# Strategies for Sustainable Architecture

Paola Sassi

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# Introduction

# Introduction

## 0.1 Sustainability

*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*
*Our Common Future*
Brundtland *et al.* 1987

Conditions for society to meet in order to achieve sustainability:

- *Its rates of use of renewable resources do not exceed their rates of regeneration.*
- *Its rates of use of non-renewable resources do not exceed the rate at which sustainable substitutes are developed.*
- *Its rates of pollution emissions do not exceed the assimilative capacity of the environment.*
  *Steady State Economics*
  Daly,1991

*The North has to understand that sustainable development worldwide simply will not happen unless and until the North itself learns to live with far smaller per capita rates of resource consumption. This is why we see Factor Four (in the North) as a target for and a prerequisite of sustainable development.*
*Factor Four*
Von Weizsacker *et al.* 1998

*Sustainable development is about ensuring a better quality of life for everyone, now and for generations to come. This requires meeting four key objectives at the same time in the UK and the world as a whole:*

- *social progress which recognises the needs of everyone;*
- *effective protection of the environment;*
- *prudent use of natural resources; and*
- *maintenance of high and stable levels of economic growth and employment.*
  *Achieving a Better Quality of Life*
  DEFRA 2002

Anyone involved in building design, procurement or maintenance in recent years will have been confronted in one way or another by the term *sustainability*. The term remains elusive to many, and while a number of definitions exist, they give little indication of how to apply principles of sustainability in practice. Moreover, these definitions differ slightly, one from another, and in any attempt to implement sustainable development it is essential that the meaning of sustainability be understood. It is generally agreed that sustainability fundamentally affects the way we live; consequently, personal ethics will influence the way an individual interprets its aims. Like architecture as a whole, sustainability involves addressing a wide spectrum of issues, sometimes, seemingly, conflicting ones. Acquiring a basic knowledge of these issues is the first step towards establishing or clarifying personal values and moving towards a more sustainable future. *Strategies for Sustainable Architecture* aims to contribute to this process.

This book illustrates many different approaches adopted by building designers and developers that all achieve some level of sustainability. The case studies examined focus on different issues within the wide spectrum of sustainable design. Perhaps one common ingredient in all the different approaches taken is the wish to provide better buildings, buildings that are better for the environment, the users and the community.

This publication is designed to provide basic theoretical and practical information about sustainable design to help the reader formulate a personal approach to sustainability, and make more informed decisions with respect to sustainable architectural design. The case studies show how sustainable design principles have been implemented, offer practical support and provide confidence to those who would like to replicate particular design strategies. Clearly, not all existing technical solutions can be described here, nor can more than basic details be included; therefore, each section includes references, which point the reader to further sources of useful and relevant information.

This book demonstrates that sustainable design is feasible and that much has already been done. Thousands of completed buildings have addressed sustainability in one way or other and many more are on the drawing boards, despite the fact that sustainable designers are still struggling with issues of lack of awareness among clients, authorities and the public; the potential for higher costs; and difficulties in complying with legislation and standards. The challenge for the future is to address sustainability in a holistic rather than a piecemeal fashion. In many of the case studies included here, a holistic approach was hampered by the barriers mentioned above, yet in a few cases a comprehensive approach was possible: large-scale issues, including land use, local ecology and community issues, were addressed simultaneously with issues relating to the building's inhabitants and the use of resources.

This book advocates such a comprehensive approach and is structured to cover six main areas relating to sustainable design. Chapter 1 introduces large-scale issues of land use and the ecology of the building site and its surroundings. It considers the effects of architecture on the immediate physical and social environment, as well as its connections to the broader urban, rural and global context. Chapter 2 considers the social

implications of architecture and how buildings can help to create viable communities and enhance people's quality of life. Chapter 3 addresses both physical and mental human well-being, and considers issues of comfort, indoor air pollution and other health-related building design issues. Chapters 4, 5 and 6 deal with the use of resources to build and operate buildings, covering materials, energy and water. Appendix 1 lists the case study buildings and their sustainable design features. Appendices 2 and 3 also include weather data and location maps of the case study buildings.

## Sustainability, why bother?

> Species of plants and animals are disappearing a hundred or more times faster than before the coming of humanity, and as many as half may be gone by the end of this century. An Armageddon is approaching at the beginning of the third millennium. But it is not the cosmic war and fiery collapse of mankind foretold in sacred scripture. It is the wreckage of the planet by an exuberantly plentiful and ingenious humanity.
>
> (Wilson 2002)

In his book *The Future of Life*, Edward O. Wilson describes the state of our planet and the pressures imposed by human activity on the environment: human-induced global warming, pollution, deforestation, habitat destruction and resource depletion are contributing to an environmental crisis which is threatening the survival of many species, including the human species. Wilson warns against a human attitude that considers itself separate from its environment. He points out that humans are not aliens that colonised the Earth, but have evolved on Earth as one of millions of species. Importantly, '[the] natural environment we treat with such unnecessary ignorance and recklessness was our cradle and nursery, our school, and remains our one and only home' (ibid.).

It is not only the nature of human activities that threatens the environment, but also their increasing occurrence. Currently up to two billion humans, without reliable access to safe food, urgently require resources to cover their basic needs, while several billions more are rapidly increasing their resource use to improve their living standards. Compounding this, the global population is growing: currently at 6.2 billion, it is expected to stabilise at around 9 billion by the end of the century (Whitaker 2004). Ninety per cent of this population growth is expected to take place in developing countries. Population growth and the raising of low living standards will require more resources, produce more waste and increase the impact on the natural environment.

The principles of sustainability aim to address the problems of environmental degradation and lack of human equality and quality of life, by supporting development that is sustainable in economic and social terms and is capable of retaining the benefits of a healthy stable environment in the long term.

### 0.2 Main environmental issues

**Global warming** Global warming describes the process by which greenhouse gases accumulate in the atmosphere in abnormally high amounts, trapping the Earth's radiation and causing its temperature to rise significantly. This is linked to environmental problems such as changes in rainfall patterns, rising sea levels and expansion of deserts.

**Pollution** Pollution of air, water and land, resulting from burning of fossil fuels, industrial processes, agriculture, and other human activities, is endangering human health, biodiversity and the built environment.

**Ozone depletion** Ozone shields the Earth from ultraviolet (UV) radiation and its depletion is caused by emissions of chlorofluorocarbons (CFCs) and other ozone-depleting substances into the atmosphere. Increases in UV radiation are thought to be linked to a rise in skin cancers, damage to the human immune system, and altered crop yields.

**Water** A third of the world population is still without access to safe water and, as the global population grows, the need for water will grow, as will waste and pollution which will increasingly threaten the quality of groundwater and rivers.

**Resources** Some non-renewable resources, including natural gas and petroleum resources, will eventually be depleted. The economically viable extraction of some abundant mineral ores may also be limited. Renewable resources, such as timber, are also at risk of over-exploitation.

**Deforestation** Deforestation through commercial logging, conversion of forest land to agricultural use, and other activities causes the destruction of natural habitats and extinction of plant and animal species and exacerbates the effects of global warming and pollution.

**Soil degradation** Urbanisation, construction, mining, war, agriculture and deforestation can cause soil degradation. Soil erosion, increased salination, altered soil structure, drainage capacity and fertilisation can diminish crop yields, increase the risk of flooding and destroy natural habitats.

**Waste** Increasing amounts of waste add pressure for more landfill sites, which pollute air, soil and groundwater and for more incineration, which pollutes the air and produces generally toxic residue.

**Extinction of flora and fauna** The current mass extinction rates of plant and animal species are the culmination of the environmental damage to our planet.

**Population** Global population growth is associated with increases in the human-induced environmental impacts mentioned above.

## 0.3 Some milestone dates of the movement towards sustainable development

**1866** Ernst Häckel coins the term *Ökologie* as meaning the interlinked system of living organisms and their environment.

**1901** John Muir recounts the deforestation of the redwood forests.

**1962** *Silent Spring* by Rachel Carson deplores the effects of the use of pesticides.

**1968** Foundation of Club of Rome, a group of 30 professionals and academics from 11 countries united in their concern for the future predicament of humans.

**1969** Friends of the Earth founded.

**1971** Greenpeace founded.

**1972** United Nations Conference on the Human Environment in Stockholm is followed by the establishment of the UN Environment Programme.

**1972** Publication of *The Limits of Growth*, a report for the Club of Rome assessing the world's resources, in particular considering population, agricultural production, natural resources, industrial production and pollution.

**1973** E. F. Schumacher publishes *Small is Beautiful: Economics as if People Mattered.*

**1979** In *Gaia: A New Look at Life on Earth*, James Lovelock puts forward the theory that the Earth is a self-regulating organism.

**1982** The United Nations World Charter for Nature is passed.

**1984** World Watch Institute starts publishing their yearly State of the World publication.

**1987** The Montreal Protocol to control and eventually eliminate substances harmful to the ozone layer is signed by 24 nations.

