Environmental Management in Practice

Compartments, Stressors and Sectors

Volume II

Edited by
B. Nath, L. Hens, P. Compton and D. Devuyst

ENVIRONMENTAL MANAGEMENT IN PRACTICE: VOLUME 2

Methods of environmental management, and especially the 'tools' of environmental management, are increasingly being relied upon worldwide to deliver a degree of sustainability in all human activities. A thorough understanding of the nature, capabilities and limitations of these 'tools', as well as the conditions under which they can be best applied, is essential for students, researchers and practitioners within the field of environmental management.

Environmental Management in Practice presents three comprehensive volumes containing the most up-to-date research and practical applications in the field. Spanning the four main aspects of environmental management: instruments, compartments, sectors and ecosystems, this three-volume work contains over sixty contributions from leading specialists in each field and offers the first major source of contemporary international research and application within environmental management in practice.

Volume 1: Instruments for Environmental Management, focuses on the instruments and tools currently available to the environment manager. A theoretical background to the instruments is given together with an overview of those instruments that are in common use today, with particular attention to the physical, economic, legislative and communication instruments.

Volume 2: Compartments, Stressors and Sectors, deals with the problems that occur in the three 'compartments' of the environment – namely, air, water and soil. The contributors also address the socio-economic sectors of industry, traffic, energy, agriculture and tourism.

Volume 3: Managing the Ecosystem, focuses on those ecosystems in which human intervention has been or continues to be predominant, specifically within cities and rural areas.

Packed with accessible and up-to-date information, these three volumes provide a comprehensive overview of environmental management for those studying, researching and practising in the field.

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Compartments, Stressors and Sectors

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B. NATH, L. HENS,
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PREFACE AND ACKNOWLEDGEMENTS

Environmental management draws its knowledge base from across the spectrum of disciplines – the natural, social and medical sciences, the humanities and engineering. It aims to maintain a harmonious relationship between the environment and human society, and in its approach to this adopts a holistic, interdisciplinary stance. Since value judgements are an integral part of environmental management, it is as much an art as a science in its methodology and application.

The growth of interest in environmental management is relatively recent. It reflects a widely held perception of accelerating environmental deterioration caused by the pressure of human activities, as evidenced by worsening problems of pollution and the destruction of natural landscapes and habitats. These concerns can be traced back to the 1960s, when the interconnectedness of nature was vividly demonstrated by the way in which seemingly benign activities such as the chemical control of pests could, by diffusing through the food chain, produce adverse environmental effects in regions ostensibly untouched by man's activities.

As our knowledge of the global environment has grown, other worrying effects have come to light. The emission of greenhouse gases is linked to global warming and climate change. Although we do not fully understand the probable effects of this, it may well result in greater temperate aridity and so jeopardise the world grain supply, with potentially disastrous consequences. Moreover, resultant changes in sea level could submerge major coastal sites of population.

There is also the well-established connection between CFC emissions, the depletion of upper atmosphere ozone, and increased ultra-violet radiation at the planet's surface. This has negative implications not only for human health but also for the well-being of other species. Likewise, the destruction of the tropical rain forest is seen as a grave threat to biodiversity and the world's gene pool. The fact that these hazards are the subject of internationally agreed measures of amelioration (albeit implemented with variable commitment by individual countries) testifies to the potential gravity of global warming, ozone depletion and loss of biodiversity.

These global issues also raise concerns at the level of ecosystems. The effects of modern agricultural practices on environmental quality are a case in point. Pesticide and fertiliser residues pollute the groundwater; animal and plant habitats are destroyed as hedgerows are removed and wetlands drained in the interest of intensive cultivation; soil structure is broken down, creating problems of soil erosion. Now, in addition, intensive rearing of plants and animals is even causing concern for the safety and wholesomeness of the food produced. Populations are no longer willing to accept assurances from experts that genetically engineered crops are safe, or that it is right to feed natural herbivores, such as cattle, protein supplements derived from the rendered remains of other animals.

