products and services to meet individual customer need. The number of production steps between raw materials and final products will decrease. Inevitably, the size of the workforce required for production will also decrease as integration and automation eliminates routine jobs and the skills requirements for all jobs rise.

The availability and use of high-speed, high-capacity communications and information networks are affecting many areas of human activity. Work can now be transported around the world to wherever the cheapest, brightest and most productive workers are located.

Urbanisation (see below), almost without exception, boosts economic development. In India, for example, the contribution of the urban sector

## **Urbanisation**

The increase in the numbers and proportion of people living in urban areas has been one of the most significant demographic events of the 20th century. Worldwide, two in every five people (40%) now live in urban areas compared with one in 10 at the beginning of the century. By 2025 the proportion is likely to be 60%.

The level of urbanisation is highest in developed countries and the growth rate is rising only slowly, from 73% currently to 80% by 2025. In contrast, the developing countries' current urbanisation level is 34%, but is growing nearly four times faster than developed countries and should reach nearly 57% by 2025. Despite the lower level of urbanisation in developing countries, their much

larger populations means that these countries have the largest numbers of urban dwellers, currently some 1.4 billion but rising to four billion by 2025.

A large proportion of the world's urban population lives in 'mega-cities', the size and number of which are projected to grow in the next few years. In 1950, there was just one city with more than 10 million people (New York). By 1990, there were 13, of which nine are in developing countries. By 2010, the number is expected to reach 26, 21 of which will be in developing countries: 14 in Asia, five in Latin America and two in Africa (Figure 4, page 6).

Such rapid urbanisation – driven by the greater social and economic opportunities in urban areas, a depressed agricultural sector and the heavy pressures on natural

resources – is likely to outstrip the development of much-needed infrastructure, increase pollution and degrade marginal rural lands.

As rural resources and economic opportunities decline, the opportunities and services available in towns and cities become more attractive, not least the provision of health, educational and social services to residents and the opportunities for employment and higher incomes. Urban areas also have implications for population policies since urban residents often have improved access to family planning methods and education. The combination of these influences may lead to smaller family sizes, but as more women of childbearing age migrate to urban areas, urban population growth rates will exceed rates for rural areas.



to net domestic product rose from 29% in 1950 to 41% in 1980, and is likely to be over 60% by the beginning of the next century. Roughly two-thirds of employment in manufacturing, trade, commerce, and transport are located in urban areas. However, the economic advantages of urbanisation are not uniformly distributed and urban poverty and unemployment is still apparent. In India's largest cities, between one-third and one-half of the population lives in slum or squatter settlements while 15% of the male workforce and 25% of the female workforce have no regular employment.

### Status of women

Women have a central role in slowing population growth. Enabling women to take greater control over their own lives, make informed choices about the size and spacing of their children, take part in life outside the home and family, and participate

in decision- and policy-making will have a significant impact on fertility.

The education of girls and women is one of the main keys in population (Figure 5) and social development policies. Educating women enhances their traditional roles of infant and child nutritionists, teachers, providers of community health care, and managers of natural resources through agricultural production, use of forest products (fuelwood and non-wood products such as food, fodder and fibre) and water resources.

Educated women tend to marry and have children later than uneducated women, they are better able to take advantage of family planning programmes, and their ability to earn an income exerts downward pressure on fertility. It is also reasonable to expect that educated women value education for their children, and may be more willing to make the choice to have fewer children in whom they can invest more time and resources.

In the technologically demanding global market, education is increasingly important. A statistical correlation exists between education and economic performance. In the developing world, GDP increased 5.5% a year between 1965 and 1987 where adults had more than 3.5 years of schooling and only 3.8% a year where less schooling was available. Since education, particularly of women, is also associated with lower fertility and smaller families, education represents one of the important links between economic and population growth.

### Health

Mortality rates indicate the general health of a society. For example, infant and child (under-five) mortality rates can be used as a measure of nutrition levels, education (especially female literacy), general socio-economic status, and health services.

Improvements in child mortality rates can be made at most levels of national income, either through broad-based socio-economic development strategies, or direct interventions. Programmes aimed at improving female literacy and health care generally can have a bigger impact on child mortality than those which aim solely at increasing economic growth.

Better health lowers infant mortality and leads to lower birth rates as parents begin to believe their children will survive infancy. Smaller families tend to be healthier families: where women have many births, close together and at very young or older ages, the health risks for mother and children are increased.

Improvements in reproductive health care will help to reduce both infant and maternal

