



## Chapter 2

# Air quality and sustainable development

### At a glance

The “interdependent and mutually reinforcing pillars” of sustainable development are economic development, social development, and environmental protection. The international challenge in air quality management is to deliver cleaner air, and to do so without damaging society or the economy. The National Environmental Management: Air Quality Act clearly commits South Africa to preventing pollution and to improving and maintaining air quality, not at the expense of socio-economic development but in a way that complements it. The concept of ‘sustainable cities’ has emerged where environmental considerations, including air quality management, are systematically integrated into development plans, specifically those relating to energy, transportation, and land use. Some key aspects of sustainable air quality management include cost-effective air quality monitoring systems, appropriate air quality standards, the prioritization of sources based on impact, and future trends and cost-benefit analysis of strategies to reduce emissions. The task of addressing air pollution is connected to poverty alleviation, environmental justice, and considerations of the social acceptability of interventions.

2.1	ENVIRONMENTAL–ECONOMIC INTERFACE .....	9
2.1.1	Sustainable cities .....	9
2.1.2	Cost-effective air quality monitoring systems .....	10
2.1.3	Aligning air quality standards with sustainable development .....	10
2.1.4	Prioritizing sources on the basis of impact and future trends .....	12
2.1.5	Cost-benefit analysis of strategies to reduce emissions .....	13
2.1.6	A flexible approach to reducing the impact of air pollution .....	13
2.2	ENVIRONMENTAL–SOCIAL INTERFACE .....	15
2.2.1	Addressing air pollution through poverty alleviation .....	15
2.2.2	Addressing environmental injustice .....	15
2.2.3	The social acceptability of interventions .....	15





Sustainable development is often misinterpreted as focusing solely on environmental issues. In reality it is a much broader concept, as sustainable development policies encompass three general policy areas: economic, environmental, and social. These “interdependent and mutually reinforcing pillars” of sustainable development are economic development, social development, and environmental protection (United Nations, 1987).

In committing themselves to sustainable development, nations commit to balancing and integrating the social, economic, and environmental components of their societies. To this end, services need to be planned and delivered so as to address the nations’ social, economic, and environmental goals harmoniously and concurrently. Managing air quality within a sustainable development context emphasizes the ‘interface’ between the environment and the economy on the one hand, and between the economy and society on the other (OECD, 2005).

The international challenge in air quality management is not simply to deliver cleaner air, but to do so without damaging society or the economy. South Africa has taken up this challenge, as is evident in the object of the National Environmental Management: Air Quality Act (AQA) (Act no. 39 of 2004):

- To protect the environment by providing reasonable measures for:
  - (a) The protection and enhancement of the quality of air in the country;
  - (b) The prevention of air pollution and ecological degradation; and
  - (c) Securing ecologically sustainable development while promoting justifiable economic and social development.
- Generally to give effect to section 24(b) of the Constitution in order to enhance the quality of ambient air for the sake of securing an environment that is not harmful to the health and well-being of people.

The Air Quality Act clearly commits the country to preventing pollution and to improving and maintaining air quality, not at the expense of socio-economic development but in a way that coincides with it. Realizing this vision will require carefully tailoring the various regulations being developed and implemented under this framework act. To support regulatory development and roll-out, it is useful to consider the experience gained and lessons learned by other countries in managing air quality as well as to analyze key successes and failures both at the ‘environment’ and ‘economy’ interface and at the ‘environment’ and ‘society’ interface. The experiences of the USA and Europe are particularly helpful, as the USA has sculpted and implemented air quality management for over 40 years, and the European Union for over 25 years<sup>1</sup>.



Photography: Janet Peace

1. The US Clean Air Act of 1963 and Air Quality Act of 1967 set Air Quality Criteria and Air Quality Control Regions, and made provision for developing and implementing State Implementation Plans. Under these acts, federal government coordinates efforts through the US Environmental Protection Agency (US EPA) and sets national air quality standards and approaches to pollution mitigation, so as to provide a basic level of environmental protection to all individuals in the USA. State and local governments then develop, implement, and enforce specific strategies and control measures to achieve the national standards and goals.