Of course it is not only agriculture that is problematic. Urban living and its associated activities can be just as destructive of the environment; not least, the creation of built environments where residential, commercial and industrial areas and communications infrastructures either obliterate or radically change pre-existing landscapes and ecosystems. Moreover, urban systems depend upon the mobility of people and goods for their effective functioning, and so create the traffic problems associated with further detrimental effects on the environment. The problems caused by excessive use of energy and natural resources in production and consumption, and their implications for future generations, also have to be tackled. Measures to ensure effective waste disposal and the curbing of air and water pollution are vital for the maintenance of environmental quality.

When viewed over a longer time-scale, however, the environmental picture is somewhat less gloomy. For example, popular coverage might lead one to suppose that human activity is the only cause of climatic change: the evidence does, after all, appear compelling, with the atmospheric content of the major greenhouse gas, carbon dioxide, having risen progressively since the start of industrialisation in the seventeenth century. But the record also shows that the world's climate has fluctuated markedly both in the recent geological and even historical past, and scientists still disagree on whether the rise now observed in global temperature should be attributed solely to greenhouse emissions. That this rise may be part of a natural progression readily absorbed by global systems cannot be ruled out at this stage.

It is also worth bearing in mind that ever since the domestication of plants and animals and the discovery of fire, human beings have moulded their natural surroundings to suit their purposes. During the medieval period, for instance, much of the forest that once covered the continent of Europe was destroyed (a process analogous with the present destruction of the tropical rain forest), without any apparent harmful consequences in the long term. Moreover, it was the agricultural and industrial revolutions that created those environmental conditions we consider 'natural' and with which we are comfortable. It is debatable, in other words, whether any truly natural landscapes and ecosystems remain – they have all to a greater or lesser extent come under human influence.

For most of human history our attitude to the environment has been purely exploitative: nature was there to be conquered, and the resource endowment to be used in the furtherance of human development. Little or no attention was paid to the possibility of detrimental environmental impacts – indeed, in most instances these were simply not appreciated because the complex relationships and linkages of environmental systems were not understood. It is only in this century that this attitude – of man as the conqueror of nature – has changed (indeed in Eastern Europe it persisted, with disastrous consequences, right up until the demise of communism). We now think more in terms of stewardship, whereby humans owe a duty of care to the environment, and in terms of sustainability. However, it is still invariably the case that when choices have to be made economic self-interest wins the day.

The broad scope of environmental management creates its own particular problems. The information on which it relies is scattered across disciplines isolated from one another by the traditional boundaries that demarcate major branches of academic endeavour. It follows from this that relevant advances in the natural sciences may not be appreciated by those working from a social science perspective, and so on. It is therefore a major objective of this book to bring together the expertise found within the diverse fields of environmental management, with the aim of providing an accessible overview of its content and methods. The treatment is biased towards environmental management as practised at the regional level – the so-called meso-scale. Global issues such as climate change and loss of biodiversity lie outside the scope of this book and so receive only incidental mention.

The idea for this book came initially from the involvement of the four editors in environmental training programmes in Eastern Europe, and a book was duly published by the Free University of Brussels Press in 1993. This publication is a revised, improved and extended edition of that earlier version and is presented in three volumes. The theoretical principles of environmental management are illustrated with the use of up-to-date examples and case studies, and self-assessment questions are included to aid students who may wish to use it as a textbook. It should also be of interest to policy-makers and researchers seeking information about the management of today's environmental problems.

Volume 1 considers the instruments for environmental management under four main headings

– predictive and scientific instruments; economic instruments; legal instruments; and instruments for environmental communication and education. It not only covers relatively long-established instruments of management, such as environmental impact assessment and risk assessment, but also introduces more recently developed approaches such as material flow analysis and life-cycle assessment. Volume 1 aims at up-to-date, comprehensive coverage and includes discussion of such important topics as the concept of sustainable development, environmental legislation in the European Union and the USA, and the management of environmental conflict.

Volume 2 is devoted to the environmental management of compartments, stressors and sectors. It covers the impact of population and the way environmental information is processed and interpreted through the filter of human culture. Soil, air and water are the environmental compartments referred to in this volume. They are subject to stress through over-use and pollution, and the manner in which these stressors should be managed constitutes a major strand of enquiry. The sectors referred to are agriculture, forestry, industry, transport and tourism, and how these should be managed in the interests of preserving environmental quality.