**1992** United Nations Conference on Environment and Development (Earth Summit) in Rio de Janeiro focuses on six main areas:

1. Framework Convention on Climate Change
2. Convention on Biological Diversity
3. Statement of Principles on Forests (unsuccessful due to US wish to confine agreement to tropical rainforests)
4. Rio Declaration of aims, also known as the Earth Charter
5. Agenda 21, including assistance to developing countries and access to environmentally sound technologies.
6. Montreal targets brought forward.

However, thinking about and applying sustainable principles are not easily done. Sustainable thinking goes against our primitive instinct of putting ourselves before others in the fight for survival. It rationally prioritises globally favourable long-term solutions over short-term individual gains; it is, therefore, in contrast to the most primitive survival instincts, which remain powerful despite no longer having a rational basis in today's developed countries. Sustainable thinking, which is altruistic and long term, requires reasoned and sophisticated thought processes that involve high levels of abstraction and are underpinned by an understanding of complex interconnecting networks.

Sustainability, therefore, necessitates a contemporary way of thinking. It requires the scrutiny of traditional values and economic measures and a definition or perhaps a redefinition of *quality of life*. Questioning values that are often culturally determined is challenging, and perhaps for this reason definitions of sustainability remain open to interpretation. As part of the process of reviewing values and ethics with respect to sustainability, it is essential to consider their development.

The roots of sustainability, as currently defined, lie in the environmental movement of the 1960s and 1970s, which built upon an increasing consciousness of the link between living beings and their environment dating back to the 1800s. From the 1960s to the present, a growing number of scientific publications have supported the notion that current (and historic) human activities are affecting the environment. Furthermore, changes to the environment are affecting all species on the planet, including humans.

Why should human-generated changes to the environment matter? Do humans need the environment to survive? Does the environment have 'rights'? The responses to these questions range from the technocratic anthropocentric to the non-anthropocentric, reflecting opposing views of the place of humans within the environment. The anthropocentric view believes that nature exists for the benefit of humans and that when a choice has to be made between human and environmental interests, human interests should always be put first. The non-anthropocentric views put sentient beings, living beings and nature as a whole on equal standing, deserving equal priority. Somewhere in between these two extremes are many shades of green, including the mixed theorists, who put human life, but not other human benefits before environmental welfare (Shrader-Frechette 2003)

At the technocratic anthropocentric extreme lies the belief that technology will resolve any environmental challenges and problems, whether they result from human activities or not (many sceptics still deny any human responsibility for the current environmental crises, such as global warming). Pre-emptive action to protect the environment is not only unnecessary, but detrimental to current economies and, consequently, to human well-being.

An anthropocentric view with less confidence in technology reacts in a similar way to the technocrat, but adopts a slightly more cautious approach. An anthropocentric approach may include wanting to know if the destruction of the environment will affect humans and, if so, how. If nature does provide humans with benefits, it may be important

to control changes that can affect nature's ability to contribute to humans' well-being. Nature does in fact provide humans with physical and psychological life support. The 'goods and services' provided by nature include:

- Provision of food, fuel and fibre
- Provision of shelter and building material
- Purification of air and water
- Detoxification and decomposition of wastes
- Stabilisation and moderation of the Earth's climate
- Moderation of floods, droughts, temperature extremes and wind forces
- Generation and renewal of soil fertility, including nutrient cycles
- Pollination of plants, including many crops
- Control of pests and diseases
- Maintenance of genetic resources as key inputs to crop varieties and livestock breeds, medicines and other products
- Cultural and aesthetic benefits
- Ability to adapt and change

(Convention on Biological Diversity 1992)

In monetary terms, nature is thought to contribute globally the equivalent of $33 trillion or more each year, nearly twice the world's gross national product of $18 trillion (Girardet 2004). Ecological economists believe that it would be physically impossible for humans to replace all the services nature provides, even if they wanted to, as the rise in value (and therefore cost) of nature's services rises sharply as their availability decreases. Consequently, a cautious anthropocentric viewpoint may aim to protect the environment so that humans can continue to benefit from it.

In opposition to a view that values nature only for its ability to satisfy human needs, is the non-anthropocentric view, which perceives the value of nature as intrinsic to all life on Earth. This approach sees humans as part of nature and dependent upon nature; their intelligence does not give them rights, but rather the responsibility of stewardship. The non-anthropocentric view is becoming more prominent, manifesting itself in a growing membership of and political power exerted by pressure groups ranging from animal rights to forest preservation organisations. While believing a flower has the same rights as a human may seem radical, it simply represents one extreme of a sliding scale of values that is constantly shifting. Historically, the Western world accepted the view that slaves were inferior beings; now, this is unthinkable. Today, we know that dolphins communicate with one another, we know that animals suffer stress, we know of numerous animals that use tools and others that mate for life. In future, as we understand more about animal behaviour, we may all come to accept some or all animals as being equal to humans and deserving of equal rights. The non-anthropocentric view, driven by the belief that nature has intrinsic value, therefore, not only advocates taking action to

**1995** The Intergovernmental Panel on Climate Change concludes that 'The balance of evidence suggests that there is a discernible human influence on global climate.'

**1996** The Habitat II Conference focuses on sustainability in the city in view of the increasing urban population and trends towards a predominantly urban population.

**1997** *Factor Four,* a report by Von Weizsacker *et al.* for the Club of Rome, illustrates how current technology can produce four times the efficiencies typical at the time and advocates environmental taxing.

**1997** Kyoto Summit for Climate Change – terms for an international legally binding protocol to reduce greenhouse gas emissions are negotiated.

**1999** *Natural Capitalism* by Paul Hawken puts forward and illustrates the concept of nature's value.

**1999** The world population exceeds 6 billion, half live in cities, 2.8 billion live below the poverty line.

**1999** The Worldwatch Institute reports that 7 out of 10 scientists believe the world is undergoing the greatest mass extinction of species in history.

**2001** The EU's Sustainable Development Strategy is agreed in Gothenburg.

**2001** The Bonn Agreement – 189 countries adopt the Kyoto Protocol. Despite scientific advice for a reduction of 60–80 per cent of greenhouse gases by the 37 more developed countries, the 189 signatory nations agree to reduce greenhouse gases by 8 per cent of 1990 levels by 2010, whereby industrialised countries will set higher targets to allow developing countries to develop. Annually £350 million is to be provided by developed countries to developing ones. Nations can claim credits by increasing $CO_2$ sinks, such as woodlands which absorb $CO_2$.

**2002** The World Summit on Sustainable Development in Johannesburg is regarded as unsatisfactory by environmentalists, but does set a number of goals including that for reducing by half the number (2.4 billion) of people without sanitation, and halting the decline of fish stocks by 2015.

**2002** Monterrey Conference on Financing for Development – international agreement to increase the volume and effectiveness of international aid.

**2004** Russia ratifies the Kyoto Protocol.

**2004** Scientists warn that global warming is happening at a faster rate than previously believed.

**2005** The Kyoto Protocol comes into force, but the US (the biggest $CO_2$ polluter in the world) and Australia think it is too expensive and have not signed up.

## 0.4 The value of nature

**Services in water supply and drainage**
In 1997, the city of New York faced the fact that the water from the Catskill Mountains, which they had been drinking for generations and which used to be exceptionally clean, was now polluted. The pollution had come about as a result of the reduction of watershed forest to make room for farms, houses and resorts for the increasing population in the area and the increase in sewage and agricultural run-off. To clean the water the city had two choices: reinstate the watershed area or build a new filtration plant. The new filtration plant would have cost between $6 and $8 billion to build and $300 million to maintain yearly. Reinstating the watershed forest cost $1 billion and had minimal subsequent running costs. The city upgraded septic tanks in the Catskill area and purchased and maintained forest area, which helped filter the water and at the same time provided a leisure area for the local population.
(Wilson 2002)

**Services in provision of medicine**
Three thousand plants are known to have some medicinal properties and 75 per cent are in the tropical rainforests. Only 4 per cent of tropical plants have been analysed for their medicinal properties.
(Bush 1997)

address environmental problems, but accepts the possible need to compromise human quality of life to prevent environmental degradation.

A truly non-anthropocentric approach is, in practice, rare. Perhaps nature conservation organisations that invest time and money towards saving and protecting natural environments are the closest examples of a non-anthropocentric approach. In reality, most humans would put human survival before that of nature, and many would put human well-being before nature's survival.

As mentioned earlier, addressing sustainability requires in the first instance the formulation of a personal position regarding the relation of humans to the natural environment. Only then can one attempt to turn principles into actions. However, while establishing a position on the issue may be difficult enough, implementing one's theoretical views in practice is even more difficult. Whether adopting a person-, quality-of-life- or nature-focused approach, the translation of a personal philosophy into practice comes up against practical issues that can be difficult to consolidate.

It is unrealistic, for instance, to expect loggers struggling to feed their families in the central African rainforest to see the advantage of conserving the forest, even if the environmental facts are made clear. Faced with starvation, most individuals would instinctively place their survival before nature's, even if unwittingly they may be compromising their own distant future.