In the European Union, air quality management started in 1980 with the publication of Directive 80/779/EEC, which set air quality limit values for sulphur dioxide and suspended particulates. The 1996 Air Quality Framework Directive and its daughter directives were a significant step aimed at establishing a harmonized structure for assessing and managing air quality throughout the EU. Within this structure, the EU member states have considerable scope to determine the actions they will take to meet their commitment to achieve air quality standards. They must, however, at the same time implement the other EU-level measures comprising the overall EU air quality management system, including stationary source emission controls, technical requirements to limit emissions from motor vehicles, fuel quality standards, and others.



## 2.1 ENVIRONMENTAL–ECONOMIC INTERFACE

The Organisation for Economic Co-operation and Development (OECD) review of key results in implementing sustainable development during the period 2001–2004 noted that more ambitious environmental objectives could have been achieved, for little or no additional cost, had policy-making incorporated environmental and economic concerns from the start. Noting the potential for abatement costs to rise markedly in future as environmental standards become stricter and 'low hanging fruit' and gross polluters are progressively eliminated, the need for cost-efficient options in the coming years is increasingly being emphasized (OECD, 2005).

The key mistakes made in air quality management, with specific examples, may be summarized as follows:

- Failure to integrate air quality considerations into energy, transportation, land use, housing, and other development planning processes has increased the cost of improving air quality, and impeded the management of emissions from significant sources such as vehicles, residential fuel-burning, and power generation.
- Failure to integrate economic concerns into air quality management and planning has strengthened the environmental pillar of sustainable development at a cost to the economic pillar, as a direct consequence of choosing relatively inefficient policies. Specific actions have included:
  - The adoption of costly air quality monitoring systems, with emphasis on continuous monitoring of 'everything, everywhere', regardless of the actual state of air quality at the relevant locality
  - The adoption of overly ambitious air quality objectives. The failure of countries to analyze costs and benefits of air quality management policies systematically, or to integrate such findings into decision-making, have largely been responsible for their adopting unrealistic objectives
  - The creation of regulations based on the mandated use of a particular technology to



The Cape Town city bowl.

realize emission reduction. In many instances, such regulations have brought high costs and discouraged cost-saving innovations

- Targeting sources on the basis of their contributions to total emissions rather than on their contributions to ambient air pollutant concentrations and, more specifically, to the impacts on health and the broader environment
- Putting the primary focus on 'command and control' measures without formulating or implementing other mechanisms, such as market instruments.

The above mistakes have most successfully been addressed through the implementation of several approaches documented in the subsections that follow.

### 2.1.1 Sustainable cities

The concept of 'sustainable cities' has been developed where environmental considerations, including air quality management, are systematically integrated into development plans, specifically those relating to energy, transportation, and land use. This approach illustrates the recognition of the inherent links among issues of transport, environment, energy, and spatial development, and the need for closely coordinated policies. This broadened approach to air quality management is not being implemented just by

**Common international responses to non-compliance with mandatory air quality limits have been to allow offenders to deviate from the legislation**

developed countries, but also increasingly by developing nations that realize that cost-effective and sustainable solutions require more than the adoption of stringent standards or the implementation of advanced air pollution control technologies.

The South African AQA provides the context for harmonizing air quality management and development planning. Each national department or province responsible for preparing an environmental implementation plan or environmental management plan in terms of Chapter 3 of the National Environmental Management Act (NEMA) (Act no. 107 of 1998) is required to include, as part of it, an air quality management plan.

National departments required to include an air quality management plan in their *environmental implementation plans* include those of Environmental Affairs and Tourism; Land Affairs; Agriculture; Housing; Trade and Industry; Water Affairs and Forestry; Transport; and Defence. National departments required to include an air quality management plan in their *environmental management plans* include those of Environmental Affairs and Tourism; Water Affairs and Forestry; Minerals and Energy; Land Affairs; Health; and Labour. These plans have to contain a description of policies, plans, and programmes that could significantly affect air quality, and a description of the manner in which the relevant national department or province will ensure that the policies, plans, and programmes comply with NEMA principles.