The theoretical and practical considerations involved in the appropriate management of major natural ecosystem types – wetlands, tropical forests, desert areas, the coastal margin, river and inland water environments – are discussed in Volume 3. These are, of course, 'natural' ecosystems only in a relative sense; the question of management arises precisely because of human impacts. Of equal importance are those environments created entirely by human activities, and in recognition of this Volume 3 also deals with rural and urban environments, as well as human ecosystems under threat, and the management of archaeological sites.

The three volumes of this textbook contain over sixty chapters written by more than eighty authors. This large project would have been impossible without the support and active contributions of many colleagues whose names are not mentioned in the individual chapters. We would like to thank especially the secretarial staff of the Human Ecology Department, Free University of Brussels (VUB) for their excellent work; especially Mr Glenn Ronsse, who was responsible for the final formatting and overall secretarial management of the project. Sincere thanks are due to the peer reviewers of the chapters.

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LIST OF ABBREVIATIONS

a.q.s.	Ambient Quality Surveillance
a.s.l.	Above Sea Level
ADR	European Agreement Concerning the International Transport of Dangerous Goods by Road
AIT	Action Initiation Time
AQS	Air Quality Standard
AWC	Available Water Capacity
BAT	Best Available Technology
BATNEEC	Best Available Technology not Entailing Excessive Cost
BGH	Bovine Growth Hormone
BIC	Business Innovation Centres
BOD	Biological Oxygen Demand
BOD_5	5-day, 20°C Biochemical Oxygen Demand
BT	Bacillus Thuringiensis
BTX	Benzene, Toluene and Xylene
C	Carbon
C/N	Carbon/Nitrogen
CANMET	Canadian Mining Research Institute
CAP	Common Agricultural Policy
CETEM	Brazilian Mining Research Institute
CFC	Chloro-fluorocarbon
CFP	Common Fisheries Policy
CMR	Convention relative au contrat de transport international de Marchandises par Route (Convention on the transport of goods by road)
CNOOC	China's National Offshore Oil Corporation
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CPA	China Pacific
CSO	Combined Sewer Overflow
DC	Developing Country
DDT	Dichlorodiphenyltrichloroethane
DG	Directorate General
DICE	Dynamic Integrated Climate Economy
DNA	Deoxyribo Nucleic Acid
DOAS	Differential Absorption Spectrometry
DQO	Data Quality Objective
EC	European Community
ECOMOST	European Community Model of Sustainable Tourism
ECS	Environmental Care System
EEZ	Exclusive Economic Zone
EFTA	European Free Trade Association
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ESA	Environmentally Sensitive Area
EU	European Union
EUS	Environmental Utilisation Space
FAO	Food and Agricultural Organization (of the UN)
FC	Field Capacity
FDA	Food and Drug Administration
FID	Flame Ionisation Detector
FOC	Flag of Convenience
GCM	Global Circulation Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas

GIS	Geographical Information System
GMO	Genetically Modified Organism
GQA	General Quality Assessment
HDPE	High Density Polyethylene
HOV	High-Occupancy Vehicle
ICAO	International Civil Aviation Organization
IFM	Integrated Fertiliser Management
IIASA	International Institute for Applied Systems Analysis, Luxemburg
INC	Industrialised Country
IPM	Integrated Pest Management
IPPC	Integrated Pollution Prevention and Control
IQ	Individual Quota
ISO	International Organization for Standardization
ITQ	Individual Transferable Quota
IUCN	International Union for Conservation of Nature
L	Level
LAC	Limits of Acceptable Change
LD_{50}	Lethal Dose for 50 per cent of a Population
LDC	Less Developed Country
L_{eq}	Equivalent Sound Level
LME	Large Marine Ecosystem
L_n	Sound Level
L_{NP}	Noise Pollution Level
LPG	Liquid Petrol Gas
MAC	Maximum Admissible Concentration
MERN	Mining and Environment Research Network
MHD	Magnetic-Hydro-Dynamic
MSY	Maximum Sustainable Yield
NGO	Non-Governmental Organisation
NIMBY	Not In My Backyard
NIMTO	Not In My Term of Office
NMHC	Non-Methane Hydrocarbons
NMVOC	Non-Methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
NPL	Noise Pollution Level
NR	Noise Rating
NRA	National Rivers Authority
OECD	Organization for Economic Co-operation and Development
OECD Pacific	OECD Countries of the Pacific Including Japan, Australia and New Zealand
OY	Optimum Yield
P	Pressure
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCDD	Polychlorodibenzo-p-dioxin
PCDD/F	Dioxin
PCDF	Polychlorodibenzofuran
PET	Polyethylene Terephthalate
PIC	Product of Incomplete Combustion
PM-10	Particulate Matter (10% smallest fraction)
PT	Public Transport
PVC	Polyvinylchloride
PVE	Product Volume Efficiency
PWP	Permanent Wilting Point
R&D	Research and Development
RQO	River Quality Objective
SADC	South African Development Community
SIA	Strategic Impact Assessment
SME	Small- and Medium-Sized Enterprises
SPM	Suspended Particulate Matter
SSO	Storm Sewer Outfall
SSZ	Source Sewer Zone
TAC	Total Allowable Catch
TCM	Tetrachloromercurate
T.C.M.	Transport Control Measure
t_1	Actual time exposed to a given noise level
T_1	Maximum permitted time for a given noise level
TNC	Transnational Company
TSP	Total Suspended Particulates
TSS	Traffic Separation Scheme
TURF	Territorial Use Rights in Fisheries
UAM	Urban Airshed Model
UNCED	United National Conference on Environment and Development (Rio de Janeiro, Brazil 1992)