As mentioned earlier, sustainability thinking goes against our primitive instinct for immediate survival. A significant problem the world faces today is that too many people are still struggling to survive and do not have the education or financial means to consider environmental issues at all. There is immense inequality between developed and developing countries: developed countries, on the whole, enjoy provision for health, employment, education and an average gross national product hundreds of times greater than that of some developing countries, while elsewhere in the world 1.1 billion people lack access to clean water and 2.4 billion lack adequate sanitation (Worldwatch 2003). While the media brings us news of the launch of Richard Branson's Virgin space travel service for individuals with £100,000 to spend for a few hours of entertainment, over 800 million people globally are chronically malnourished. Addressing such deprivation and inequality must be a priority for the global community if individuals in developing nations are to be able to consider environmental issues. Developed countries have a major role to play in this respect, particularly since the high debt repayments they require of developing nations divert funds from basic services. In Zambia, for example, 30 per cent of the yearly budget in the 1990s was used for debt repayments while only 10 per cent went to social services (ibid.).

Given their advantageous economic position, developed countries must lead the drive for sustainability and substitute a single-minded focus on economic growth with a balanced concern for sustainable growth and environmental stability. Such an approach, however, is hampered by pressure groups lobbying against environmental improvements for fear that they will affect company profits. For example, house-builders in the United

Kingdom, concerned with safeguarding their interests, have lobbied for years against increases in the required thermal properties of houses, obstructing attempts to reduce carbon dioxide emissions from buildings. The reality is that even educated people, who enjoy comfortable lives, will address immediate and personal interests before long-term communal or environmental interests. This has led to a complex approach to addressing environmental issues. Today the UK government recognises the need for 'reconciling aspirations for social progress, economic development, protection of the environment and conservation of natural resources, and the integration of these into decision-making, so that progress in one does not adversely affect another' (DEFRA 2004a).

The current government approach to sustainability, while reflecting an understanding that both environmental health and social inequalities need to be addressed, pragmatically accepts the reality of human behaviour, which makes a socially stable and economically prosperous environment a prerequisite to environmental improvements. The concept of sustainability now embraces a triple bottom line that addresses social, economic and environmental sustainability concurrently. Social and economic issues are considered of equal importance to environmental issues, despite the fact that many perceive any further deterioration of the environment ultimately as negatively affecting the social and economic well-being of the global population. The current approach and the most used definition of sustainable development – 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland 1987) – reflect a deeply anthropocentric position, and while purporting to consider long-term impacts, the focus on human interests may, in fact, prove short-sighted.

For most individuals, embracing principles of sustainability, whether adopting an anthropocentric or non-anthropocentric approach, requires a major ethical shift. One of the key concepts of sustainability is equity: equity between all people around the world living today, and also equity between people living today and people living in the future. In addition, a non-anthropocentric approach extends the concept of equity to all species and nature. Embracing the concept of equity requires refocusing away from personal benefits onto the needs and interests of others. Achieving the ambitious goals of sustainability requires a realism that recognises the limitations of humans, but also recognises the urgent need to embrace a different life philosophy. 'If sustainability is to be achieved, the ethics and values that support it will be just as important as scientific and technological advance' (Parkin *et al.* 2004).

Society has to recognise that, in developed countries, economic growth is no longer inextricably linked to increased well-being (Daly and Cobb 1989; Max-Neef 1995; Layard 2005). This is in contrast to developing countries where an increase in economic wealth is still essential to provide a basic standard of living to nearly a third of the world population. Once a basic quality of life is achieved, the benefits of economic growth begin to decline: quality of life and happiness are not perceived to increase with rising economic wealth. In developed countries, economic wealth, often perceived as a

## 0.5 Environmental impacts associated with the construction, use and disposal of buildings in the UK

- Buildings are responsible for 50 per cent of primary energy consumption
- Buildings account for 25 per cent of sulphur and nitrogen oxide emissions and 10 per cent of methane emissions
- In 1997, the construction industry was responsible for 16 per cent of the water pollution incidents in England and Wales
- Construction work on site is responsible for 4.7 per cent of noise complaints
- 6 tonnes of materials per person are used for construction
- 30 million tonnes per year of excavated soil/clay waste are estimated to arise from construction site preparation
- 30 million tonnes of waste arise from demolition work each year
(Howard 2000)

## 0.6 Action for the construction industry

The Department of Trade and Industry's *Sustainable Construction Brief* suggests the following themes for action for the construction industry:

- design for minimum waste
- lean construction and minimise waste
- minimise energy in construction and use
- do not pollute
- preserve and enhance biodiversity
- conserve water resources
- respect people and local environment
- monitor and report
(DTI 2004)

## 0.7 Addressing sustainable design

Issues to consider taken from the Royal Institute of British Architects' Key Indicators for Sustainability Design and the RIBA Environmental Checklist for Development and grouped according to the structure of this book.

**Issues to be recommended for consideration:**

**Land and ecology**
- use of brownfield sites
- reuse of existing buildings
- appropriate density
- investment in landscaping
- public transport
- new pedestrian routes
- effects on micro-climates

**Community**
- consultation with the local community
- mixed development
- contribution to the economic and social well-being of the community
- amenity of the wider area
- visual amenity space
- aesthetic excellence
- collaborative enterprise involving all the design professions

**Health**
- comfort for building inhabitants
- maximum use of natural light

**Materials**
- conservation of natural resources
- use of recycled materials
- low embodied energy materials
- renewable materials from a verifiable source
- no ozone-depleting chemicals
- no volatile organic compound materials

**Energy**
- highest standards of energy efficiency
- renewable energy sources
- use of natural ventilation
- use of passive solar energy
- user-friendly building management systems
- exploiting the constant ground temperature
- use of planting for shading and cooling

**Water**
- efficient use of water
- harvesting rainwater and greywater
- minimising rainwater run-off

measure of personal success, has failed to provide increased happiness: individuals, particularly in the US, are no happier now than they were in the 1950s, despite relative wealth having greatly increased (Layard 2005). It can be argued that concepts of progress and quality of life urgently need to be redefined; indeed, the consumerist society needs to reinvent itself. Non-materialistic, socially- and nature-oriented values of sustainability could form the basis for a new ethics.

Given the above, working towards sustainability may appear to be an overwhelmingly daunting task and individuals may be tempted to question their own potential for contributing to the goal. To answer such concerns, one must look at environmental history. Change has been slow and fraught with compromise. Sometimes it has been driven by unrealistic idealism that pushed the agenda of sustainability well beyond its pragmatic possibilities. Nevertheless, change has taken place, and it is primarily because of individuals deciding to go it alone or at least go against the tide that today we have a wealth of examples of sustainable ways of life and sustainable buildings. Many individual small steps have together created big changes. No matter how seemingly isolated a contribution may appear, it can add to a growing mass that will eventually become large enough to alter mainstream thinking and practice.

## Sustainable building design

As suggested above, sustainability is not an academic pursuit or even a professional activity: it is a way of life affecting everything an individual does. Knowing what kind of a relationship we want to have with the global and local environment is the first consideration. Then we should address how to achieve this relationship. To move from theory into practice it is necessary to understand the impacts associated with our work- and life-related activities.

Buildings, their construction, use and disposal, have a significant impact on the natural environment and social fabric of our society. Sustainable architecture can help put into practice and even encourage a sustainable way of life. But how can buildings be designed and built to contribute positively to the sustainability agenda, to achieve economically strong, socially inclusive, stable communities while minimising the impact on the environment? There are perhaps two main aims for sustainable architectural design.

- First, sustainable buildings should metaphorically 'tread lightly on the Earth' by minimising the environmental impacts associated with their construction, their life in use and at the end of their life. Sustainable buildings should have small ecological footprints (discussed in Chapter 1).

– Second, buildings should make a positive and appropriate contribution to the social environment they inhabit, by addressing people's practical needs while enhancing their surrounding environment and their psychological and physical well-being.

The above are neither optional nor mutually exclusive. It is not a question of addressing one or the other point, but both. No matter how energy- and water-efficient a building might be, it becomes a waste of resources and a potential detriment to the community if no one wants to occupy it. Also, making a positive contribution to the community environment means addressing more than just practical requirements, it means addressing the aesthetic and psychological needs of people. Buildings that are loved become part of the community's own culture, have long lives and are economically sustainable. The concept of economic sustainability is well understood among architects: successful buildings make money, sell quickly, command more rent, have long lives or help induce the regeneration of an area. Sustainable buildings are those that can be an asset for many years to come.

Buildings have potential lives spanning hundreds of years. What is being built now could affect the next ten generations. Not to build for maximum energy, water, materials and waste efficiency is to place an unacceptable burden on future generations.

Sustainable technologies are available, sustainable design strategies have been implemented, and studies have proved that these approaches can contribute positively to reducing the ecological footprint of a society. There aren't any practical or ethical reasons for not designing and building sustainable buildings. The case studies in this book show that it is feasible to create architecture that is socially responsible and desirable, economically viable in the long term, and that respects and protects the environment.