Figure 4  
Growth of the megacities



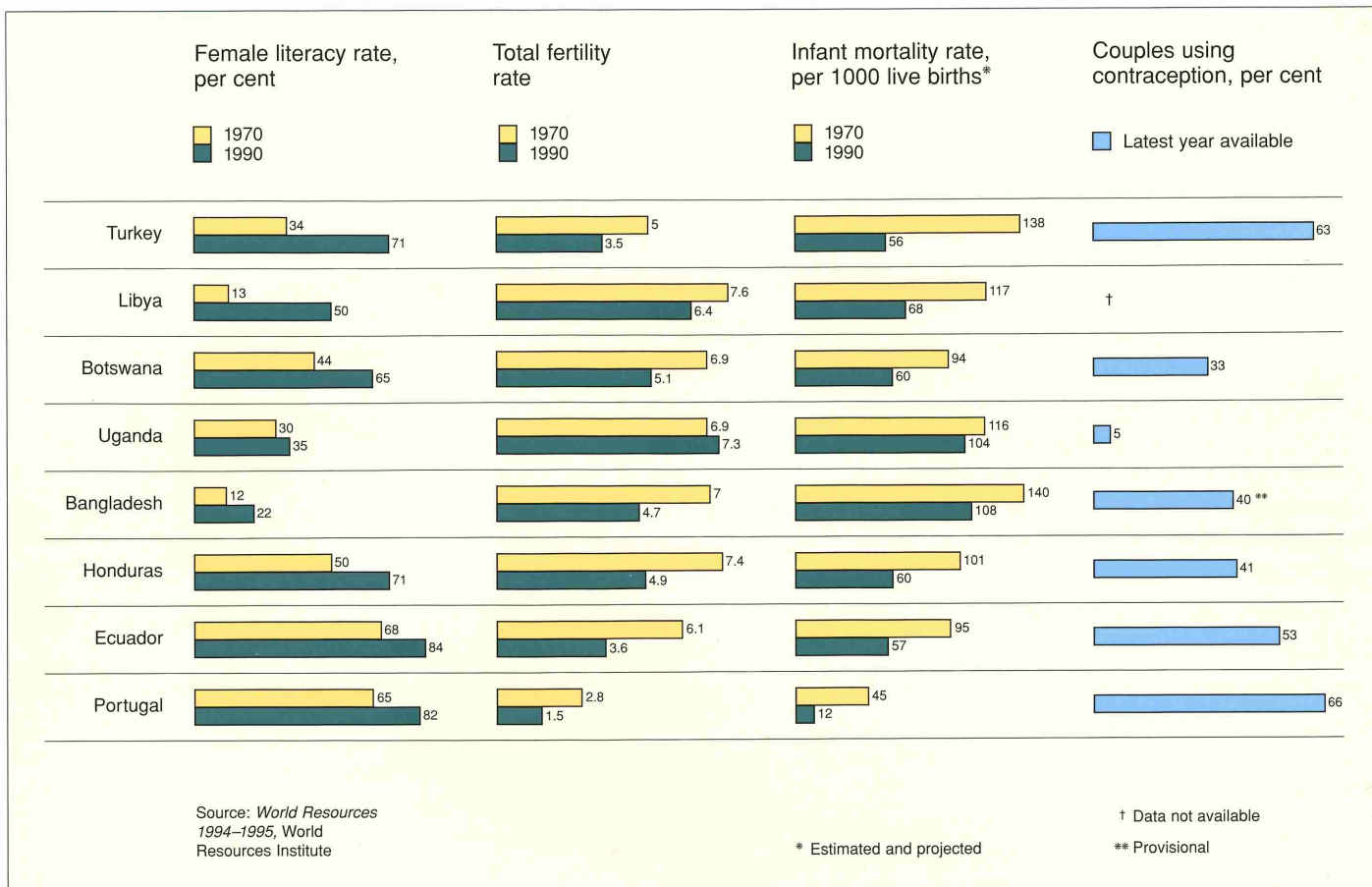


Figure 5  
Fertility and infant mortality rates by female literacy

mortality. Of the 500 000 women who die annually from pregnancy-related causes, 99% are in developing countries. The root causes of these deaths are linked to socio-cultural traditions, poverty, lack of education and low social status for women, which can only be addressed through social development strategies. The immediate medical causes however can be remedied by community level access to doctors or nurse-midwives with appropriate training and medical technology.

Clean water and sanitation facilities are essential to good health. Significant progress was made during the 1980s – the UN's International Drinking Water Supply and Sanitation Decade – to increase the availability of these services in the developing world. The success of this initiative – an extra 1.3 billion people gained access to safe water and 748 million had sanitation facilities – was achieved through community participation, particularly by involving women in planning, managing and decision-making, and the adoption of low-cost water and sanitation technologies. However, population growth has outpaced the achievements and currently 30% of the developing world lacks access to safe water while some 40% has inadequate sanitation.

Nutrition, particularly among pregnant women, infants and children, is an important

health factor influencing population growth. Increased nutritional information and training for parents and health workers will help to alleviate the incidence of severe and moderate malnutrition among children. Education about the value of exclusive breastfeeding in early infancy is crucial. UNICEF estimates that breastfeeding could reduce infant deaths by 1.5 million each year.

### Global initiatives

While national population policies need to be enacted effectively at the community level, the population issue is of such seriousness and widespread impact that global initiatives are also necessary. The International Conference on Population and Development held in Cairo in September 1994 built upon the findings of previous international conferences but demonstrated that a new wisdom now informs previous demographic concerns. The problems associated with rapidly growing population are well-known but there is now greater acceptance that they should not be treated in isolation but in the broader context of human development, without which other global concerns relating to the environment will not be properly addressed.



# ENERGY

Energy is one of the world's most important resources. It is essential to industry, underpins global economic growth and helps to create the wealth and support the technology needed to combat environmental degradation. Energy also provides the amenities which make human life comfortable and the secure supply of energy at affordable prices has a role in reducing population growth by underpinning many of the factors needed to bring about fertility decline. Higher world population results in increased demand for energy and the consequent environmental implications of that energy use must be balanced against its developmental role.

## ■ Global energy demand

The main upward forces on world energy demand are size of population, industrialisation and economic growth, which are partially offset by improvements in energy intensity or the amount of energy needed to produce one unit of economic output.

In the last 20 years, overall world demand for commercial energy has grown by 2.25% a year (Figure 6) and currently totals 170 million barrels a day of oil equivalent. More than half of that energy is used by countries within the Organisation for Economic Cooperation and Development where demand has risen by 1.5% a year in the last two decades. The developing countries' commercial energy demand has risen much faster – 5.5% a year in the same period – but accounts for just over a quarter of the world total. With underlying trends of growing populations and economic activity, that proportion could double in the next 30 years.