UNCLOS	UN Convention of the Law of the Sea
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
UWC	Underwater Clearance
VAM	Vesicular Arbuscular Mycorrhiza
VOC	Volatile Organic Compound
WCED	World Commission on Environment and Development
WHO	World Health Organization
WRI	World Resources Institute
WTO	World Tourism Organisation
WWF	World Wide Fund for Nature (formerly World Wildlife Fund)

LIST OF UNITS

Prefixes to the names of units

G	giga (10^9)
M	mega (10^6)
k	kilo (10^3)
d	deci (10^{-1})
c	centi (10^{-2})
m	milli (10^{-3})
μ	micro (10^{-6})
n	nano (10^{-9})
p	pico (10^{-12})
f	femto (10^{-15})

Units

a	annum
Å	Ångstrom (0.1 nm)
atm	atmosphere
bbl	billions of barrel
boe	barrels of oil equivalent
Bq	Becquerel
°C	degree Celsius or centigrade
cal	calorie
d	day
dB	decibel
g	gram
Gt	gigatons (= 10^9 tons)
Gtce	gigatons of coal equivalent
GWe	gigawatt electricity
h	hour
ha	hectare
hrs	hours
Hz	hertz
J	joule
K	degree absolute (Kelvin)
l	litre
lpcd	litres per capita per day
m	metre
M	molar (mol/litre)
min	minute
P	phon
Pa	pascal (unit of pressure; 100 kPa = 1 bar)
pe	percentage
PM_{10}	fraction of particulates in air of very small size ($\leqslant$ 10 μm)
ppm	parts per million
ppmv	parts per million (volume)
S	sone
s	second
t	tonne
Tcf	tonnes of carbon fuel
TW	terawatt
Twyr	terawatt per year
V	volt
W	watt
yr	year

Other abbreviations

kg_{bw}	kilogram body weight
ln	logarithm (natural, base e)
log	logarithm (common, base 10)
n or N	total number of individuals or variates
ppb	parts per billion
s^2	sample variance

PART I

ENVIRONMENTAL COMPARTMENTS AND STRESSORS

INTRODUCTION

Paul A. Compton

Part 1 of this volume introduces readers to the strategies employed in the management of the three environmental compartments of soil, air and water, and defines the major problems involved. The stressors that operate on these compartments arise from the growth and activities of the human population. Management strategies must therefore seek to reconcile the needs of the human population for environmental resources with the preservation of environmental quality. Many of these strategies are designed to combat the adverse consequences of pollution, and the management of solid waste disposal and noise pollution are also discussed here.

The proper management of soil, air and water is integral to the well-being of the human population. Our food is dependent upon maintaining the soil in good heart. Water is not only needed for personal consumption and hygiene but also to support the basic activities of society, including the proper functioning of settlements, industry and agriculture. None of these can be taken for granted and their management is becoming increasingly complex and costly. As for air, this is ubiquitous and treated as a free good, but here, too, it is obvious that air quality cannot be left to look after itself and that proper measures of pollution control go hand in hand with healthy living. The importance of air, soil and water is not, of course, to be measured solely against the yardstick of human well-being; they are also the environmental compartments within which ecosystems exist. The sensitivity of ecosystems to alterations in their environmental surroundings as a result of human activities is well known and profound changes have already been recorded.

