MEASURING & MODELLING

SUSTAINABLE DEVELOPMENT

Ian Moffatt, Nick Hanley
& Mike D. Wilson

PARTHENON
PUBLISHING

MEASURING & MODELLING SUSTAINABLE DEVELOPMENT

Ian Moffatt, Nick Hanley
& Mike D. Wilson

The Parthenon Publishing Group
International Publishers in Medicine, Science & Technology

NEW YORK LONDON

Published in the USA by
The Parthenon Publishing Group Inc.
One Blue Hill Plaza
PO Box 1564, Pearl River,
New York 10965, USA

Published in the UK and Europe by
The Parthenon Publishing Group Limited
Casterton Hall, Carnforth,
Lancs LA6 2LA, UK

British Library Cataloguing in Publication Data

Moffatt, Ian
Measuring and modelling sustainable development:
1. Sustainable development – Scotland. 2. Economic development – Environmental aspects – Scotland – History 3. Sustainable development – Scotland – Mathematical models
I. Title II. Hanley, Nick III. Wilson, M.
333.7'09411

ISBN 1-84214-008-6

Library of Congress Cataloging-in-Publication Data

Moffatt, Ian.
Measuring and modelling sustainable development / I. Moffatt, N. Hanley, and M. Wilson
p. cm.
Includes bibliographical references and index
ISBN 1-84214-008-6 (alk. paper)
1. Sustainable development. 2. Sustainable development – Scotland. 3. Environmental policy – Economic aspects – Scotland. I. Hanley, Nick. II. Wilson, M. (Mike) III. Title

HC79.E5 M6267 2001
333.7'09411–dc21 00-057443

Typeset by H&H Graphics, Blackburn, UK
Printed and bound by J.W. Arrowsmith Ltd., Bristol, UK

Acknowledgements

We would like to thank the authors and publishers for permission to use some of our material which came from earlier papers developed during the course of this research. First, *The International Journal for Sustainable Development and World Ecology* (IJSDWE) for allowing us to re-use much of the paper on Environmental Space. The authors would like to thank the authors and publishers for permission to use some figures and tables. Throughout the study we have had helpful comments from an advisory panel consisting of members of Friends of the Earth; the Scottish Office and the Scottish Environmental Protection Agency (SEPA). The team are indebted to them for their helpful comments.

We would also like to thank our editor Helen Lee for her support. The Library staff at the University of Stirling for efficiently obtaining obscure references. David Aitchison for his design and graphical skills and Michael Duffy who designed the front cover and John McArthur who helped with the computing systems and printers. Robin Faichney supported the research. Linda Goodall at the University of Edinburgh completed the first draft.

We would also like to thank several groups of students at the Universities of Stirling and Edinburgh who have hopefully enjoyed our lectures on the MSc courses in Environmental Management and Environmental Change and Sustainability, respectively. Nick and Ian were invited to present papers on some aspects of this research at several meetings including SEPA; the Rio Plus Five conference at Stirling hosted by Council of Scottish Local Authorities (COSLA). Presentations took place at the University of Geneva, Forestry Canada, and University of Reno, Nevada. Presentations of the modelling work were made at the International Mathematics and Computer Society (IMACS) at Tasmania. We were given constructive criticisms from numerous people who attended these research meetings. We hope that some of their constructive criticisms are included in the text. The Economic and Social Research Council (ESRC) and colleagues who offered useful comments are not responsible for the views expressed in the book and the property rights remain ours.

IM/NH/MW
University of Stirling
Scotland
04/07/00

PREFACE

This book represents the culmination of several years' research into sustainable development in Scotland supported by the Economic and Social Research Council (ESRC) Global Environmental Change programme (GEC). Over the last decade there has been a growing recognition that current patterns of economic and social development are not sustainable. Furthermore, if we are to offer ways of living within the constraints of our environmental and ecological systems, then alternative paths of ecologically sound economic development must be found. The rest of this text illustrates one way in which we can explore alternative patterns of living that permit development which is sustainable, using Scotland as a detailed case study.

This book examines the ways in which sustainable development can be measured and modelled. It should be noted that there is a large and growing literature concerned with sustainable development (Moffatt, 1996a) and any attempt to cover the literature cannot be comprehensive. In the first chapter sustainable development is described in terms of the four Es: economics, environment, equity and ethics. These four Es represent one way of organising the vast literature into a coherent message so that the uninitiated reader can gain some understanding of the basic arguments underpinning the sustainable development debate. The need to measure and model patterns of sustainable development is also introduced. In particular, four questions are posed: what do we want to sustain? For how long do we intend these systems to flourish? How do we assess a sustainable from an unsustainable path? What policies could we adopt to make development sustainable? It will be argued that if we wish to answer these questions and contribute to the sustainable development debate then we must develop models and measures which can handle global as well as local or national issues.