## 0.8 Further reading

**The Ethics of the Global Environment**
Attfield, R. (1999) Edinburgh University Press, Edinburgh

**The Human Impact on the Natural Environment**
Goudie, A. (2000) Blackwell Publishers, Oxford

**Happiness: Lessons from a New Science**
Layard, R. (2005) Penguin Books Ltd, London

**The Sixth Extinction**
Leakey, R. (1996) Phoenix Press, London

**Our Changing Planet**
Mackenzie, F. (1998) Prentice-Hall, Upper Saddle River, NJ

**The Future of Life**
Wilson, E. (2002) Abacus, London

Worldwatch Institute publications including:

**Vital Signs**
Worldwatch Institute W. W. Norton and Co, New York

# Chapter 1
# **Site and Land Use**

# 1.0 Introduction

## 1.0.1 A sustainable site and land use

**Select the development site with care**

- Select sites with public transport facilities
- Select sites with existing or potential links for pedestrians and cyclists
- Select sites with low ecological value
- Select sites, the development of which would benefit the community

**Use land efficiently**

- Consider the needs of the community
- Create viable and attractive developments
- Consider mixed use developments
- Design to appropriately high densities
- Build on previously used and derelict land

**Minimise impact of development**

- Protect local natural habitats
- Enhance existing and introduce new planting
- Enhance potential for pedestrians and cyclists
- Include food production opportunities where possible

Land is one of the Earth's most precious resources, not only because it provides space for human inhabitation, but because it provides many of the resources required to enable human activities and to absorb the waste from these activities. Land is also essential to support the life of plant and animal species other than humans. While some plant and animal species can live together with humans in an environment structured to suit human requirements, many cannot.

Historically, humans have had significant impact on the nature of the land and the flora and fauna supported by it. Activities such as agriculture, mining, forestry and urbanisation have changed the landscape from, for example, grassland to desert, or forest to agricultural land. Such changes can be catastrophic for the flora and fauna dependent on these habitats. Moreover, as illustrated in the previous chapter, changes to the land can compromise its ability to provide useful services that benefit humans. As human impacts on the land increase, the land suitable to support species of flora and fauna, to absorb pollution and waste, to support farming, and to provide humans with material resources and natural environments for leisure steadily decreases.

This chapter focuses on the local impacts of the handling of development sites and considers the associated global impacts. It illustrates ways to use land efficiently, ways to minimise the encroachment onto natural ecosystems, and ways to develop new and enhance existing ecosystems.

### The 'ecological footprint'

Considering the impact of buildings beyond their outline is the first step towards a sustainable architecture. The selection and use of a development site affect a number of sustainability issues, including land use, the conservation of natural ecologies, flora and fauna, and the provision of natural spaces to enhance human well-being.

Land is a limited resource used in a variety of ways: it may be built on, covered by roads, forests or other plants, it may remain barren or be used for agriculture. Land uses vary from country to country. While globally 11 per cent of the land is used for agriculture, in the US it is approximately 20 per cent, in the UK 25 per cent, in Australia 7 per cent, in Germany 35 per cent, in Austria 18 per cent and in Switzerland 11 per cent (FAO 2005). In agricultural-based economies the percentage is far higher. In India, for example, approximately 50 per cent of the land is used for agriculture. Land uses depend on the nature of the land, the economy and culture of the country and the population. In environmental terms, what counts is how much land is required to sustain life, including that of humans and of other species.

The ecological footprint is a way to address this question. This concept, developed by William Rees and Mathis Wackernagel, is a measure of the amount of land required to sustain human activities, in the long term, by providing food, water, energy and materials and by assimilating waste. The ecological footprint can be used to calculate the land requirements of a population, building or activity.

For example, using this system, it was calculated that to sustain the average US lifestyle an area of 9.6 hectare is required. The typical European's ecological footprint ranges between 3–6 hectare and that of the average Indian is 1 hectare. The ecological footprint of the total population of the US is well in excess of the country's total land area. Even considering populations with low ecological footprints, such as that of India, the mere number of inhabitants means that the ecological footprint for that whole country is 50 per cent larger than the country's productive land area. Today most cities and several countries have ecological footprints that are larger than the land available to them, including the UK, with an ecological footprint three times its surface area (Chambers *et al.* 2000; Girardet 1999a).

The global ecological footprint is affected by the nature and the quantity of human activities. If the current world population of 6 billion were to adopt a lifestyle associated with a high ecological footprint of 5 hectare per person, three more Earth-like planets would be required. Population increases are equally detrimental as they are associated with a greater quantity of human activities. Ninety per cent of population increases are expected in developing countries, but this does not mean that population increases in developed countries are insignificant. The population of the US grows by 3 million per year and that of India by 16 million per year; however, as a result of the far higher consumption rates of the US, the 3 million Americans will be responsible for an additional 15.7 million tons of $CO_2$ emissions, while the 16 million Indians will be responsible for only 4.9 million tons of $CO_2$ emissions (Worldwatch 2004).

Current thinking is that the world is living beyond its means, using resources faster than they can regenerate and producing waste in larger amounts faster than can be assimilated naturally and without danger to the environment or to humans (Meadows *et al.* 1992).

If the global population, projected to rise to 9 billion by the end of the century, is to share a total global landmass of 14.9 billion hectare, of which 11.5 billion hectare is vegetated (excluding ice, rock and deserts), the average available vegetated land per person would be 1.3 hectare. Of the 11.5 billion hectare of vegetated land 1.9 billion have been degraded by human activities such as overgrazing and deforestation, thus leaving less than 1.1 hectare per person. Living within the limits of a sustainable and just global society would imply all world inhabitants adopting a lifestyle associated with an ecological footprint of a maximum of 1.1 hectare per person. This would necessitate a reduction in ecological footprints of 85-90 per cent for the average person in the US and 60-85 per cent for the average European. This ambitious goal is, however, necessary, as the Worldwatch research team concludes in their *State of the World 2004* publication: moving to a less consumptive society is fundamental to achieving a sustainable society.

Such a huge reduction is only, if at all, possible by addressing all aspects of human activity concurrently with the aim of reducing resource use and waste production. Methods for reducing resource use associated with architecture are discussed in Chapters 4, 5 and 6. While efforts to reduce resource use now benefit from new technologies,

## 1.0.2 Human impact on biodiversity

The rate of species extinction is considered to be catastrophically high. It is estimated to be between one thousand and ten thousand times the rate before the impact of humans on the environment became significant (Wilson 2002).

This high level of extinction represents what scientists believe to be the sixth period of mass extinction in the Earth's history. Previous extinctions, including the most recent Cretaceous extinction 65 million years ago, are thought to have been caused by cataclysmic occurrences such as the collision with an asteroid. This time the destruction is triggered by human activity (Leakey 1996).

The extinction of plants and animals as a result of human activities has a long history. Some 10,000 years before, present in America, 1,000 years ago in New Zealand and Madagascar, and similarly in Australia, the arrival of humans coincided with a steep decline and eventual extinction of large mammals and birds (Wilson 1994). These changes in the ecosystem would also have had repercussions on the survival of other species. An example of the interdependence of different species, including humans, can be seen on Easter Island. Settled by the Polynesians in 400 AD, over-harvesting of the palm trees on the island left the Polynesians without palms as a source of food or a means to build boats and hunt. Suffering from famine and war the Polynesians and the biodiversity of Easter Island failed to recover and by 1500 AD the Polynesians had died out (Bush 1997).

Today the threat to biodiversity comes from human activities involving the conversion of natural habitats into urban areas or areas for infrastructure, agriculture or mining; pollution that renders natural habitats inhospitable to native plants and animals; and directly through over-harvesting and poaching.

## 1.0.3 Assessing the level of environmental impacts

IPAT is a formula to assess environmental impact that considers factors that negatively affect the overall impacts as well as those that positively affect the impact.

**Impact = population x affluence x technology**

Where:

- the higher the population, the higher the impacts
- the higher the affluence, the higher the resource consumption and therefore the impacts
- the more developed the technology, the higher the efficiencies and the lower the environmental impacts (Phillips 2003)

## 1.0.4 Protecting the environment by reducing urban sprawl

The UK Department of the Environment, Trade and the Regions recognises the importance of protecting the natural environment from over-development. The publication *Our Towns and Cities: The Future. Delivering an Urban Renaissance* (DETR 2000a) sets out a recommended approach to the design and development of urban areas which:

- makes efficient use of the available land and buildings and reduces the demand for greenfield development
- provides homes that are attractive and environmentally friendly
- encourages well-laid out urban areas with good quality buildings, well-designed streets, and good quality public open spaces
- allows people to get to work easily and to the services they need like local shops, post offices, schools and health and leisure facilities
- makes good public transport viable and makes walking and cycling attractive options

which increase efficiencies and make use of alternative energy and water sources, assimilating waste still relies largely on natural land-based processes. The purification of water and the assimilation of carbon dioxide are two examples. Water is purified by the filtering mechanism of the earth, a mechanism that is compromised when the extent of natural landscapes is reduced and pollution increases. Carbon dioxide, the most significant greenhouse gas associated with global warming (see Chapter 5), is absorbed by growing plant matter. The continuing reduction of global forest cover is rapidly reducing the Earth's natural ability to counteract global warming. Reliance on dwindling land resources to assimilate an increasing amount of waste produced by a growing population is one of the reasons why waste production is seen by some researchers as more serious than resource depletion (Edwards and Du Plessis 2001).