The aim of soil management is the preservation of soil structure and fertility. As Cruickshank shows in his chapter, these are maintained, in the absence of human intervention, through the processes of nature. But agriculture disturbs the natural chain of events and good husbandry is needed to prevent soil deterioration and erosion. What constitutes good husbandry varies according to climate, topography and underlying geology. Agricultural practice is therefore a function of environmental conditions and historically humans have adopted a range of different strategies to maintain the soil in good condition. In tropical areas, for instance, the device of 'slash and burn' was used, whereby the soil is cultivated for a short time and then abandoned to allow fertility and structure to recover naturally. Fallow periods were also part of traditional agricultural practice in Europe, which evolved later into systems of mixed farming, with crop rotation, periods of temporary grass, and the return of animal waste to the land to maintain soil structure and fertility.

Pressure of population and the quest for greater production and profitability have, however, made these 'environmentally friendly' forms of agriculture unattractive to modern farmers. Sometimes the response has been to extend farming to uncultivated areas; but since this has invariably been done with only the haziest prior knowledge of local environmental conditions (which have subsequently turned out to be marginal for agriculture) the extension of cultivation to such areas has usually been accompanied by the adoption of inappropriate farming practices. In the case of the US Dust Bowl in the 1930s, and as we are currently seeing in the Amazon rain forest, these activities have resulted in rapid deterioration of soil fertility, the breakdown of soil structure and rapid erosion of the soil, in which the top layers are literally washed or blown away.

The other response has been the intensification of existing farming, in which soil fertility is maintained through the use of artificial fertilisers. Combined with the application of other chemicals to control weeds and pests, this has led to the adoption of virtual cereal monocultures in many temperate regions. The problem here is not one of maintaining soil fertility (which is actually enhanced through the use of chemicals) but the adverse effect on soil structure of the abandonment of mixed farming systems. The use of heavy machinery on the land compacts the subsoil, and the absence of farm animals from these arable systems means that organic matter is no longer returned to the top soil. Subsoil compaction impedes drainage, leading to increased runoff; this together with the breakdown of the structure of the top soil again leads to enhanced rates of soil loss through the erosive action of wind and water.

The management of water resources and the monitoring of air quality overlap in the sense that both are concerned with pollution control. They also share a common set of principles for controlling pollution, either by setting maximum permitted emission levels for different sources of pollution or by establishing minimum standards of air or water quality. The former approach is associated with direct regulation and the latter with indirect regulation, in which economic mechanisms and incentives may play a leading role.

However, as Pescod and Younger show, the management of water resources involves a much broader remit than that of merely controlling pollution. Basic to this is an understanding of the hydrological cycle which describes the transport of water in its various forms from atmosphere, to earth's surface, to groundwater and its return to the oceans. Water resource management is also concerned with ensuring the availability of adequate water resources for human use. As consumption goes on rising, society is increasingly coming up against the limits set by water availability. Consequently conservation is now a pressing issue in many countries. Although the use of water for industrial purposes may well have declined in recent decades, this has been more than offset by rising domestic use and the use of water in agriculture.

There is also the matter of climate change to be taken into account. For instance, the climate of Western Europe now appears to have entered a phase of lower rainfall, with drier winters and therefore inadequate recharge of the groundwater table. Hence the need for conservation through measures such as wastewater reclamation, artificial recharge and proper pricing structures is not an exclusive feature of areas subject to drought, but also occurs in areas where rainfall might otherwise appear to be adequate. A strong case can be made for building grid systems that enable water to be moved from water surplus to water deficit areas in similar manner to the transport of electricity. The desalination of sea water may also become a more attractive proposition.