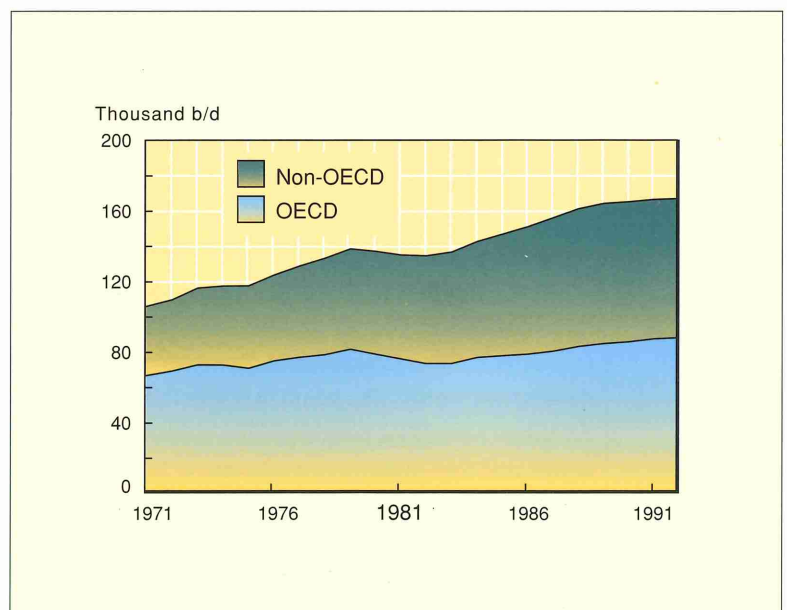
The disparity between the energy consumption in the developed and developing world is most marked in per capita levels of consumption. Overall world average is some 60 gigajoules per person each year, but this masks huge regional variations. For example, a US citizen consumes more than five times the world average, a European more than three times, and an African just one-fifth of the world average.

## Energy efficiency

As world energy demand rises, conservation and efficiency will become ever more important. Prompted by the oil price shocks of the 1970s, the developed economies have applied this two-pronged approach to reduce energy demand, cut production costs, and latterly for environmental reasons. Developing countries have focused more upon economic output than on energy conservation, so that their improvement in energy efficiency has been slower.

However, current technology, as well as good operational and management techniques, offer scope for further sizeable energy savings. Acquiring such technology is economically attractive since the resultant lower energy costs usually pay for the investment, often within a short period of time. Technology can also improve the efficiency of traditional wood or kerosene stoves and thus alleviate rural energy shortages and ease pressure upon fuelwood supply.

Figure 6  
World  
commercial  
energy  
consumption



Policy and price reform are also essential. Much of the energy consumed in the developing world is heavily subsidised, which encourages high demand and discourages efficiency. Removing



subsidies and introducing tariffs to reflect the real costs of electricity alone, could save some \$125 billion a year, which could be used to advance other fundamental development projects.

But pursuing energy efficiency alone will not satisfy increased developing world energy demand nor solve the environmental impact of energy use. While electricity has been made available to an extra one billion people in the developing world in the past 20 years, another two billion are still dependent on animal dung and fuelwood for energy, a dependence which reinforces the cycle of poverty, high population growth, and environmental degradation. One way ahead for them is either the provision of a greater share of the world's modern energy sources, for example, through rural electrification schemes, or to encourage more effective use of renewable energy.

The level of future energy demand in developing countries will be influenced by those countries' ability to 'leapfrog' the development process. By gaining access to modern technologies and by employing skills and knowledge already acquired elsewhere, developing countries have the opportunity to set a more sustainable course and build their industrial base while circumventing some of the environmental and energy-efficiency problems historically associated with industrialisation. It is therefore possible that the level of consumption in the developing world need not necessarily shadow that formerly followed by developed countries.

## ■ Energy supply

Most of the total world demand for energy is met from commercial sources. Conventional fossil fuels supply almost 86% of the demand for commercial energy: oil supplies nearly 40%, coal 26% and natural gas about 21%. In addition, nuclear power contributes just over five per cent, and hydropower about six per cent. Less than two per cent comes from the 'new renewables' which include modern biomass (for example, wood waste for heating and sugar-derived ethanol as a transportation fuel component), solar power, wind and geothermal, in situations where they are economically viable.

Non-commercial sources of energy – mostly the traditional biomass fuels of wood crop waste and animal dung, supplemented by human and animal power – are estimated to provide some 14% of total world energy, most of which is consumed in developing countries and supplies

more than one-third of their total energy requirements.

All the currently available energy sources will be needed to meet projections of future demand with fossil energy dominating for many years to come. Fossil fuels have sizeable proven reserves with the prospect of future discoveries and better extraction rates through advanced technology. While some substitution of fuels may occur, the long lead times that characterise energy projects prevent rapid changes to existing energy structures. At this time, there is no single or group of substitutes which offer a commercial alternative to fossil fuels, particularly in transportation and petrochemical production.

Nonetheless, fossil fuels are finite and development of other energy sources for the longer term is both inevitable and prudent. Analysis of how energy systems have evolved over the last 100 years may help us to envisage the shape of the future energy supply mix.

The last 100 years of energy use is a complex picture of progress in terms of costs, quality, variety and use of energy, shaped by market forces. To meet the underlying rise in energy demand, driven by population growth, industrialisation and economic development, productivity in supply and demand increased, stimulated by competition and market mechanisms. At the same time, new needs emerged, for example, the increased demand for mobility, met first by rail, then by the car, and latterly by air transport. These new needs were generally the result of the convergence between emerging new technologies and changes in social development and were accommodated through transitions which increased the diversity of energy sources.