In terms of land use, there is therefore a need to increase the area of land able to assimilate waste and pollution including areas to filter water, biodegrade waste and absorb carbon dioxide. Not only are natural systems for waste assimilation cost-effective in providing these services, but the same systems can also provide habitats for flora and fauna and natural environments for people to enjoy.

Despite the advantages of retaining natural environments, the trend is still one of increasing encroachment resulting from expanding urban developments and transport links. In the UK, 6,300 hectare, equivalent to an area of a small city, is urbanised each year (CPRE 2003). Such encroachment not only destroys the land's potential for providing useful services, but it also endangers biodiversity. While concerns regarding biodiversity often focus on equatorial regions with the highest numbers of different species, habitat loss occurs world-wide. In the UK since 1945, 97 per cent of wildflower meadows, 98 per cent of peatland raised bogs and 50 per cent of ancient woodlands, heaths, farm ponds, fenland and coastal marshes have been cleared. There are 1,666 wild species in the UK that are of environmental concern and 3,612 are endangered or rare (FOE 1997).

To counteract this trend it is vital to concentrate new developments in previously developed areas and avoid further encroachment on greenfield land. The UK government recommends making efficient use of land and encourages high density developments as part of its sustainable urban agenda. Chapter 1.1 discusses issues relevant to high density compact cities and the link between high density developments and reduced car dependence. Compact developments not only reduce land use by virtue of their more intense use of land, they also reduce the need for land for roads connecting developments. Research in the US has shown that, based on the same house sizes, dispersed low density developments can require twice as much road area as compact development and four times as much development land (Maurer 1998). Car use impacts on land use directly in terms of tarmacked areas, but also indirectly through the emissions of carbon dioxide and pollution that need to be assimilated by natural waste sinks. To reduce these impacts, sustainable development aims to reduce car dependence and offers a framework for a car-free existence with a high standard of living (see Chapter 1.2).

Avoiding encroachment on greenfield sites is fundamental to retaining natural ecosystems and the flora and fauna they support. Equally there is a need to reinstate lost habitats and generally increase the amount of land supporting natural ecosystems to counteract the rate of species extinction. Natural landscapes should not be restricted to rural areas and should be extended into urban environments. People need contact with nature and studies have shown that even individuals who are not interested in nature benefit physically from contact with it (see Chapter 4). As cities become home for the majority of people in the world, more natural environments need to be introduced into cities and existing landscaped areas must be enhanced and enlarged. Parks, planted corridors and landscaped streets as well as landscaping within individual developments can contribute to creating a green network in the city. Chapter 1.3 illustrates a number of developments that protect existing natural environments, enhancing and enlarging them or introducing new ones into an urban context. These planted areas need not only be decorative and absorb carbon dioxide; they can be designed as productive planted areas. Growing food within development sites combines the advantages of natural environments with a reduction in energy use for the preparation and transport of food. This is particularly relevant for cities, which are normally reliant on large land areas outside their own boundary for food production. Chapter 1.4 completes this chapter on land use with two examples where food production is integrated within building development.

## 1.0.5 Further reading

**Green Urbanism**
Beatley, T. (2000) Island Press, Washington DC

**Sustainable Urban Design**
Brophy *et al.* (2000) Energy Research Group, Dublin

**Sharing Nature's Interest: Ecological Footprints as an Indicator of Sustainability**
Chambers *et al.* (2000) Earthscan Publications Ltd, London

**Planting Green Roofs and Living Walls**
Dunnett, N., Kingsbury, N. (2004) Timber Press, Oregon

**Sustainable Housing: Principles and Practice**
Edwards, B., Turrent, D. (2000) E & FN Spon, London

**Creating Sustainable Cities**
Girardet, H. (1999) Green Books, Totnes

**Building Green: A Guide to Using Plants on Roofs, Walls and Pavements**
Johnston, J., Newton, J. (1997) London Ecology Unit, London

**Sustainable Cities**
Satterthwaite, D. ed. (1999) Earthscan, London

**Our Ecological Footprint: Reducing Human Impact on Earth**
Wackernagel, M., Rees, W. (1996) New Society Publishers, Gabriola Island, BC

# 1.1 Compact Cities

## 1.1.1 Characteristics of sustainable cities

- compact living
- mixed land uses
- public transport-oriented designs
- pedestrian-friendly streets
- well-defined public spaces
- integration of nature in developments
- developments based on walking and cycling distances (Lock 2000)

## 1.1.2 High density developments

**Potential advantages**

- efficient use of land
- protection of the natural landscape
- access to culture and leisure facilities
- access to commercial facilities
- employment opportunities
- access to transport
- potential for district heating
- efficient recycling

**Potential disadvantages**

- less space availability
- predominance of flats versus houses
- no parking and smaller roads
- small or no gardens
- reduced potential for food production
- loss of privacy
- higher levels of noise and pollution
- higher levels of crime
- higher levels of deprivation

At the end of the twentieth century nearly half of the global population was living in cities, and this figure is expected to rise to 60 per cent by 2030 (Girardet 2004). In many developed countries already more than two-thirds live in cities (Australia: 91 per cent; the UK: 90 per cent; Germany: 88 per cent; the US: 78 per cent; Austria: 68 per cent; Switzerland: 67 per cent) (World Bank 2004). Urban growth and economic growth are linked and research shows that city dwellers currently have higher consumption rates than rural dwellers, linked to their higher spending power. The high consumption levels and concentration of people in cities mean that the ecological footprint of many cities is often many times their own areas; that of London has been calculated to be 125 times its area of 159,000 hectare at nearly 20 million hectare (Girardet 1999a). As the current urbanisation trend persists, considering how to reduce the environmental and social impacts of cities is becoming ever more urgent. The compact city is believed to offer many opportunities to reduce some of these impacts and develop sustainable communities.

High population densities make services such as public transport, recycling and district heating more viable. Compact cities supported by the provision of public transport effectively reduce car dependence and research shows a link between urban density and transport fuel consumption. A comparison of European, Australian and US cities shows the five main Australian cities with average densities of up to 30 persons per hectare consume 30,000–45,000 MJ (MegaJoules) of transport fuel per year; US cities, which generally have similar low densities, consuming between 40,000 and 80,000 MJ of fuel per year; while European cities with densities varying from 50–125 persons per hectare consuming between 10,000 and 22,000 MJ of fuel per year (Newman and Kenworthy 1989). Overall energy use per capita is also reduced in compact cities where energy-efficient building forms, such as terraces or flats, predominate. A comparison of per capita carbon dioxide emissions from US and European cities, which on average proved to be 12.7 tonnes and 8.4 tonnes respectively, supports this view (Torrie 1993). The proximity of buildings not only reduces the amount of energy used, but also the extent and consequently the cost of infrastructure. District heating, for instance, becomes viable above densities of 40 dwellings per hectare. Other services such as recycling and community composting are also more economically viable at higher development densities.

Compact cites not only can provide efficient living and working settlement configurations, but can also offer a high standard of living. Cities, with their access to culture, leisure facilities, and employment, attract many people aspiring to a high quality of life. The prospect of employment also attracts people hoping for work, but who may fail to fulfil their aspirations. Unemployment is a cause of deprivation, stress and unhappiness, and statistics show cities to have higher levels of unemployment, poverty, graffiti, crime and, ultimately, a higher death rate compared to rural areas (DETR 2000a). While city living can prove very attractive, especially to those with sufficient financial means to enjoy what cities can offer, others are priced out of affluent areas or

feel threatened by the potential of antisocial behaviour, no matter how low the risk of it occurring might be, and retreat to the suburbs or to the countryside. In the UK more people are moving out of cities than moving into cities. In depressed city neighbourhoods, buildings are abandoned, businesses fail and communities disintegrate.

To create sustainable cities, life has to be brought back into the city, not only to a privileged few, but to all social groups. Employment, housing, education, culture and leisure facilities should be available to all. Architecture can contribute to creating a framework for people to realise their ambitions within a viable community.

Appropriately high development densities help to create economically viable communities. However, developing to high densities without considering the social infrastructure is not enough. The outdated principle of zoning uses has been overtaken by the concept of mixed use, where working, leisure and living are as close as possible. The city becomes a configuration of small self-sufficient neighbourhoods linked by public transport, with the advantages of low car dependency, more leisure time, strong community feeling and a high quality of life. Such neighbourhoods can be sized to human scale and, as opposed to suburban sprawl, can provide many of the facilities required by residents within the neighbourhood, including shops, schools, transport and leisure facilities. The ultimate aim is to create communities where people will want to live in the longer term.

In countries with an already large urban population, sustainable development aims to increase the viability and improve the sustainability of existing cities. There is a need to repair the urban fabric and regenerate depressed areas, and create quality public spaces and more green areas that enhance people's health and quality of life. The first step should be to regenerate abandoned and derelict parts of the city. In England alone there are currently 58,000 hectare of brownfield land (see 1.1.3), that is not in use and which could be built on (DETR 2000a). This is enough to accommodate the 3.8 million new dwellings required in the UK by 2021 at a density of approximately 65 dwellings per hectare. By building on brownfield sites, which often add to an atmosphere of desolation, poverty and insecurity in a city, land is used efficiently, development densities are increased and whole neighbourhoods benefit.