Although Christolis *et al.* focus on the technical aspects of air monitoring and management, they also introduce the reader to the general aspects of air pollution and the impact on human health and the environment. Emphasis is placed on monitoring because the effective management of air quality depends, above all, on the availability of regular and reliable information. Much has, of course, been accomplished over the last few decades in the improvement of air quality. A reduction in the emission of particulates has accompanied the shift away from the burning of coal as an energy source towards the use of cleaner fuels; the classic urban smog is now a thing of the past. Sulphur dioxide emissions, a major cause of acidification, are also coming under more effective control as power stations install technology to remove the sulphur produced during the generation process or switch to the use of more efficient and cleaner gas turbines.

But offsetting these improvements is the increase, resulting from the growth of road traffic, in pollution involving nitrogen oxides, carbon monoxide and hydrocarbons . This is now perhaps the most pressing air quality issue awaiting resolution. Not only does it damage the built environment, but it is also hazardous to human health: it is associated with diseases of the respiratory system, and contains carcinogens. However, the efficient working of modern societies is almost totally dependent upon the motor vehicle, and it seems unlikely that the problem of road traffic pollution can be solved in the foreseeable future. It is bizarre, to say the least, that governments should be attempting to curb car usage through piling on additional costs at the same time as they actively compete to encourage the multinationals to locate new vehicle manufacturing plants within their borders, in the interests of boosting employment opportunities and export earnings. One might be tempted to believe that this is prompted more by the need to raise general revenue than by a desire to improve environmental quality.

When excessive, noise, like air pollution, may fall into the category of environmental stressor. In the workplace it may become an issue because of its adverse effects on the health of the workforce. But of more concern here is the effect of noise in the broader environmental context. Obvious instances are the noise generated around airports and alongside arterial motorway routes, where the environmental impact results in general loss of amenity as expressed in terms of depressed property values. These matters, along with measures of noise control and the legislative framework regulating noise in the European Union, are discussed by Marc Van Overmeire and his co-authors.

Alfons Buekens' chapter is a comprehensive treatment of waste management. The aim of waste management is the safe disposal of waste without causing harm to the environment. This requires the separation of hazardous from non-hazardous waste and a thorough understanding of the consequences and implications of the various methods of disposal. For instance, landfill sites should be selected with regard to geological conditions so as to prevent the leachate infiltrating the groundwater table. Care is also needed when operating such a site so as to minimise the production of methane gas during the process of material breakdown. Similarly, care should be exercised in the location of incinerators and appropriate technology employed so as to avoid the release of toxic substances into the atmosphere. But attention is increasingly being redirected away from the mechanics of disposal and towards reducing the amount of waste produced by the use of economic and other instruments. Within this, recycling is an obvious and attractive strategy, although this needs to be thought through carefully: the overall amount of energy expended in implementing some of the most obvious candidates for recycling, such as glass and paper, may well be greater than in traditional methods of disposal.

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SOIL MANAGEMENT

James G. Cruickshank

SUMMARY

Soil management is presented as a selective review of the practices and problems of managing certain elements of soil, such as the physical survival of soil, soil conservation, soil structure, soil water, soil organic matter and plant nutrients in soil.

Soil is introduced as a central part of the natural environment, and is itself a complex, sensitive and reactive system. Soil management is seen as the management of a vital environmental resource within the framework of the whole natural environment, and particularly within ecological and economic constraints for sustained agricultural production. The broadening of this concept of soil management into a soil protection policy is considered with reference to the European Soil Charter (1972) and the European Soil Protection Policy (1987). Europe is taken as the geographical context of this chapter, and the present as the time and technological context for this review of soil management.

The chapter starts with soil reclamation as exemplified by Dutch polders and Danish heathlands, but devotes more space to the physical conservation of soil against the erosive forces of wind and running water, giving examples from areas in Europe. The management of soil water examines the availability of water to plants, and demonstrates how drainage or irrigation may improve soil water status. Soil structure and soil organic matter are described and, more importantly, discussed as soil properties critical for the development and maintenance of a fertile soil for agricultural production. Chemical fertility is seen as the need to supply chemical nutrients in amounts close to the requirements of plants, but avoiding levels reaching a pollution state in soil. The contemporary chemical problems in Europe of soil acidification, salinisation and metal contamination in soil are considered briefly in conclusion. The review of soil management is selective in topics and restricted to European examples.