In 1890, fuelwood and coal met the world demand for energy in roughly equal proportions, with oil contributing only two per cent, despite its discovery in significant quantities in 1860. By 1920, oil supplied five per cent of the world energy mix. Fifty years later, it was the leading energy source, but the oil price shocks of the late 1970s and early 1980s led to a decline in its share which has benefited, for example, the nuclear energy industry. At the same time, renewable energy technologies began to appear. The result of these shifts is the wide diversity of energy sources which are available today.

The historical pattern indicates that future energy systems may comprise an even greater mix of energy sources, with the higher visibility of renewable sources being a new transition. The place those new sources hold in the future energy



mix will depend upon their technical development and price, as well as safety and environmental impact. Nuclear and hydro are already in use. Several technologies which exploit the energy potential of wind, modern biomass, and solar photovoltaics are established in market niches. Modern renewable energy technologies are progressing quickly down their 'cost learning curves' and gaining from the economies already achieved by more mature energy technologies. Some of the more promising renewable technologies may well become commercially competitive and start to make a measurable contribution to energy supply by 2020.

Renewables offer some environmental benefits over fossil fuels, particularly in respect of carbon dioxide emissions, and their wider use therefore has implications for the climate change debate. However, they are not without environmental problems. For example, wind farms are noisy, can disfigure areas of natural beauty and cause electromagnetic interference. Some materials used in photovoltaic systems are toxic and may be hazardous during production and in disposal. The direct combustion of biomass and waste products also releases pollutants. As with current energy sources, there may in time be calls to evaluate the trade-off between the costs and environmental impact of renewable energy technologies.

### ■ Role of energy in development

Energy plays an important role in enabling and sustaining development, most obviously by underpinning the economic growth of a nation and raising overall living standards. Figure 7 shows how energy use increases with wealth, although such a correlation needs to be treated with caution since other factors – the size, population levels, and even the climate of countries – also influence energy demand.

In developing countries, energy is crucial to economic and social aspirations but access to reliable commercial energy sources remains limited. Building an effective energy sector is costly and complex, particularly when limited financial resources must also meet other pressing development needs.

The contribution energy makes to development can be seen in a number of areas:

#### ● Industrialisation

Industrialisation introduces new technologies to

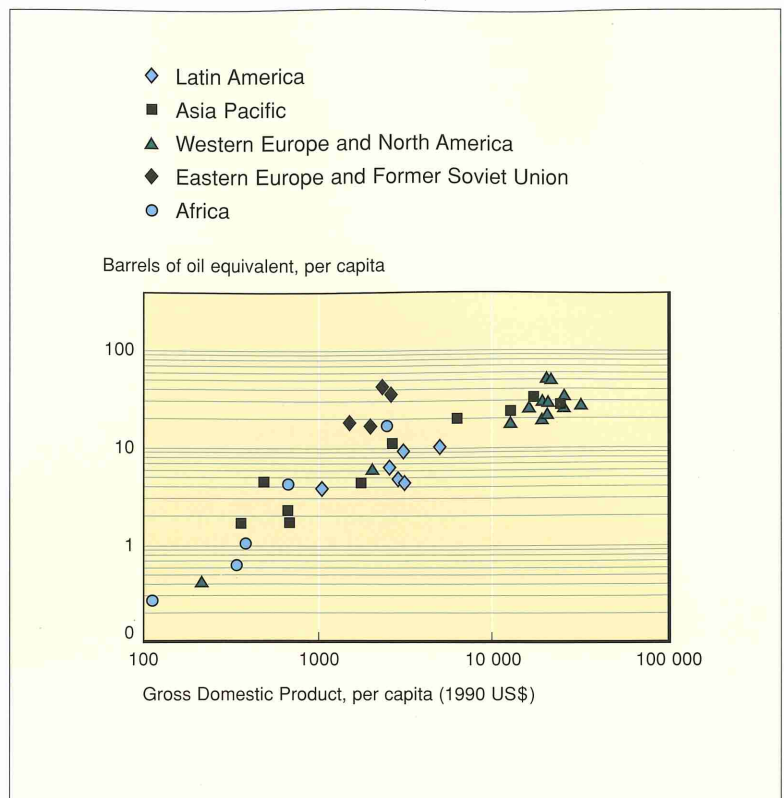
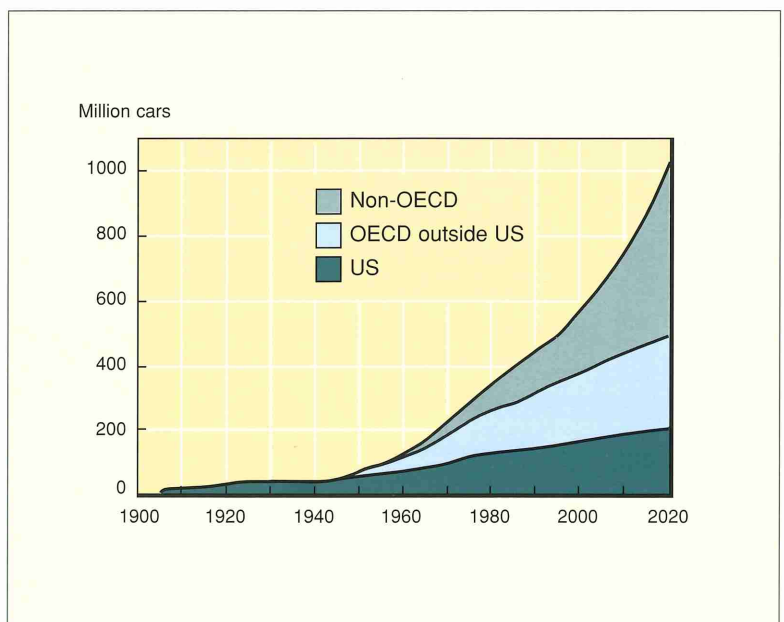


Figure 7  
Commercial energy consumption and GDP, 1992

make existing and new products. Virtually all industrial production is more energy-intensive than either traditional methods of agriculture and manufacturing and several industries which typify the early stages of industrialisation are particularly energy-intensive, for example, oil refining, chemicals, primary metals, construction materials (stone, clay, glass, and related cement, lime and brick), and paper.

