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Integrated environmental assessment: an urban perspective

John Murlis

Jackson Environment Institute, University College London, London WC1E 6HA, UK

Abstract—A broadening of the strategic approach to environmental issues coupled with changes in the mechanisms of environmental governance and management has generated demands for new kinds of environmental knowledge and for new ways of using it. In particular there is now a strong demand for information about the environment to be linked to information about the impacts of human activities so that the unsustainable aspects of economic development can be anticipated and controlled. The scope of environmental assessment has enlarged to provide information that will help a wide range of stakeholders, including business and publics to make decisions, choosing between alternatives on the basis of sound environmental information set in a social and economic context.

This paper provides a discussion of these developments and illustrates how integrated environmental assessment of a specific urban environmental problem, the reduction of health impacts of air-borne particles, can deliver broad strategic information for participants in the solution.

Keywords: integrated environmental assessment, urban perspective, London.

1 Introduction

Urban areas throughout the world are increasingly a focus of environmental concern. They are places of intense and growing economic activity. In response, urban populations are growing rapidly. It is estimated that, by 2000, more than half the world's population will live in towns and cities. This is a measure of the benefits offered by urbanzation. The success, however, has to an extent been overshadowed by environmental problems: air and water pollution, loss of amenity, land contamination, and the problems of handling waste threaten the quality of urban life. Such problems are not new: the towns and cities in which rapid industrialization took place in the last century, as in many parts of Europe and the America, have experienced the environmental problems of development, often in ignorance of their impacts on human health and society. Now broad urban areas of these regions face the problems of postindustrial regeneration with the legacy of past economic activity, polluted land and water, for example.

In many large urban areas, the environmental problems are now seen by city authorities as an issue to be tackled as part of a broader strategy to ensure continued economic development. In London, UK, for example, the organization London first, a consortium of business and local government, seeks to maintain the city's international standing by continuing to attract inward investment. It recognises that environmental quality, as an essential component of quality of life, plays a key part in the decisions made by companies choosing locations for their operations. Urban authorities in many countries have come to similar conclusions. The assessment of the urban environment, the many pressures on it and the options for managing them have therefore begun to occupy the energies of planning authorities world-wide.

In urban areas, the environment is highly complex. Physically, the built environment is heterogeneous, with high and low buildings combining to create a complex pattern of wind movements, including areas where pollutants can become trapped, in "street canyons", for example where a street is lined on either side by high buildings. The requirements for paving urban areas and for handling high volumes of waste in liquid form make urban hydrology highly complex, and the interactions between surface water pollution and ground water are difficult to predict.

Chemically, the urban environment suffers from the great concentration of industry, introducing new molecules with the potential for harm to health and of damaging by-products, such as PAHs (polycyclic aromatic hydrocarbons) from combustion and from industrial processes.

Given the complexity of the urban environment is not surprising that the quantity of environmental information required for comprehensive assessment tends to be considerable. Current information resources are, however, fragmentary. This makes all the more important the such information as is available is used to full advantage and that those who provide environmental information are responsive to the needs of users. In order to use information effectively it is first necessary to consider the context in which it will be used, and the needs of specific users. This paper illustrates the use of available data, and the requirements generated for new information, to illuminate a specific urban environmental problem and to provide a wide range of stakeholders with a basis for their decisions.

2 Trends in environmental agenda

Observers see a number of developments in the way in which environmental issues are handled at national, regional and global levels.

Historically, environmental problems have been treated on a piecemeal basis. Single impacts of individual processes or pollutants were tackled as they arose. For example, emissions of sulphur dioxide (SO_2) have been controlled in Europe over the past two decades because of their role in producing acid rain. However it is increasingly apparent that a more integrated approach is required. Other pollutants such as oxides of nitrogen (NO_x) contribute to acid rain, but also have further impacts on the environment, through eutrophication, for example in this case. The UNECE Convention on Long Range Transboundary Air Pollution (LRTAP), the legislative body under which international protocols to reduce SO_2 were made, is now considering a "multi-pollutant, multi-effects" protocol for controlling air pollutants at a European regional scale.