ACADEMIC OBJECTIVES

This chapter shows that soil management entails management of land for optimal and sustained agricultural production. It is possible to have soil management for other land uses, notably for horticulture and forestry. Soil management involves the adoption of certain management practices that are understood to be designed to improve the condition of the soil for agriculture, and to allow the land to sustain long-term production. Subsidiary aims include defining the differences between soil management and other, similar concepts such as soil protection and soil conservation; placing soil management in a context of time and space and showing that ecological and economic constraints limit practices and achievements of soil management for agriculture. To achieve these aims, it is proposed to show how selected management practices contribute to better management and so improve the condition of soil for crops and livestock enterprises.

CONCEPTS

Soil is central to the natural terrestrial environment. No part of the environment is more important than any other, either in economic or ecological terms, but soil has the most linkages to other parts of the total natural environment. The interaction of other elements of the environment at any one place is expressed in the character of the soil. In itself, soil is a very complex environment, highly variable over space because it is produced by the interaction of environmental factors at any one point in space.

Soil is a three-dimensional mantle of organic and inorganic material over most of the earth's land surface. It is a multi-function medium, providing a rooting place for the anchorage and growth of plants, a habitat for soil flora and fauna, an environment for the decay of organic litter, a reservoir and drain for soil water, a store and supply of plant nutrients, a sink and pathways for pollutants, a foundation for buildings and roads, as well as being a vital natural resource for agriculture. Soil functions as an open system of many parts. To modify one part of the soil system, possibly through management, may create changes in other parts of the system. All parts are interconnected and interactive as defined in an open system. Frequently, mistakes of bad management occur simply because of lack of understanding of the functioning of the soil system and, conversely, recovery may also be due to the resilience of its system character.

Management of soil for agriculture has the joint aims of growing crops for profit and of maintaining or even improving soil fertility. Both must be within the long-term constraint of sustaining agriculture for future generations. Good management can make constructive improvements to soil fertility, such as long-term drainage and irrigation works, maintaining levels of organic matter by introducing manure, building terraces and barriers for soil conservation, as well as short-term measures such as the use of artificial fertilisers, chemical herbicides and pesticides. All these management practices are merely manipulations of the natural soil system, and always and everywhere on earth, soil management is constrained by natural, ecological controls. But it is usually a concern for economy that prevents the creation