Levels of industrial energy consumption in developing countries will be affected by the

Figure 8  
World passenger car registration



energy-intensities of the production processes selected, the maintenance and operational procedures, and the learning curves of companies newly engaged in manufacturing.

#### ● *Mobility*

Car ownership, and therefore the consumption of automotive fuels, increases with per capita income. Currently, there are marked differences in the level of automobile ownership between developed and developing countries, which reflects significant differences in wealth. However, income levels in many of the less developed countries are approaching the point at which car ownership reaches its maximum growth rate (Figure 8) and the steepest rise in car ownership is expected to occur in the less developed countries. By 2020, car ownership in today's developing world could be as high as in developed countries at present, with obvious energy demand implications.

#### ● *Social development*

Energy-using technologies can underpin socio-economic conditions which help to reduce fertility rates and speed up demographic transition. For example, energy is needed to provide adequate supplies of safe domestic water which help to reduce infant mortality. Efficient energy sources and cooking equipment reduce the time women and children spend on essential domestic tasks. This removes one of the main reasons to have large families and frees women and children to take advantage of educational opportunities.

Electric lighting extends the time available for schooling and removes the imperative for women to complete their domestic tasks during daylight hours. Energy-consuming industries provide employment and income for women which, in turn, tends to delay age at marriage, an important determinant of fertility.

### Urbanisation and energy use

Urbanisation has been a characteristic of economic growth and development and increases energy use for a number of reasons. Concentrations of large numbers of people in towns and cities provide a large labour force which can be employed in energy consuming, large-scale, specialised activities.

Urbanisation also requires the use of more energy to develop the infrastructure required to support higher concentrations of people.

In agriculture, the structure of production changes as fewer agricultural workers are required to feed larger urban populations. More energy is required as operations are mechanised, commercial fertilisers displace traditional fertilisers, and food is more highly processed to preserve it during transportation.

Real per capita incomes rise with

economic growth. Higher incomes influence energy source choices, increase the demand for energy-consuming appliances (where available), and drive up consumption of traditional and new products.

Per capita incomes, together with higher population density, also increase demand for fuels which are easy to use and transport. For example, while charcoal is more compact than fuelwood, kerosene is more portable than either. It has been estimated that a 10% increase in population density causes a 2.5% decrease in energy generated by fuelwood and charcoal. Urbanisation is therefore an influence upon fuel substitution and may encourage further shifts in fuel use patterns, particularly in favour of liquid and gaseous fossil fuels with their advantages in transportation, storage and energy efficiency.



The world's natural resources support human life and development but human activities in developed and developing countries are placing those natural resources under considerable pressure. Technical solutions exist or may be developed to alleviate most environmental problems but in many cases these technologies themselves require greater use of fossil energy and the inevitable production of higher levels of carbon dioxide, one of the greenhouse gases. High levels of population and energy use are two of the most important factors associated with increasing pressure on the environment, locally, regionally and globally.

## ■ Local impacts

Both developed and developing countries experience local pollution problems associated with industrial activities, energy consumption, inappropriate agricultural methods and the high density of urban populations (see page 13). High levels of population exacerbate pressure on urban infrastructure and rural resources which can increase local environmental degradation.

Land degradation, caused by deforestation, overgrazing, unsustainable agricultural practices or industrial development, ultimately leads to desertification, particularly in arid lands. Overall the world has lost nearly one-third of its arable lands in the last 40 years and soil erosion rates continue to outstrip the speed of soil formation. More than 10% of the world's vegetated surface has been classified as moderately to extremely degraded since 1945 with a much more sizeable area categorised as lightly degraded and capable of restoration through appropriate farming practices. In absolute terms, Africa and Asia contain the largest areas of degraded soils but the problem is not restricted to the developing world. On a continental basis, Europe suffers the highest percentage of soil degradation from physical and chemical impacts.

## ■ Regional impacts

Sulphur dioxide and nitrogen oxides are among the atmospheric acidic gases that contribute to

long-range air pollution which can affect regions far beyond the countries where the gases originate. These pollutants, derived in the main from power stations, oil refineries and other industrial operations, as well as from vehicles, have been identified with the acidification of soil and water as well as forest damage, particularly in Europe and North America. Much has been done by the industries involved to reduce the emissions of these pollutants, including the use of low-sulphur fuels, improved combustion and sulphur recovery technology, and catalytic converters in cars.

While damage to forests in some areas has been attributed to high local concentrations of sulphur dioxide, in other locations it appears to be the result of a combination of natural and anthropogenic factors. Soil acidification occurs if the ability of the soil to neutralise acidic inputs is exhausted. As well as the resultant potential damage to trees and crops, the acidity may affect streams and lakes which may eventually be unable to sustain aquatic life. Soils and water high in calcium carbonates can neutralise acids more effectively.

## ■ Global impacts

The natural greenhouse effect is essential to sustain life on earth. The 'greenhouse gases' – water vapour, carbon dioxide, methane, nitrous oxide and ozone – allow the free passage of incoming sunlight but re-reflect part of the outgoing infra-red radiation (the so-called radiative forcing). As a result, the average surface temperature of the earth is some 35°C higher than it would otherwise be. Since the industrial revolution, human activities – notably the use of fossil fuel energy, deforestation, and, more recently, the production of synthetic greenhouse gases such as chlorofluorocarbons (CFCs) – have contributed to increased concentrations of greenhouse gases which has led to concern that an enhanced greenhouse effect will result in global warming.