Chapter 5 of the Municipal Systems Act (Act no. 32 of 2000) requires each local government to prepare an integrated development plan (IDP), and the AQA requires each local government to prepare an air quality management plan as part of its IDP. The success of local air quality management planning will be gauged in terms of the extent to which pertinent aspects of the air quality management plan are reflected in the transportation, energy, housing, and spatial development policies and programmes documented in other sections of the IDPs.

Although the AQA has introduced an air quality management planning regime that fits seamlessly within existing planning regimes, government recognizes that much work remains to be done to ensure that such planning is properly implemented and fully integrated with existing plans.

## 2.1.2 Cost-effective air quality monitoring systems

A broad approach to air quality monitoring is increasingly being adopted, which comprises various measurement techniques ranging from passive diffusive monitoring and biomonitoring to continuous, automated, near-real-time measurement. The use of cost-effective passive diffusive monitoring campaigns to screen areas and determine the need and most suitable locations for more costly continuous monitoring is common in Europe.

In addition to screening and varied monitoring, emission inventories and atmospheric dispersion modelling are widely used in Europe and elsewhere as supplementary activities.

- Dispersion models simulate the dispersion and deposition of pollutants, using the source and emissions data from inventories, as well as meteorological, terrain, and land-use data. Some dispersion models can also simulate chemical transformation in the atmosphere.
- While continuous monitoring is typically able to provide time-resolved information on air pollution concentrations at specific points, dispersion models can characterize spatial and temporal variations in air pollution concentrations for the entire domain and period for which source, emission, and meteorological data are available.
- Monitoring, when conducted properly, offers the most accurate information, so monitoring data are used to verify the completeness and accuracy of emission inventories and dispersion models.

The integration of emission inventories, dispersion modelling, and a range of monitoring techniques into comprehensive air quality monitoring systems is an efficient and cost-effective means for characterizing baseline air quality and for tracking trends.

## 2.1.3 Aligning air quality standards with sustainable development

Setting air quality limits at levels that cannot be achieved through reasonable policy approaches can potentially undermine the credibility of the air quality management system that such limits aim to support. Common





**Passive diffusive samplers are used for monitoring air pollution concentrations.**

Photography: Hans Linde

international responses to non-compliance with mandatory air quality limits have been to allow offenders to deviate from the legislation (NSCA, 2004). This has taken the form, for example, of relaxing the timeframe for compliance. For industry-related non-compliance, the most common approach is to allow older industrial installations to continue operating until a specified date outside the new regulations in instances where using pollution abatement equipment would render them uneconomical.

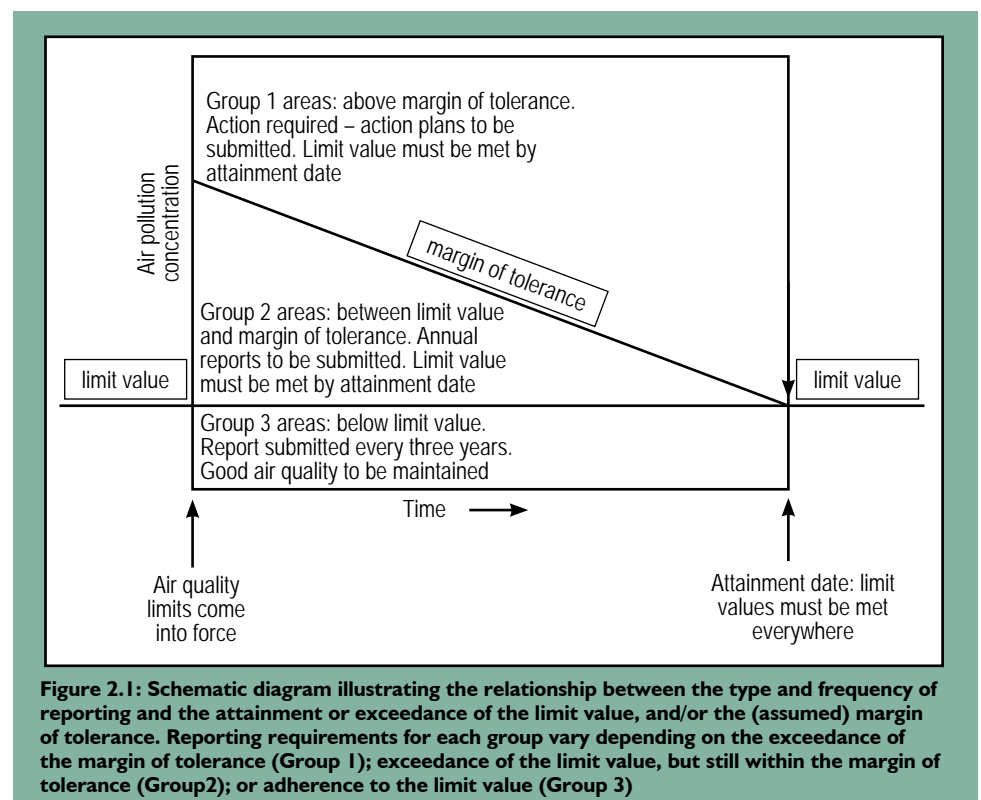
The European Commission (EC) approach to this problem has been to establish and implement a system of multiple levels of air quality objectives, which include: limit values, target values, and alert thresholds, defined as follows.