A second trend that is becoming apparent is towards the use of environmental quality standards in setting environmental objectives, as opposed to "end-of-pipe" emissions limits. This is now the approach for setting vehicle emission standards in the Europe Union. Vehicle manufacturers and fuel producers work with the European Commission to set the future fuel and vehicle emission standards in the context of objectives for air quality in Europe's cities.

The third trend arises from the growing understanding that environment and economic development are linked and that sustained growth will depend on the maintenance and improvement of quality of life. This is described, for example in the World Commission on Environment and Development's report Our Common Future (WCED, 1987) as the condition of Sustainable Development. In its simplest terms this trend is towards the integration of economic and social considerations into environmental policymaking (Man, 1998). However, the trend towards sustainable development as a basis for policy has also created pressure for changes in governance, the mechanism whereby decisions are made and implemented.

3 Trends in environmental governance

In parallel with the broadening and integration of the environmental agenda, changes are occurring in environmental governance, driven at least in part by the technical complexity of the decisions which have to be made, but also by the complex interactions between decisions and the many different interested parties.

The first of these trends is towards increasing subsidiarity in environmental decision making. This means that there is growing interest in taking decisions at the most appropriate level. For global issues, climate change, for example, decisions are taken at international level with the United Nations acting as a global forum for governments, for such regional issues as environmental acidification, the UN's Regional Commissions Act to provide decision making frameworks. The growth of subsidiarity at a local scale is seen, for example, in the growth of Local Agenda 21 groups.

The mechanisms of implementing policy are also changing. Reliance on regulatory mechanisms alone is giving way to a more flexible approach combining negotiated agreements with such economic measures as charges or tradable permits. The mechanisms for delivering the Netherlands National Environment Plan (NL Government, 1994), for example is of this kind, with targets set nationally and implemented through a series of "covenants" with different sectors of the economy.

One of the characteristic features of these new approaches to environmental governance is that a wider set of different groups within society is recognized as legitimate stakeholders. The relationships these stakeholders have, with each other and with authorities have also developed. There is a tendency towards a more inclusionary approach and one in which relationships are more in the nature of a partnership. The practical consequences of this are, at one level, the co-operation between regulators and industry seen for example in the California RECLAIM project (SCAQMD, 1994), in which difficult air pollution targets are approached by industry and regulator together using information on costs available only to industry. At another level this trend is seen in the growth of interest in "deliberative" process as a means of forming environmental plans, involving stakeholders from authority, business and publics at the outset.

In summary, environmental issues are increasingly seen as an integrated whole, closely related to questions of economic and social development, and the process of governance at all levels involves a broader range stakeholders, including publics. This change of emphasis and the wider range of expertise in the different groups involved places new demands on the information required for decision making.

4 Information requirements for environmental decisions

The growth in environmental sciences in the last 25 years has provided an enormous resource of basic data on the environment in general, focused on the scientific task of improving understanding of environmental processes. This is essential information but not necessarily sufficient for the development and implementation of policy. Policy makers and other stakeholders require particular kinds of knowledge to form, evaluate and communicate options and to enable them to participate effectively in debate and decisions.

The community of environmental science "users" require data to be interpreted to produce usable knowledge and integrated to cover all dimensions of the problem at hand, they need the scientific understanding translated into terms which they (or the communities to which they belong) can understand, and the need to the knowledge provided to be associated with its wider context of economy and society.

The way in which information is used in environmental policy is in itself a subject with a large and rapidly growing literature. Jager (Jager, 1998) describes current thinking about the application of scientific knowledge to the assessments of environmental problems and of the options for addressing them. Rotmans (Rotmans, 1998) describes integrated assessment as a process which attempts to shed light on complex issues by illuminating different aspects of the issue under concern: from causes to impacts and from options to strategies.