The persistent uncertainty about the causes and potential effects of climate change continues to make this a most complex global issue.



## Urbanisation and the environment

The size and speed of urbanisation in developing countries has significant environmental implications, compounded by high levels of population growth.

The growth of 'megacities' (see page 6) has been accompanied by environmental and health problems, particularly in developing countries. Rapid urban growth has frequently outstripped the investment needed to develop infrastructure and services, with the poorer residential areas being most vulnerable. The result has been a rapid expansion of the numbers of people living in overcrowded, often illegal or informal settlements such as 'squatter camps', in poor quality housing without adequate access to even basic services. Case studies of cities in Africa, Asia and Latin America suggest that between 30% and 60% of the population live in such illegal settlements. Extrapolated worldwide, this figure equates to some 600 million urban residents living in inadequate conditions.

Urban areas, particularly cities, concentrate human activity and demands

for natural resources (including energy, water, and land), basic infrastructure (sanitation and waste disposal), services (education, health, transportation) and employment. Urban consumption patterns and their environmental impact differ from those in rural areas. City residents tend to consume a higher proportion of industrial goods and energy-intensive services, particularly in developing countries. In India, for example, per capita consumption in urban areas is roughly twice that of rural areas. In addition, cities are typically a disproportionate source of the wastes and pollutant emissions generated by a country.

Air pollution, once a problem particular to the industrialised world, has now become almost a fact of urban life throughout the world as a result of increased motorisation, poor vehicle maintenance, industrial growth, and the lack of effective and enforced air quality regulations. In addition, the domestic burning of biomass fuels on open fires in homes with no chimney or poor ventilation leads to significant indoor air pollution.

Scientific understanding of the carbon cycle and climate processes is, as yet, incomplete. There is difficulty in accurately measuring global average temperatures and estimates of the possible consequences of global warming and the responses of the ecosystem to climate change vary considerably. In addition, the likely future improvements in energy efficiency and conservation, and the longer-term growth of the 'carbon-free' renewables in the energy supply mix have implications for long-term projections about the size of carbon dioxide emissions.

While the potential risk of global climate change indicates that governments should seek measures to address the issue, the scientific

uncertainty and the natural evolution of energy systems suggest that policies to curb greenhouse gases, beyond the 'no regrets' principle, may be premature. In addition, they may risk diverting resources from more pressing needs and further distorting markets which may have serious economic impact, particularly in developing countries.

Inevitably, the market will drive the energy industry towards improved supply and energy efficiency, including renewable technologies, to meet long-term demand. Future policies should aim to foster, rather than stifle, the commercial drive and innovation which will bring this about. Any policies adopted should be based upon sound scientific



principles and cost-benefit analysis where possible, and should avoid distorting markets.

## ■ Sustainable development

Environmental problems have the potential to damage human health and degrade natural resources so that future development is limited and economic expansion put at risk. To achieve sustainable development requires societies – governments, businesses, industry and consumers – to find a

balance between maintaining a healthy natural resource base and satisfying the demands of human and economic growth.

Economic development and environmental protection should be regarded as compatible, complementary and mutually reinforcing aims. For example, poverty is widely recognised both as a consequence and a cause of environmental degradation since it reduces incentives for long-term resource management and encourages rapid resource extraction and short-term production

### Water management for sustainable use

Water is essential in supporting the economic aims of increased agricultural productivity, industrial expansion and urbanisation, and as a fundamental life-support mechanism, vital to human health and ecological maintenance.

However, globally, water is under considerable pressure, evidenced by falling water tables and shrinking lakes and wetlands. Global water use has more than tripled since 1950, and demand has grown faster than population. Per capita use of water today is nearly 50% higher than in 1950 and, in most countries, continues to climb.

Water scarcity – defined as the point at which lack of water becomes a severe constraint on food production, economic development and protection of natural systems – occurs when annual water supplies fall below 1000 cubic metres per person, about 725 gallons per person per day. Today, some 26 countries, with a combined population of more than 230 million, suffer from water scarcity. Since many of these countries also have high population growth rates, the problems they face are likely to increase.

Agriculture claims some two-thirds of all water taken from rivers, lakes, streams and aquifers. Irrigation has underpinned the drive to achieve

global food supply security. Traditional planning solutions to meeting ever-increasing demands for water have been the construction of more and larger water development projects, particularly dams and river diversions. However, the rate of dam construction worldwide has fallen steadily during the last 10 to 15 years, as developed and developing countries have given closer scrutiny to the economic, social and ecological costs of such projects.

For example, the world's fourth largest freshwater lake – the Aral Sea located between Kazakhstan and Uzbekistan in the former Soviet Union – has been largely destroyed by a scheme to irrigate adjacent semi-arid areas to meet demands for food and fibre production. Over the past 30 years, some two-thirds of the water that was in the sea have drained away, salinity has tripled, the water level has fallen by 13 metres and the sea's surface has been halved.

Increasing the efficiency of irrigation schemes is therefore a priority in establishing more sustainable use of water. Careful management of the water resource is required in order to balance the apparent conflict of interests which results as more water is devoted to human needs, leaving less available to sustain the ecosystem. Similarly, measures to improve agriculture's use of water are important,

including, for example, new and improved agricultural technologies, better management practices by farmers, water resource managers, and structural changes to the institutions which control the distribution and use of irrigation water.