The challenge for compact cities is to make the advantages of energy efficiency, independence from cars, access to employment, culture, leisure and green spaces outweigh potential disadvantages and dispel the prejudices many people still have. Compact cities do not need to compromise quality of life. On the contrary, they can provide a multitude of opportunities only available in agglomerations of people and activities.

### 1.1.3 Building on brownfield sites and contaminated land

**Brownfield sites**

Brownfield sites are previously used sites. Previous uses can include any type of built structure, including industrial uses associated with contamination (see below).

The UK government has set a target of 60 per cent of the new housing to be built on brownfield sites or provided by conversions by 2008. Despite these targets pressure groups such as the Council for the Protection of Rural England (CPRE) continue to express their concerns that too much urban sprawl is still taking place. Should the 3.8 million new dwellings be built at current average densities of 25 dwellings per hectare, an area larger than that of Greater London would be required. In 2003, a CPRE survey identified proposals for greenfield housing development which would cover an area of 35,000 hectare, the equivalent of Birmingham and Coventry combined. Consequently CPRE supports a higher target of 75 per cent of housing to be built on brownfield sites.

Using brownfield land is considered to have the following advantages:

- It reduces pressure on undeveloped land including greenfield sites.
- It raises densities, making better use of infrastructure and improving the viability of public transport.
- It assists social and economic regeneration.
- It enhances the appearance of towns.
  (DETR 1997)

**Contaminated land**

Contaminated land is defined as land representing a potential hazard to human health or the environment. Contaminated land arises as a result of past industrial and other polluting uses of a site. Contaminants that may have been left behind include oils, tars, heavy metals, organic compounds and soluble salts. Much of the contaminated land is located in urban areas, but rural mining, agricultural or waste disposal areas may also be contaminated.

As more brownfield sites are developed, the issue of contamination needs to be addressed. Brownfield sites that are contaminated require remediation before development can commence. Past examples of developments on contaminated land, that had not been suitably remediated, resulted in the residents suffering serious ill-health.

# **Case study:** Appropriate high densities

**The Point**
Bristol, UK

**Client:** Crosby Special Projects
**Architect:** Feilden Clegg Bradley
**Consultation:** BDOR
**Town planning:** Chapman Warren
**Services engineers:** BME Partnership
**Structural engineers:** Clarke Bond Partnership
**Landscape architect:** Cooper Partnership
**Quantity surveyor:** Cyril Sweett
**Main contractor:** Skanska
**Completed:** 2002

The Point includes three-, four-, five- and six-storey blocks of flats.

The town houses and the top floor flats of the four-storey blocks have roof terraces with views over the river.

The Point is a city centre speculative housing development on the south side of the Bristol Harbourside regeneration area. It is an energy-efficient, high density development that addresses many of the prejudices against high density living, while also taking advantage of the benefits of its city centre location (see Chapter 1.2). The development includes 105 apartments and nine houses. The location on the River Avon provides residents with an attractive and quiet environment benefiting from relatively good air quality, which easily competes with the typical suburban environment. The development addresses the availability of indoor and outdoor space. The units have floor areas 25 per cent larger than typical developments in the UK. Each unit has an outdoor space: flats benefit from generous balconies or terraces and the houses have both a small garden and a roof terrace. Secure parking is provided in an underground car park and in overground garages. Unlike the typical car-oriented suburb, The Point has also succeeded in creating car-free outdoor areas where children can play safely and which everyone can enjoy.

The mix of dwelling types addresses the current need in the UK for single-person dwellings. By 2016, nearly 2.7 million new dwellings for single-person households are expected to be needed, representing 70 per cent of the total 3.8 million houses required. These single-person dwellings are expected to be a mixture of one-bedroom flats and larger units for those with higher disposable income, such as two- or even three-bedroom dwellings with a garden or alternative outdoor spaces. The Point's mixture of one-, two- and three-bedroom flats, all with generous terraces, responds to this demand.

In the UK development density can be measured in dwellings per hectare (dph), persons per hectare or habitable rooms per hectare (hrh) and can be gross or nett. Gross development densities relate to whole communities or cities and take into account the infrastructure, while nett densities relate to individual developments. Using dph as a measure does not necessarily give a clear indication of the nature of the development, as the size of a dwelling, which could be a one-bedroom flat or a five-bedroom house, is not taken into account; hrh gives a better idea of the massing of the development. However, as discussed in relation to single person households, it does not necessarily reflect the occupancy levels. In other countries different measures are used. In Germany and Austria, development densities can be defined as the ratio of built area to total development area. Recent housing schemes in Germany and Austria used a development density ratio of between 0.6 and 0.7 (see following case study).

| | Density in dph | Density in people per hectare | Density in hrh | Comments |
|---|---|---|---|---|
| Broad acre, typical in areas of USA | 2.5 | | | |
| Garden City | 15 | | | |
| Average densities in rural England | 22 | | | |
| Average densities in UK 1997–2001 (4) | 27 | 50-60 | | Supports a school/post office |
| Minimum density in areas designated for development in the Netherlands | 33 | | | |
| Minimum target for development in England set by UK government Planning Policy Guidance note 3 (Housing) | 30 | | | |
| Older UK suburbs (3) | 35-40 | | | Supports combined heat and power and bus services/ 50 dph is maximum density to ensure good solar access in the UK (2) |
| solarCity Linz, including infrastructure | 40 | 100 | | |
| Higher development densities encouraged by UK government | 40-50 | 100 | | |
| New development in Harlow, East London | 45-80 | | | |
| Victorian terraces, Hertfordshire (3) | 80 | | | |
| 9% of UK population live in densities of 85+ dph | 85 | | | |
| London Bloomsbury and Regent's Park | 100 | | | |
| Greenwich Millennium Village with infrastructure | 106 | | | |
| The Point development in Bristol | 114 | | 400 | 500 persons per hectare is the maximum recommended density, 1000 persons per hectare is possible, but not advisable |
| Areas of San Francisco (3-storey houses with gardens and integrated garages) (3) | 118 | 237-474 | | |
| Edinburgh centre | 250 | | 500 | |

**1.1.5** Comparison of development densities – Newman 1999/Barton 2000 (2)/Hall 2001 (3)/ CPRE (4)

The Point has a density of 114 dwellings and 400 habitable rooms per hectare. This is substantially higher than current average development densities in the UK (27 dph), than older suburbs (30-40 dph) and higher than the UK government targets (30-50 dph). Similar densities of around 100 dph can be found in many city centres including some of the most desirable areas of San Francisco or London. The Point's development density is very high, yet appears appropriate in an environment with so much to offer. The character of the development is not one of crammed or impersonal housing, often associated with high density. The dwellings are grouped in apartment blocks, between four and six storeys high, and the treatment of the blocks gives each one an individual and human character.

Had the whole site been occupied by flats, such as those developed at The Point, a density of at least 130 dph could have been achieved, while if the site had been designed as terraced housing, a density of 40-50 dph could still easily have been achieved. The Point successfully illustrates how UK government targets can be achieved and surpassed with a variety of housing types, without compromising quality of living and creating a framework to support a sustainable lifestyle.

## 1.1.4 Sustainable design features

**Site and ecology**
The development was built on a brownfield site and forms part of a city regeneration programme in Bristol.

**Community and culture**
The local community was consulted during the design stage. Community facilities such as communal children's play area, shop and communal garden are included.

**Health**
The dwellings benefit from ample natural light and are easily heated.

**Energy**
The dwellings are well insulated, relatively airtight and heated efficiently. Perhaps the biggest problem to overcome on the project was the conflict between orienting the development towards the south for solar access and towards the north for views to the river.

All dwellings benefit from good natural light and views of the river and the surrounding city.

A children's play area is situated on the south side of the housing development.

**See also:** desirable city centre living **Chapter 1.2**

# **Case study:** Comprehensive planning

**solarCity**
Pichling, Linz, Austria

**Masterplan:** Prof. Roland Rainer
**Architects:** Richard Rogers, Norman Foster, Herzog+Partner, Martin Treberspurg, Schimek, Loudon, Auer+Weber+Partner
**Energy consultant:** Norbert Kaiser
**Landscape architect:** Atelier Dreiseitl
**Construction began:** 2001
**Completion:** due 2005

The community and commercial centre, where the future tram stop will be located, forms the heart of the new neighbourhood. (Architects Auer+Weber+Partner)

The commercial/community centre in the centre is surrounded by housing. Green spaces and a lake are to the north and the school is in the south-east section of the site. A tree-lined boulevard connects to the development centre from the southwest and southeast.

Designing for high density has to be part of a comprehensive approach to sustainable design. A high density development should not be isolated from the services that people need, including access to transport, work, and essential facilities such as grocery shops, schools, leisure facilities and green spaces. Essential needs have to be accommodated in a coordinated manner. Such a holistic approach was adopted by the planners for the solarCity in Linz.