- *Limit values* have to be based on scientific knowledge, with the aim of avoiding, preventing, or reducing harmful effects on human health and the environment as a whole. Limit values must be attained within a given period and, once attained, are not to be exceeded.
- *Target values* are intended to avoid harmful long-term effects on human health, and environmental target levels are to be attained where possible over a given period. Such levels represent long-term goals to be pursued through cost-effective progressive methods, and are frequently termed 'long-term acceptable thresholds'. At these levels, pollutants are harmless to health and the

environment, or, alternatively, unable to be reduced<sup>2</sup> because they occur naturally, for example.

- *Alert thresholds* refer to levels beyond which even brief exposure carries a risk to human health. Exceeding such thresholds means that immediate remedial steps must be taken.

The EC system also provides for what are known as 'margins of tolerance'. Each of these represents a proportion of the limit value by which that value may be exceeded, subject to the conditions laid down in the framework for standard implementation (see Figure 2.1). The margin of tolerance is reduced each year, so as to reach zero on the date by which the limit value must be met. The purpose of the margin of tolerance is to identify areas with the worst air quality (that is, Group 1 areas, in which the margin of tolerance is exceeded). It is also designed to distinguish between areas in which air pollutant concentrations exceed the limit value but are within the margin of tolerance (Group 2 areas), and areas in which concentrations are below limit values (Group 3 areas).



2. Sometimes, as in South Africa (as a result of natural veld fires, for instance), a certain level of pollution pre-exists in the atmosphere. No amount of abatement technology demanded of industry is able to remove this kind of naturally occurring level of pollution.



Air quality planning and reporting requirements are stipulated for each group, with the most stringent ones set for Group 1 areas. A margin of tolerance is therefore not a deviation from a limit value, but rather provides a trigger for action in the period before the limit value must be met.

The EC system of air quality objectives explicitly links air pollution concentrations to appropriate air quality planning and remedial action over suitable timescales. The system emphasizes the fact that changes in ambient air quality take place over extensive periods, and that long-term planning is more effective than corrective action that attempts instantaneous improvements.

The EC approach to setting and implementing air quality limits was adopted by Standards South Africa, as documented in its publications (SANS 69:2004, and SANS 1929:2005).

#### 2.1.4 Prioritizing sources on the basis of impact and future trends

The extent and toxicity of emissions is not necessarily a concise indicator of contributions to ground-level air pollution concentrations or of risks to health and the environment. Such contributions are also a function

of the height of emission, temporal variations in the release of pollutants, and the proximity of the source to the people or the environment affected by exposure to the pollutant (such as, for instance, children, or the elderly, or people who are ill, or others who may be particularly sensitive receptors to a specific pollutant above a certain concentration). If an industry is operating close to a school or hospital or centre for the elderly, the potential exposure (in combination with the other contributing factors) is high.

Three factors govern the significance of household fuel-burning emissions: (i) the low level of emissions (that is, their height above the ground is generally about 3 m, within people's breathing zone); (ii) the simultaneous occurrence of peak emissions (during the coldest months of winter and in the early mornings and throughout the evenings) and poor atmospheric dispersion (stable atmosphere with low wind speeds, with the possible development of temperature inversions); and (iii) the release of such emissions within high human exposure areas, given that such emissions generally occur in dense, low-income settlements where population density is high (in addition, the pollution is not only outdoors, but frequently indoors as well, due to poor ventilation, so it affects the whole family).