It is the purpose of the rest of this paper to illustrate how information is used to assess and address a specific issue with the example of particulate air pollution in the United Kingdom. The term integrated environmental assessment (IEA) is applied loosely here, without the elegant structure provided by Jager or Rotmans, as a term for a series of activities which, in sum, lead towards understanding of the problem at hand and to decisions on strategy and action. As it is described here, the process takes on an orderly form that is, strictly, only accessible through hindsight. Haigh (Haigh, 1998) provides a warning that in reality the process by which environmental problems emerge and the development of policies to deal with them are "unpredictable" and even "muddled", even when well supported by cohesive bodies of evidence.

5 Integrated environmental assessment: measures to protect health against air-borne particles

The problem of air borne particles has long been treated as a question of amenity, mainly because smoke from coal burnt in industrial and domestic furnaces soiled buildings and was generally unpleasant. It was suspected, however, that it also had an impact on health, although this was strongly contested. The first substantial evidence came in a study of health and air pollution in six widely different American cities, Dockery *et al*. (Dockery, 1993), which showed a significant linear association between "excess mortality" and annual mean concentration of particles in air. The following is an account of the response to this new evidence in the United Kingdom and the subsequent policy development. The process is described as an example of IEA, following the schematic illustration in Fig.1, with the aim of enabling the policy makers and other stakeholders to assess the problem and to make appropriate responses. The different participants may have different assessments of the problem and the viability of different solutions. Progress depends on debate and resolution of these differences.

The first step shown in Fig.1 was the interpretation of the available information to provide policy makers in central government with an assessment of the extent of the problem nationally, and the sources to be addressed. The UK has a countrywide air quality monitoring system and a comprehensive electronic air quality database. The mass concentration of particles less than 10μm in aerodynamic diameter, known as PM10, is measured and recorded as an hourly average. An assessment of data from the network, QUARG (QUARG, 1996), showed that ambient levels of air-borne particles vary geographically and in time, with highest levels in urban centres and in winter. The peak levels of daily means in each month ranged up to about 100μm/m^3 (QUARG,

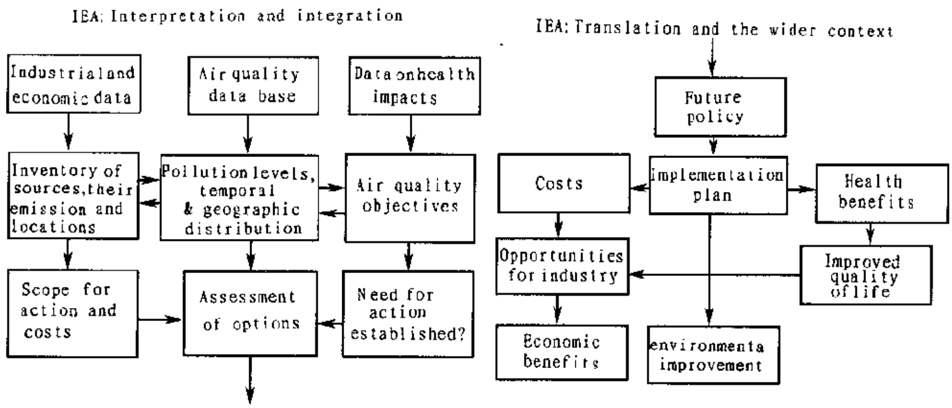

Fig.1 Intergrated environmental assessment inputs and outcomes

1996). For comparison, PM10 levels measured as a winter mean in Beijing in 1985 exceeded 350μm/m^3(WHO, 1992).

Industrial and economic data are interpreted to provide information on sources and emission levels of particulate and published in the National Atmospheric Emission Inventory (Salway, 1996; DETR, 1998). The national inventory showed that the largest single anthropogenic source of air-borne particulate on a national basis is road transport, which accounts for over 50%. In urban areas (Chell, 1993), road transport accounts for some 90%, mostly from diesel-fuelled motor vehicles. Further studies on the particles in the urban air of the UK, summarized in QUARG (QUARG, 1996) showed that PM10 contains, in addition to the particles directly from fuel combustion, a coarse fraction consisting mainly of wind-blown grit and a fraction of secondary particulates which come from the oxidation of pollutants from distant power plant. In China, the principle source of particulate remains combustion of coal, but as the road transport fleet grows and as energy conversion technology improves, it can be expected that diesel-fuelled vehicles will become a far more significant source in future (IBRD, 1997).