The idea for the solarCity came about in 1990 in response to a housing shortage in the Linz region. In 1992, the city of Linz commissioned Professor Roland Rainer to prepare a masterplan for the area of Pichling, located south of the city centre. The development was to have a potential to accommodate 5,000–6,000 dwellings, and by 1995 the city of Linz had the commitment of 12 non-profit housing developers to develop a first phase of 1317 mixed tenure dwellings on 32.5 hectare of land. The development density is 40 dph, equivalent to 100 persons per hectare or 0.65 ratio of built footprint to overall area. Construction began in 2001 and completion is due in 2005. Over a third of the construction cost (190 million euro) is associated with development infrastructure including community facilities, transport network and landscaping.

The solarCity is intended as a model of sustainable city development, the name referring to the all-encompassing use of the sun, which ranges from providing passive and active heating and electrical needs to contributing to human comfort and plant growth. All buildings are low energy and the development addresses issues of occupant health, women's needs (which focus on security and safety), sustainable water use and drainage, community building and restoration of natural environments.

The houses are of mixed tenure with approximately half shared ownership, 40 per cent for rent and the rest for purchase. Half of the dwellings are generously sized three-bedroom flats or terraces, a quarter are two-bedroom and a quarter four-bedroom dwellings. By 2005, fourteen fully accessible flats will be available for disabled individuals together with a ten-person shared and supervised accommodation. Car parking is underground, creating landscaped car-free spaces between terraces and children's play areas with sandboxes, climbing frames and other games.

The development has been designed as a self-sufficient neighbourhood. At its centre is a commercial and community centre, which includes general facilities (grocery shop, bakery, medical centre, pharmacy, bank, citizens' advice office, hairdresser, bookshop, tanning studio) as well as facilities for leisure activities (library, children's club, seniors' club, adult college, café, restaurant). The centre building consists of timber- and glass-clad blocks joined by glazed roofs, forming attractive all-weather covered streets.

A new school and nursery, which is already oversubscribed, are located on the south side of the development and on the north side is a landscaped park that connects to a nature reserve with a lake. A tram line is under construction that will link the solarCity to the centre of Linz by the end of 2005. In the interim, bus and taxi services are in operation. The tram stop at the commercial and community centre is designed to be no

more than approximately 300 metres from any of the houses, thus encouraging people to walk and use public transport rather than cars.

The holistic approach adopted on this project considered people's needs beyond the basic housing requirements and consequently provides a framework for a healthy and sustainable life with a high standard of living. Feedback was sought from new residents, who reported to be very satisfied with the development. Whether young or old, with or without family, the development seems to have universal appeal. The combination of low energy and healthy homes, the facilities and infrastructure that make cars dispensable, and the access to nature is clearly a successful solution to achieving a sustainable neighbourhood with a potential for a very long sustainable life.

The seating in the internal street of the community and commercial centre.

A play area is located near each housing block.

The restaurant entrance in the centre.

The centre forms a square that accommodates a seating area for the café and restaurant. Facilities on the first floor are accessible via a lift.

## 1.1.6 Sustainable design features

**Site and ecology**
See Chapter 1.3.

**Community and culture**
The design involved a community consultation and provides help for people newly moved into the area. The community and commercial centre provides most facilities required by individuals.

**Health**
The scheme focuses on providing healthy indoor and outdoor environments through the use of healthy materials and access to natural sunlight as well as providing an accessible environment for disadvantaged people. See also Chapter 3.

**Materials**
A document listing preferred material specification is part of the building contract agreement (e.g. avoidance of polyvinylchloride (PVC), chlorofluorocarbons (CFCs) and preference for natural and local materials).

**Energy**
Levels of energy efficiency vary. Solar thermal collectors have to make up a minimum of 34 per cent of the roof area. District heating provides the rest of the heating requirements.

**Water**
See Chapter 6.3.

**See also:** sharing nature **Chapter 1.3**

**See also:** deleterious materials **Chapter 3.2**

**See also:** electromagnetic fields **Chapter 3.2**

**See also:** sewage as a resource **Chapter 6.3**

**See also:** sustainable urban drainage **Chapter 6.3**

# 1.2 Reducing Transport Impacts

## 1.2.1 The environmental impact of cars and other motorised transport

- Cars currently consume half the world's oil and create nearly one-fifth of its greenhouse gases.

  (*Ethical Consumer,* Feb/March 1997)

- Motorised transport is responsible for a fourth of total greenhouse gases.

  (Metz *et al.* 2001)

- Over 40 per cent of vehicle mileage is in built-up areas.
- Nearly half of airborne particle emissions arise in urban areas.
- 3,400 people die on the roads in the UK each year.

  (DETR 2000a)

- More than 20 million people are severely injured or killed on the roads each year world-wide.
- 3,000 people die each day on the roads world-wide.
- In certain countries, such as Austria, France and Switzerland, pollution from vehicles causes twice the number of deaths than those caused by road accidents.
- Noise from traffic causes annoyance.
- The global economic cost of road crashes has been estimated at about $518 billion annually, of which the developing world shares $65 billion.
  (WHO 2003a)

## 1.2.2 Reducing pollution by using alternative car technologies

Since 1950, annual car production has grown by 500 per cent. In 2002, there were 531 million cars in the world, of which one-quarter were in the US. However, while global annual car production is growing at approximately 2 per cent, in China the number of cars increased by 60 per cent in 2002 and by 80 per cent in 2003. Car use is not abating and a realistic approach to minimising the impacts of car use has to include the use of alternative, less-polluting technologies. Alternatives to fossil fuel-burning cars are commercially available and include:

- electric cars and electric hybrids
- liquid petroleum gas and natural gas cars
- biodiesel cars
- fuel cell cars

The impact of road-based transport is manifold, ranging from global warming to fragmentation of communities. The most urgent issue is currently global warming. Most vehicles run on fossil fuels, the burning of which is associated with global warming. Transport is responsible for approximately 26 per cent of $CO_2$ emissions in the UK (Howard 1995). In the US, road transportation accounts for half the oil consumption and one-third of $CO_2$ emissions (Hoffman 2001).

Vehicles are also responsible for environmental problems other than those concerned with global warming. Vehicle emissions pollute the local environment and are linked to increases in respiratory illnesses, particularly in cities. Transportation accounts for 77 per cent of CO emissions, 57 per cent of all NO emissions, 40 per cent of all volatile organic compound emissions, 73 per cent of atmospheric lead emissions, 51 per cent of black smoke and 28 per cent of particulate (PM10) emissions in the UK (Howard 2000). Vehicles are also smelly, noisy, dangerous and cause congestion. Road accidents cause more deaths than wars: in 2002, nearly seven times as many people were killed on the roads than as a result of armed conflict (WHO 2003a). Vehicle use is also associated with substantial land use. World-wide a third of urban land is allocated to car use (Southworth and BenJoseph 1997).

The dominance of cars has changed the way people live, reducing the extent to which people walk and have opportunities to meet neighbours, interact and develop closer communities. The convenience of the car has reduced the physical exercise people used to enjoy by walking to local facilities and to work; and the lack of exercise, combined with current eating habits, is contributing to high levels of cardiovascular disease, which is the cause of nearly 30 per cent of deaths globally (WHO 2003a). Developments built around the use of the car are also discriminatory against those who are too old, too young or unable to drive and those without access to a car.

A historic look at travel shows a trend for travelling more, faster and further than before and consuming increasing amounts of energy and space (Marshall 2001). This trend is not sustainable and changing it requires that alternative lifestyles, which are not dependent on car use, be made attractive and easily adopted.

At a strategic city level, reducing car dependency requires the provision of affordable and efficient public transport, including buses, trams, trains or underground; sufficiently high development densities that can support different types of public transport; and the integration of pleasant, sheltered and safe cycle and pedestrian ways in the streetscape (Newman 1999). Other effective methods to reduce car use within a city include making car ownership more problematic, for example, by reducing public and private parking places (Caborn 2002; CPRE 2003); and measures to encourage walking and cycling, such as the Copenhagen Free Bicycle Scheme for the city centre. The scheme makes 2500 bicycles available between April and December. They can be taken at specific racks by leaving a returnable deposit and can be used within the centre for an unlimited time (Brophy *et al.* 2000).

Building developments can also contribute to reducing car dependence as well as reducing the impacts of the car on the quality of life of building users. When selecting a site for development, proximity to public transport should be considered. Four hundred metres, which can be walked in five minutes, is a suitable distance for locating transport facilities from homes and encouraging walking. To achieve a sustainable urban transport system, it is recommended that these transport nodes should include other facilities such as shops and links to larger nodes, including train stations, work and leisure areas. The highest density of development should focus around a train station, with slightly lower density near the tram and bus nodes and decreasing density further away. This would make different housing options available and create a varied city landscape, while maximising the number of people with good access to public transport (Lock 2000).

For developments with no easily accessible public transport, it may be possible to persuade local bus service providers to extend their routes to a development site. Wessex Water, near Bath in England, built a new headquarters building and commissioned a bus stop just outside its main entrance, where employees can catch a bus direct to the local train station and travel with a bicycle if desired.