The significance of vehicle emissions as contributors to air-pollutant concentrations and health risks is similarly increased by the low level (close to the ground) of the emissions, and their proximity to highly populated areas – on highways, for example, with emissions being particularly high when traffic is congested. Vehicle emissions tend to peak early in the morning and in the evenings, when the potential for atmospheric dispersion is reduced (for example, wind speeds are generally low in the early mornings and evenings, reducing their potential for dispersing pollution).

Given the high volumes of pollutants emitted from fuel-burning within the industrial and power-generation sectors, their contribution to ambient concentrations and public health risks is often lower than might be expected. This is because these sources are generally characterized by constant releases, relatively high above ground level, and further away from residential settlements than are household fuel-burning and vehicle emissions.

Ranking the significance of different sources of pollution on the basis of the total emissions for which





each source is responsible would, for example, place industrial emissions above household fuel-burning. If the aim is to reduce impacts on human health, however, then household fuel-burning would need to be targeted as a top priority (Scorgie *et al.*, 2004d).

Future trends in emissions are a further consideration for ranking sources in terms of their significant effects. Vehicle emissions, for instance, are currently responsible only for infrequent exceedances of air quality limits at sites close to busy roads. It is, however, advisable for this source group to rank high as a priority, because of the significant rise vehicle activity in many South African urban areas and, as is evident from Europe's experience, the substantial lead-time required to reduce such emissions successfully.

### 2.1.5 Cost-benefit analysis of strategies to reduce emissions

Before adopting air quality standards and emission-reducing strategies, it is imperative for such standards and strategies to be reviewed for their economic (and social) consequences, and for the findings of such analyses to be integrated successfully into decision-making processes. Such reviews must examine not only the costs of implementing air quality standards and reducing emissions, but also include the consequent benefits arising from these actions, such as reduced health costs, for example.

In South Africa, a cost-benefit analysis was undertaken for several emission reduction options, targeting fuel-burning sources within the industrial, transportation, and residential sectors (Scorgie *et al.*, 2004e). Findings from this study have been taken into account by various government departments in considering cost-effective emission-reduction opportunities (for example, the departments of Environmental Affairs and Tourism, Minerals and Energy, and Trade and Industry).

Cost-benefit analysis helps not only in selecting cost-optimized mitigation measures for implementation across source sectors, but also with decisions about the types and groupings of pollutants to be targeted. Important lessons can be learned from Europe and the USA, whose emission-reduction strategies were historically developed for individual pollutants. They realized, however, that implementing

emission-reduction strategies for individual pollutants was not the most effective or economically efficient way to reduce the ill-effects of air pollution on human health (NSCA, 2003). On the basis of their experiences, it is recommended that South Africa consider implementing health assessment methods and emission control measures for multiple pollutants.

The use of cost-benefit analysis is suggested in targeting source groups and multiple pollutants, and in designing solutions that achieve synergy between local air quality management and global climate protection strategies. It represents an effective way to achieve the highest level of human and environmental protection by the most cost-effective means.

### 2.1.6 A flexible approach to reducing the impact of air pollution

Historically, air pollution control in South Africa has primarily emphasized the implementation of 'command and control' measures in the industrial sector. The shift from source-based control, to the management of the air that people breathe, emphasizes the importance of targeting a wider range of sources and using more flexible and varied approaches. It means



**Unpaved roads are a source of vehicle-entrained dust all over South Africa.**

Photography: Janet Peace



**The geographically dispersed nature of vehicular sources makes it difficult for monitoring and enforcement authorities to target each source**

paying greater attention to ambient air quality, as it is more important (and more cost-effective, in many cases) to make sure that the ambient air complies with air quality standards. This approach ensures that human and environmental health is protected and that the cumulative impact of pollution from a number of sources is addressed. Approaches adopted or considered for future implementation have included: regulation (for example, the use of Atmospheric Emission Licences for Listed Activities); market instruments (such as atmospheric user-charges and pollution taxes); the potential for voluntary agreements, education and awareness raising; and emissions trading.