In order to assess the significance of the measured ambient levels, for national policy makers and the public, criteria are required. The epidemiological evidence showed a linear association between levels of particles and health and there appeared to be no "zero-effects" level. Criteria for health protection are therefore a matter of expert judgement. In the UK the Expert Panel on Air Quality Standards advises government. The panel considered information on health impacts of particles in air, with information on ambient levels and particle composition, and, as the level at which it would become "progressively less easy to detect effects on health", set a criterion of 50 μm/m^3 as an hourly mean (EPAQS, 1995). An assessment of measured ambient levels against this criterion (Environment Agency, 1996) showed that there were currently widespread exceedences of the criterion. On the basis that it is desirable to achieve levels below the criterion, the need for further reduction was established.

Decisions on whether new policy was needed then depended on an assessment of the scale of emission reduction required and on whether this was likely to be achieved with current policy. A rough calculation of the scale of the action needed (QUARG, 1996) shown in Table 1 suggests that, assuming a proportional relationship between reductions emission reductions and in ambient levels, a reduction of about 60% to 70% in today's emissions of particles from road transport would be needed. The next step was to assess the impacts of current policy on these emissions. As a means of understanding the impacts of current policy, future emissions are estimated on the basis of assumptions about future vehicle activity and about how policy on emissions standards will effect vehicle emission in practice. In the case of particles, the calculations made suggest that, on current policy, the maximum reduction from 1997 levels is expected to be some 55%, before emission levels start to increase again after 2015, as the projected increase in traffic overwhelms gains through improved emission standards. There is therefore a policy gap in the UK. To place these figures in context, Word Bank projections for particulate emissions from transport in China (IBRD, 1997) in 2020, assuming an active policy to address the problem, show an increase of between 4 and 10 times the level of 1993 (see Mackett, this issue, for details).

Once a policy gap is found, there will be more detailed and geographically focused calculations of the impacts of future vehicle emissions policy and assumptions about, for example, road traffic projections and the effect vehicles emissions legislation on emissions "on the road" will be re-examined. If the gap cannot be resolved there will be the need for new policies. In the case of particulate pollution, new policy rested on measures to reduce the impact of road transport, in particular diesel-fuelled vehicles, on urban air quality. This is important strategic information for the vehicle manufacturing and fuel industries, and for consumers. There would clearly be considerable pressure on urban vehicle emissions, fuel quality and on transport users.

Table 1 Action required to reduce airborne particulate levels to air quality standards (from QUARG, 1996)

Aim: to reduce 100 $\mu g/m^3$ to AQS of 50 $\mu g/m^3$	
Source	Concentration, $\mu g/m^3$
Coarse particles (PM2.5 to PM10)	15
Secondary particulate (e.g. sulphate)	10
Non vehicle (intractable) = 1 + 2	25
Transport (PM2.5) = 100 − (3)	75

In the UK, air quality objectives are set at a national level, but, an example of subsidiarity, local government has the duty to assess local air quality and to take the measures necessary to ensure that national objectives are achieved. This generated a demand for new information, on local emissions, for example. The impacts of a range of options for further action by both national and local government (Table 2), have been considered. At a national level, the UK government works within the framework of European legislation to set future vehicle emission standards. Technical measures to improve emissions performance from the future vehicle fleet include particle traps, requiring improved diesel, and the replacement of diesel by other fuels, such as compressed natural gas (CNG). These options have significant cost, however, and experience suggests that European standards may take considerable time to be agreed. At least some of the desired technical measures are unlikely to be implemented as mandatory standards within the time scale required, and there is therefore scope, and need, for local action to address local air quality problems. For example, through agreements between local transport businesses and local authorities to use advanced emission control technology before it is required by regulation. Agreements of this kind, informed by IEA, may entail costs but they also provide considerable incentive for innovation and considerable business benefits for suppliers of cleaner vehicle technologies.