Within the development site itself, cycling can be encouraged by providing accessible, secure and covered bicycle storage; the need for travel can be reduced by including both work and living facilities in the same development; a facility for housing car clubs can help reduce car ownership, which in turn reduces car use. Commercial organisations can make environmentally friendly transport options, including bicycles or electric cars, available to their employees to use for errands. Car pools can be encouraged by providing an organisational framework and facilities to search for carpooling partners. Larger organisations such as the Presidio Trust in San Francisco encourage carpooling by offering a Guaranteed Ride Home programme that makes alternative transport available for emergency situations when carpool members are unable to travel at their standard time. The Presidio Trust also provides free shuttle buses within the Presidio area and cars, including electrical ones, which can be borrowed to travel for work or other purposes.

In order to reclaim social space lost to cars, as well as to reduce noise and air pollution and the risk of accidents, motorised traffic can be segregated from areas of the city and individual developments. Car-free pedestrian zones in cities have become very popular and have proved economically successful. Similarly, cars can be excluded from sections of developments, handing space over for individuals to enjoy, for children to play in safely or for communities to use. Perimeter parking and underground parking are solutions that reduce the impact of cars. In dense developments close to public transport, car ownership may not be necessary and parking spaces can be reduced, freeing up more space for other uses, including planting. The less that motor vehicles dominate the urban landscape, the more likely it is that individuals will spend time outside their home, sharing public spaces and strengthening community links.

**Electrical vehicles** use an electric motor and a battery that needs recharging every 60 kilometres or less and have a lower than average maximum speed. They have no emissions during use and are quiet. However, to reduce overall emissions the energy used to charge the battery has to come from a renewable source.

**Electric hybrids** run on petrol, but also use a battery that is charged through the braking action of the car and are therefore very fuel efficient at over 55 miles per gallon. Honda and Toyota have models available on the market.

As with buildings, an efficient operating system alone may not result in the desired environmental improvements if the base structure is not designed for efficiency. Ford is bringing out a new hybrid four-wheel drive SUV, but as SUV are inherently inefficient, this model is only rated at 36–33 gallons per mile, which is no better than a well-designed standard petrol engine car.

**LPG (liquid petroleum gas) motors** emit 10–15 per cent less $CO_2$ than petrol engines, but slightly more nitrogen oxides. Compared to diesel engines, LPG emits 10–15 per cent more carbon dioxide, but 75–85 per cent fewer nitrogen oxides.

**Methanol ($CH_3OH$)** is a natural gas alternative fuel that produces 20–30 per cent fewer $CO_2$ emissions and 95 per cent fewer particulates than petrol engines. Natural gas engines are quiet and in the UK there is an extensive pipeline in place. In Brazil, 90 per cent of new cars run on methanol using conventional internal combustion engines.

**Biodiesel** can be produced from the oil of crops like rape, sunflower and soybean as well as waste cooking oil. It can be used mixed with standard diesel fuel, typically 5–95 per cent. As biodiesel crops absorb $CO_2$ while growing, biodiesel can be considered a renewable fuel.

**Hydrogen fuel cell** car technology is attracting much attention and a small number of fuel cell cars running on hydrogen are now on the roads. The fuel cells are electrochemical engines that, by electrochemically combining hydrogen and oxygen in a flameless process (cold combustion), produce electricity, heat and pure distilled water. This is the mirror image of electrolysis where water is split into hydrogen and oxygen by passing an electric current through it. If the hydrogen is produced with electricity from renewable sources, a fuel cell vehicle can be considered 'zero $CO_2$ emission'. With this potential in mind, fuel cell technology is perhaps the most sustainable option. This technology is being pushed forward by numerous companies.

By the end of 2004 Daimler Chrysler will have over 100 fuel cell vehicles on the road, including 30 buses already active in cities in Europe, approximately 10 mopeds and 60 cars.

(Hoffman 2002/ EC 2000 / EST 2004 / DaimlerChrysler 2004 / Ford 2004)

# **Case study:** Live-work

**London Fields Housing Co-operative**
London Fields Road, London, UK

**Project details, Chapter 2.2, p.68**

The Victorian houses were renovated, extended and reconfigured to provide maisonettes and flats with integrated work facilities.

To the rear are the extensions clad in cedar, metal stairs to access the flats and communal gardens for growing foods and ornamental plants.

Reducing the distance between home and work is one way to reduce the need to travel and, in particular, the need to use the car. Mixed use developments which combine work, retail, leisure and living accommodation can achieve this aim. Another way to reduce the need to travel is to incorporate working areas in the home. Increasingly people are working from home, either running a business from home or working a number of days per week from home, while maintaining an office base. A home office can easily be integrated within a standard home, whilst purpose-built live-work units are designed to accommodate a wider variety of work activities.

Working from home can improve people's quality of life by providing the flexibility that many people, in particular, parents, want, as well as freeing up time normally needed to travel to work. Improvements in information technology have facilitated the move to home-working, while a trend towards sub-contracting work, as opposed to undertaking it in-house, creates opportunities for small consultancies and home-working individuals. With increasing evidence that home-working can be as productive, if not more productive, than working in an office, companies are more inclined to allow employees to work from home, in particular, if overheads can be reduced by doing so. In 1993, 21 per cent of the working population in Australia worked from home (Barton *et al.* 2002) and the numbers are increasing.

As well as reducing car dependence, home-working can help create a cohesive and vibrant community. Grouping live-work facilities together can provide the critical mass required for support facilities, such as cafés, libraries or local meeting facilities that attract people and encourage social interaction. Such facilities can also help counteract the isolation sometimes experienced by home-workers.

The London Fields Housing Co-operative is a successful example of live-work units located in East London. The development is of particular interest as it involved the introduction of live-work facilities in existing buildings. Existing Victorian terraced houses were extended and refurbished to provide a variety of different-sized live-work units. By addressing the needs of home-workers at the project design stage, issues such as building loadings, building accessibility, noise transmission, provision of natural light and other practical building issues could be addressed at an early design stage and included in the construction tender to keep costs under control.

At London Fields other sustainability issues were also high on the agenda. The houses were renovated to be energy efficient and achieved a Standard Assessment Procedure (SAP) rating of 80-90. The development also created terraces and a shared garden space, which together with the communal stairs, provides opportunities for residents to meet their neighbours. This not only helps guard against potential isolation of home-workers, but also creates a quality living environment and helps develop a community feeling.

**See also:** self-build **Chapter 2.2**

# **Case study:** Desirable city centre living

'One could say that housing is not sustainable unless it can be served by non-car modes' (Lock 2000). Reducing car dependence is key to achieving sustainable communities and city centre developments can contribute to this aim. Both commercial and residential developments in city centres are often close enough to public transport to rely on it for all travel needs. In respect of residential developments, the ability to walk to work, shops, transport facilities and leisure facilities makes the everyday use of the car redundant. However, in the UK, as in other countries, there has been a tendency for people to move away from city centres to the suburbs to find more affordable, larger, quieter and perhaps safer housing. Addressing the real or perceived disadvantages of city centre living is the challenge for new housing designs.

The Point housing development has many of the characteristics that make a development an attractive and desirable place to live. The city centre location on the bank of the River Avon has much to offer. The site is between two daytime tourist attractions, the Bristol Industrial Museum and Brunel's SS *Great Britain*, and there is no through traffic, resulting in a generally quiet location free from road traffic noise and noise from the sometimes problematic city centre night life. The environment on the edge of the river is attractive and soothing. Virtually all dwellings have good views of the river and many also overlook a semi-private planted communal area. The design is contemporary, comprising flat roofs and terraces and making use of metal and rendered finishes. The dwellings have large windows and are light and larger than the average in the UK.

Bristol's Old City, with its restaurants, theatres and art centres is a ten-minute walk away and The Harbourside, which includes an Imax and the Science Centre, is a similar distance. Shopping centres and the main train station are approximately a mile away and accessible by bus. Away from the city centre is the Avon River Walk, which leads into the countryside.

Despite easy access to most facilities, The Point does include car parking, which was seen by its speculative developers as an essential selling point. However, owing to its location, cars should not be required for day-to-day activities. A study of the development showed that The Point offered the potential to reduce carbon dioxide emissions associated with transport to 56 per cent of those associated with similar typical suburban developments (Rickaby 2002). Much of the car parking is in an underground car park located below an elevated and car-free communal area with planting and seating. Other communal facilities include a small children's play area on the south side of the housing and one commercial premise. All dwellings in The Point have private external areas in the form of balconies, gardens, patios or roof terraces.

Through its convenient and attractive location and spacious and well-designed dwellings, The Point makes it easy for residents to adopt and enjoy a healthy and car-free way of life.

**The Point**
Bristol, UK

**Project details, Chapter 1.1, p.18**

| Facility | Distance |
|---|---|
| Toddler's play area | 100 m |
| Allotment<br>Community garden | 200 m |
| Bus stop | 300 m |
| Playground<br>Primary school<br>Pub<br>Local shops | 400 m |
| Railway station | 600 m |
| Playing fields<br>Park/open green space<br>Health centre | 800 m |
| Secondary school | 1000 m |
| District centre<br>Leisure centre | 1500 m |
| Technical college<br>Major green space | 2000 m |
| Cultural/entertainment facilities<br>Major commercial centre<br>General hospital | 5000 m |

**Figure 1.2.3** Maximum recommended distances from homes to local facilities (Burton 1995).

The Point viewed from across the River Avon.

**See also:** appropriate high densities **Chapter 1.1**