Among developing countries, which make up the largest proportion of water-scarce countries, a number of small-scale schemes are proving valuable. Improving the performance of canal systems has been most effective where farmers are themselves involved in the layout, operation and management of systems, for example in the Philippines, China and South Korea. Rainwater management, using small-scale irrigation and techniques to make better use of rainwater and water harvesting, for example building check dams of earth and stone to capture run-off water from hill-sides, contribute to increased food production at village level.

Such 'grassroots' practices rarely gain the publicity associated with new dam building, yet can achieve significant results. For example, analysis in the USA has shown that a combination of a number of proven small-scale techniques can collectively offer a viable alternative to the irrigation component of the Sardar Sarovar Dam in western India.

strategies. Economic growth reduces poverty and is a strong downward influence upon the rate of population growth and the pressure that growth places upon natural resources. It is therefore the quality of growth, rather than economic growth itself, which must be modified in order to achieve sustainable development and leave the environment in a fit condition for future generations to inherit.

Businesses and industry play a crucial role in the economic and social development of a nation. Stable policy regimes which encourage and enable businesses to operate responsibly and efficiently and to take a long-term view of investment, increase a nation's prosperity and provide people with opportunities for employment and professional development, not only in large, capital-intensive industries but also in small, local, labour-intensive operations.

Commercial enterprises therefore have a doubly important role to play: they provide the means and the channels for sustainable economic development and they offer the managerial, technical and financial know-how and resources needed to safeguard the environment by reversing past damage and resolving future challenges.

Governments have a responsibility to set national and global goals for environmental policy, which view market forces as a means to protect and enhance the quality of the environment, rather than detract from it. Traditional command-and-control regulation can limit the creativity of business in seeking solutions to environmental problems. Encouraging market forces through a regulatory framework, based on the prudent use

of economic instruments and performance-based standards, provides greater scope for businesses to be innovative and to develop new products, processes and technologies which reduce their call upon natural resources and minimise production of wastes and pollutants.

A market-based approach to achieving environmental goals also allows businesses the flexibility they need to meet objectives cost-effectively. The business climate – both commercially and technologically – can change rapidly and given the continuing degree of scientific uncertainty about many of the world's existing environmental problems, flexibility is essential.

Since many environmental issues transcend national boundaries and present challenges to the international community, the transfer of technology, know-how and management skills through international trade and investment, will help to achieve the long-term goal of sustainable development. Environmental regulations and standards set by national governments should therefore avoid distortions to cross-border trade and investment flows and the creation of trade barriers.

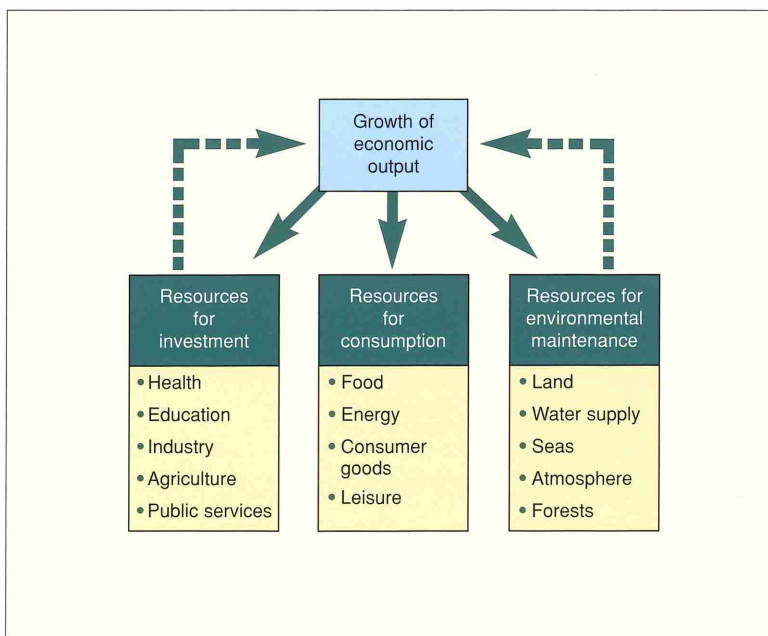
Governments, industry and businesses need to raise awareness and provide information about the balance which must be struck before sustainable development can be achieved. Consumers will then be empowered to make informed and balanced choices about their lifestyles and patterns of consumption in a manner appropriate to their local culture and environment

## ■ Resource allocation

A nation's economic output provides goods and services for consumption and makes resources available for investment in health, education, public services, infrastructure, research and development, knowledge building, and new and improved methods of industrial and agricultural production, which in turn contribute to economic output.

Given the anticipated level of population growth and the degree of poverty in many countries of the world, it would be irresponsible to use resources unnecessarily. Environmental policy must therefore be based upon rational debate, sound science and rigorous economic analysis so as to avoid expending scarce resources on 'solutions' to problems whose causes are still in dispute. Finding the right balance in the allocation of resources is a challenge for all governments and societies (Figure 9).

Figure 9  
Balance in  
allocation of  
resources





A cleaner environment, safeguarded for use by future generations, is an important objective but in a world where resources are limited and many basic human needs remain unfulfilled, its importance must be balanced against other developmental aspirations.

Businesses and industry are among the drivers of greater efficiency in the allocation and use of resources. Sound environmental policies, more efficient and cleaner production technologies and processes throughout the product life cycle, the minimisation of waste, and technology cooperation are contributions which commercial enterprises are making towards reducing their impact on resource use and the environment.

## Environmental management

Effective resource management depends upon a number of phases: a proper understanding of the issues involved, establishing the most appropriate policy measures, identifying projects, conducting feasibility studies and continuous environmental impact assessments, devising and implementing management plans using the most appropriate technology, and measuring and monitoring results (Figure 10).