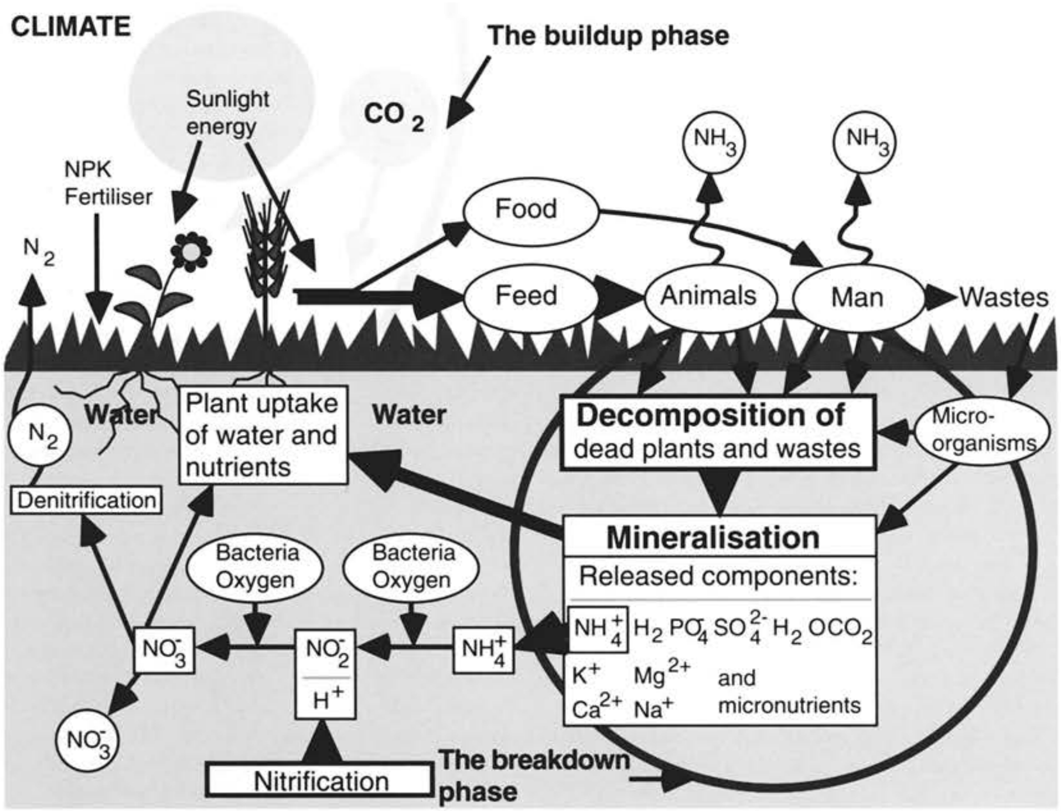

Figure 1.1 The soil system and the environment

of an artificial agricultural system (Davies *et al.*, 1993).

During the past century in Russia and the United States, and over the last 50 years elsewhere in the developed world, soils have been surveyed, sampled, analysed and mapped to provide a record of their character and distribution. In Europe, many countries have used soil maps as a guide to form secondary classifications of land quality for agriculture, and as guidance for potential land use. Soil maps have also been used in soil management to help advise on types of drainage, irrigation needs, risk of erosion and in particular soil properties that limit crop production (see Hodgson, 1991).

The concept of soil management has been enlarged in recent years to become a soil protection policy that recognises all the various users and managers of soil and the impacts they have. This is an extension beyond the concept of soil management for agriculture alone and also includes industrial and domestic activities that release pollutants which eventually enter and can damage the soil system. A European Soil Charter was adopted as long ago as 1972 and now includes elements that were developed in a soil protection policy by 1987 (see Barth and L'Hermite, 1987). Attention is still on the soil, but the condition of the soil is now evaluated in terms of quality for current and possible uses, soil degradation by erosion, acidification, salinisation and compaction, the soil's chemical buffering capacity, and the soil's resilience and sensitivity to stress (usually of an extreme, chemical nature). The source of damaging pollutants is often very distant from their impact in the soil, and that is why a soil protection policy has to be adopted internationally and the condition of the soil monitored frequently.

In this chapter, soil management will be discussed in terms of contemporary agricultural policies and their impact on soil. The geographical context will be Europe, mainly Western, Northern and Eastern Europe, and the time focus will be on present and possible future land uses and farm practices interacting with soil. The past cannot be totally ignored, because some of the best examples of good soil management can be found in traditional agriculture of the last two centuries, following scientific developments in the eighteenth century. The beneficial effects of grass were discovered and so a high proportion of grass was included in crop rotations. Nutrients and organic matter came from animal manures and weeds were controlled by cultivation. At the end of the twentieth century, large-unit monocultures prevail. Large machines are used on the land, and chemical solutions have been found for nutrient supply and the control of weeds. Management reflects a massive change in technology.

RECLAMATION OF SOIL

Reclaimed soils have been brought into agricultural production from a previously unused, unproductive state, or even from a non-existent state. A great variety of types of land are involved, with reclamation possibly their only common feature (Harris *et al.*, 1996). Likewise, a variety of soil management techniques are used for reclamation and subsequent maintenance. Reclaimed soils include land formerly below the sea, such as polders, mountain and upland areas (see Volume 3, Chapter 5, 'Upland and mountain environments'), unstable sand both as coastal sand dunes and inland heaths, marshland above sea level which requires extensive drainage, deserts, very steep slopes which have to be terraced and the land of industrial spoil or tips. Most of these are areas of large size and in hostile natural environments. The extreme environmental conditions mean that state intervention in the reclamation operation, through massive, initial grants and subsidies to farmers, is necessary for success in bringing land into agricultural production. Only two examples will be mentioned here.

The collective word 'polders' normally refers to the Polders of the Netherlands where reclamation from the sea has taken place on the largest scale and over the longest time (from the seventeenth century onwards or earlier). However, polders exist in many other countries bordering the sea, particularly in Germany, France, Italy, Ireland and Great Britain. In some cases, having become masters of the technology from work done at home, Dutch engineers started reclamation as early as the seventeenth century in areas outside the Netherlands. So polders are found extensively in the coastlands of Europe, but only where the submarine soil has been worth