International experience shows that adopting a mix of instruments and interventions is more effective than using a single instrument to improve air quality across various types of source. Although direct regulation remains important in controlling industrial sources, there is evidence that specifying emission limits is more effective than specifying the use of particular technologies, so as to give companies flexibility in selecting the method of achieving success that suits them best. This approach is advocated as being more cost-effective and more likely to stimulate technological advances in pollution

control methods and production processes. For large point sources (that is, sources of pollution that are concentrated on one site, but that have large, constant volumes of many types of pollution) that are few in number, instruments such as emissions trading have been advocated as an effective way to manage pollutant emissions and reduce the costs of compliance.

The geographically dispersed nature of vehicular sources makes it difficult for monitoring and enforcement authorities to target each source, so a mix of technical and non-technical measures is needed. Technological advances progressively reduce emissions from new vehicles through improved vehicle and fuel efficiencies. Internationally, however, such solutions alone have been found inadequate for addressing traffic emissions, and car ownership and the behaviour of users is also a major influence. In South Africa, the problem is aggravated by the fact that public transport is limited. Strategies to reduce vehicle emissions should also include other measures, such as transport demand and supply management, and traffic management, to reduce the incentive for using personal vehicles and to expand and promote the use of the public transport system.



**Informal refuse burning is a source of dangerous atmospheric pollutants which are emitted into the human breathing zone.**

*Photography: Janet Peace*

## 2.2 ENVIRONMENTAL–SOCIAL INTERFACE

### 2.2.1 Addressing air pollution through poverty alleviation

Implementing an efficient social protection system to alleviate poverty is central to maintaining conditions that facilitate not only economic growth but also environmental sustainability. Many South African households – including those with access to electricity – use coal, wood, and paraffin, due to the relative cost-effectiveness of such fuels for heating (that is, space heating) and cooking purposes.

Many low-cost housing developments and informal settlements are located close to industrial and mining operations, as such land is both available and inexpensive. Poorer communities are more likely to suffer from poor service delivery, including inadequate waste removal that sometimes results in refuse being set alight illegally.

These examples show that poverty alleviation could help to improve air quality by enabling people to choose practices that are friendlier to the environment.

### 2.2.2 Addressing environmental injustice

Environmental hazards, including exposure to air pollution, are known to have a disproportionately severe effect on people whose place in society has already compromised their health and nutritional status. Air quality management strategies must therefore aim to address environmental injustices by, for example, prioritizing sources of pollution that have an impact on marginalized communities. Integrating air quality considerations into land use planning also has significant benefits, for instance by ensuring that low-cost residential developments are not located close to potentially significant sources of emission, such as heavy industrial complexes.

Where air quality is persistently poor, or deteriorating unavoidably, it is necessary to minimize the burden on those people who are worst affected, through measures such as improvements to the medical system and compensation (using the ‘polluter-pays’ principle).



**A mine tailings dam along the Johannesburg gold reef.**

*Photography: Janet Peace*

### 2.2.3 The social acceptability of interventions

To be successful, air quality interventions must not only be technically viable and economically feasible but also socially acceptable. This lesson was learned in South Africa in the 1980s and 1990s, when the Department of Minerals and Energy (DME) investigated the introduction of low-smoke fuels as an alternative for coal- and wood-burning households.

During this period, various social studies revealed strong links between energy use and religious, cultural, and social factors and values. Both social and economic studies indicated that a single intervention was unlikely to succeed in reducing emissions from household fuel-burning, and that the DME needed to identify the least costly, most desirable, and most effective energy-mix options.

This revised approach, integrating socio-economic considerations with strategic development, was evident in the DME’s Integrated Clean Household Energy Strategy adopted in 2003. This strategy refers to a range of interventions, including refining combustion methods and appliances; replacing coal with electricity, low-smoke fuels, renewable energy, and alternative fuels; and reducing the energy requirements of dwellings through insulation and solar passive design. The NEDLAC study (Scorgie *et al.*, 2004e) included a cost-benefit analysis of several of these interventions, and its findings have been used by the DME to inform the strategy’s implementation.