For example, global concern about the continuing degradation and fragmentation of forest resources, with the consequent diminishing of biological diversity, was reflected at the United Nations Conference on Environment and Development (UNCED) in 1992. Since then there has been greater momentum to address international policy issues and gain consensus on forests and forestry.

Several international inter-governmental initiatives have been launched and environmental indicators developed to reflect the sustainable or non-sustainable use of forest resources. These are gradually changing perceptions of forest ecosystems at international and national levels and promoting sustainable use of forests while aiming to maintain trade in forest products.

However, the various initiatives have led to a complex assortment of global and regional instruments, both legally and non-legally binding, which relate to various aspects of forests and forestry. There is a need to review inter-governmental activities and international instruments, improve consensus-building, and gain a better appreciation of the effect of the international economic system on deforestation. The UN Commission on Sustainable Development has established an

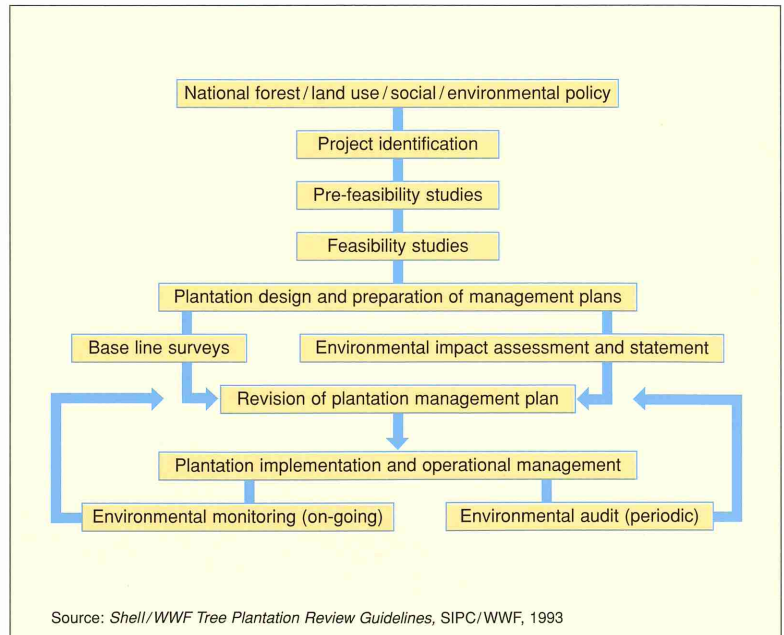


Figure 10  
*Outline of an environmental planning and management system*

inter-governmental forestry panel to develop the consensus-building process and to 'consider and advise on the need, or otherwise, for other instruments and arrangements in further implementation of the forest principles, including legal arrangements and mechanisms covering all kinds of forests'.

International agreements must be based upon national needs and priorities and should encourage governments to develop an integrated policy for forest conservation and development. The forestry industry's participation includes dialogue with governments and identifying criteria for sustainable forest management which includes specific technologies and management systems. The cooperation and involvement of local communities in small-scale enterprises increases the spread and exchange of successful forest management knowledge and experience.

## Participation process

Population, energy and the environment are inextricably linked issues but the links are not one-way. Each issue affects, and is affected by, the others in the chain. There are many instances in which the causal relationship is not completely understood and given that the issues relate closely to human and economic aspirations and development, it is clear that the 'right' solutions to the problems posed will vary according to a country's culture, economic development and the extent to which it has achieved demographic transition.

During the last decade, the spread of political and economic liberalisation, and the trend towards globalisation – of everything from capital markets to information networks – has, to some extent, reduced the power of individual states and changed traditional perceptions of governance. At the same time, there are now louder calls for new forms of participation by individuals and groups in the decisions which shape their lives.

This growing desire for greater participation, locally, regionally and internationally, is relevant to the long-term achievement of sustainable development. Individuals and organisations in developing and developed countries are seeking

creative ways to work within mutually beneficial partnerships to tackle increasingly complex global challenges. Among the stakeholders in these partnerships will be: governments and international governmental organisations; large international and smaller grassroots non-governmental organisations; industrial and commercial enterprises and associations; and individuals. Building a common sense of purpose and vision between such varied stakeholders will help to achieve the most appropriate solutions to the interlinked issues of population, energy and the environment and to bring about the long-term objective of future sustainable development.

*‘One of the major challenges facing the world community as it seeks to replace unsustainable development patterns with environmentally sound and sustainable development is the need to activate a sense of common purpose on behalf of all sectors of society. The chances of forging such a sense of purpose will depend on the willingness of all sectors to participate in genuine social partnership and dialogue, while recognising the independent roles, responsibilities and special capacities of each.’*

Agenda 21, Chapter 27, Paragraph 27.2, adopted at the UN Conference on Environment and Development.

#### **Terms and principal sources:**

Population ‘projections’ are based upon the medium variant of the United Nations’ estimates and projections of world, regional and national population size and growth and demographic indicators. The UN produces four population projections: high, medium, low and constant fertility.

The terms ‘developed’ and ‘developing’ countries or world have been used throughout this SBS for ease in use. As a

general rule, ‘developed’ countries include those in Northern America, Europe as well as the former USSR, Australia, New Zealand and Japan, while ‘developing’ countries include those in Africa, Latin America, Asia (excluding Japan) and Oceania (excluding Australia and New Zealand).

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*World Resources 1994–95*, World Resources Institute with UNEP and United Nations Development Programme

*Population – the complex reality*, The Royal Society, edited by Sir Francis Graham-Smith, FRS

*World Population – Turning the Tide*, by Stanley P Johnson; Graham & Trotman/Martinus Nijhoff, 1994.