Table 2 Policies and practices for reducing urban air pollution

Strategies	National air quality strategy Fiscal measures on fuel and vehicle taxes Improvement of public transport infrastructure
Plans	Local air quality management plans Urban regeneration plans Traffic management plans
Technical measures	Vehicle emission standards Selective fuel quality regulation Implementation of integrated pollution control
Controls on activity	Pedestrianisation Traffic circulation restrictions Controlled retail opening hours
Voluntary measures	Fuel switch for urban transport fleets Car pools for commuter travel Industry/local authority agreements on clean production

Local authorities are, however, also considering other, more strategic, measures to reduce vehicle emissions. For example, measures to reduce the traffic burden in city centres by better planning of distribution or by improved public transport. In some cases, local authorities are considering action to limit circulation, for example by closing sections of urban areas to non-essential traffic during periods when high pollution levels are to be expected.

In developing options for new policy, information derived from data about industry and the economy plans a crucial role in assessing relative costs. It can also provide important insights into causes of problems and possible economic components to solutions. In the UK, the major road transport growth over the last 25 years has been in private cars, which have doubled in number and now account for about 85% of all passenger travel. Similar trends are reported for China (IBRD, 1997), and sumarised by Mackett in this issue: in the 10 years from 1985, the public transport fleet grew by 5% per year on average; growth in privately owned vehicles grew by 45% per year. In the UK the continued vigorous growth of private cars is a threat to measures to increase use of public transport and to a degree it offsets gains from improved emission standards. According to GSO (GSO, 1996), over the period from 1974 to 1994 costs of public transport rose by over 50%, more than the rise in disposable income, whilst costs of motoring actually fell. It is not surprising, therefore, that car use increased, and clear that measures to improve use of public transport will have to take account of the considerable price differences. For the policy makers, the motor industry and the public the message is that either costs of motoring must increase or ways will have to be found of subsidising public transport.

In any case it seems clear that a mixture of measures will be needed to close the policy gap. The ingredients in the mixture and the timetable for implementing them will depend on a wide range of information about feasibility, costs and the scale of likely benefits, acceptability and convenience. It will probably turn out that some stakeholders will find certain options more to their benefit than others and for some stakeholders there may turn out to be a net loss. The consequence of this is that there will inevitably be a lively debate based on the assessment each of the parties makes of the net gains and loses.

For the authorities responsible for delivering the policy of reaching air quality objectives, integrated environmental assessment provides a structure for managing the debate, ensuring that the information available is used to produce the most effective solution broadly acceptable to the different stakeholder groups, including the publics.

Lastly, it will be important to ensure that progress is monitored. The final test will be the progressive improvement in health envisaged by EPAQS (EPAQS, 1996). This will, however, be hard to demonstrate and other, surrogate indicators will be needed, the most obvious of which is air quality. Experience in Britain suggests that improvements in air quality are, in general, slow. To extend this example, measurement of air-borne particles in London, quoted by Clout (Clout, 1978) showed a decline over the period since 1922, with progress at a highly uneven pace. To ensure the continued political will to support sustained downward pressure on particle pollution, it will be necessary to consider presentation aspects of the environmental data provided by monitoring networks. In the UK, information on air quality is provided through a public information system using the Internet and other mechanisms (DETR, 1998). This provides an open source of information on current levels, trends and sources of air pollution for the wide range of participants in the continuing debate on measures to improve air quality nationally and locally.

6 Conclusion

Where environmental issues are complex and where many stakeholders are involved both in assessing the problem and in putting solutions into place, there will be a pressing need to structure the information available so that it can work efficiently to support the production and implementation of viable and effective solutions. Integrated environmental assessment has the power to do this by integrating information of different kinds, interpreting it and translating it into a form that the different stakeholders can understand. Finally it can help to place the environmental information into the wider context of its economic and social consequences.

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