Chapter 2 moves from the very generalised discussion over sustainable development to set the case study into a real geographical and historical context, using Scotland as our case study. Whilst any country could be used for the case study, it was felt that Scotland was an obvious choice. First, all the authors live

here and have a reasonable knowledge of the geographical and historical development of the nation. We would, however, be the first to admit that none of us are environmental historians. Next, and more important, there are major political discussions currently revolving around the role of Scotland as either part of the UK and the European Union or as a distinctive nation once again. Whether this 'new' nation remains part of the UK or the EU is of course a moot point. Nevertheless, whatever the outcome of this political debate it is clear that Scotland, like any other nation, should try, through its people and their institutions, to organize their ways of life so that they are ecologically sound as well as being economically efficient and socially just. Third, many national governments and international organizations have committed themselves to Agenda 21, i.e. to pursue policies which will lead to sustainable development in the early years of the twenty-first century. In the context of the UK, the former Conservative Government has produced its own Sustainable Development Report which attempts to outline the UK strategy (HMSO, 1994) and the concepts of sustainable development have been continued by the Labour Government in their *Ideas for Change* (HMSO, 1998; DETR, 1999). Whilst this is an encouraging sign it is clear, as one commentator notes, that the UK sustainable development strategy is too shapeless to be a guide to action . . . and too vague to be refined' (Anon, 1994). It would, therefore, appear that the good intentions of successive governments have not met with universal approval. Furthermore, several environmental groups in Scotland and elsewhere find that many Government reports are too conservative and that more radical policies are required to make development sustainable (FoE Scotland, 1995). Unfortunately, these latter reports have been long on recommendations but have not, as yet, been able to examine some of the major implications of the policies they advocate. Hence, it seems obvious to us that there is a real need to explore the implications of both the conservative and radical changes to the warp and woof of contemporary Scotland which will come about from actively pursuing a set of policies which have the avowed aim of making development sustainable in Scotland.

The difficult problems of measuring sustainable development are discussed in Chapters 3 to 7. There are numerous measures that can be used to discover whether or not a nation, or any other area, is sustainable. These measures obviously require reasonably good data sets. Equally important, however, is the need to spell out clearly the basis for the measurements. In some cases these measures are pure empiricism, in other cases they have a reasonably sound theoretical basis, in other cases the theoretical base is weak. Hence Chapters 3 to 7 make an in-depth examination of the measures of sustainable development using the relevant data from Scotland. Whilst the case study material is for one nation, the methods can be applied to many other countries. This part of the text is an extension of preliminary research reported earlier (Moffatt, 1996a). In Chapter 3 a framework for measures of sustainable development is presented. The fourth Chapter examines several of the environmental/ecological measures of sustainable development, including Environmental Space and Ecological

Footprints, as well as the Human Appropriation of Net Primary Productivity (HANPP). The fifth Chapter examines in detail the ways in which neo-classical economics has been used to define the condition for sustainable development, including Green Net National Product and stock-based measures. In the sixth Chapter, attention is turned to the socio-political measures of sustainable development. Again, several measures are used in the literature and attention is focused on three. These measures are the Level of Living index, the Human Development index and the Index of Sustainable Economic Welfare. It is quite clear that many indicators of sustainable development have been described in the literature but few of these measures have been used in comparative empirical work. In fact, very few of these studies have attempted to examine in detail the performance of a nation's economy and welfare using these measures. Perhaps the nearest studies that have come up to this ideal are those concerned with the Index of Sustainable Economic Welfare (ISEW) (Daly and Cobb, 1989). In several countries, such as the USA, UK, Germany and Scotland, ISEWs have been developed and they all show a pattern of declining economic welfare, especially over the past ten years (Moffatt, Hanley and Gill, 1994; Moffatt and Wilson, 1994). A novel feature of this text is that an empirical study of many of the major indicators of sustainable development is undertaken as a time series to highlight the relative limitations and advantages of these methods. The results of this empirical work are presented in Chapter 7.

In Chapters 8 through to 11 our attention moves from the essential measures of sustainable development to consider the ways in which it is possible to model patterns of sustainable development for Scotland. Again, the models we develop are relatively simple and could, with suitable modifications, be used for other countries. Chapter 8 describes a theory of sustainable corridors. A sustainable corridor is a feasible trajectory or pathway that a specific nation could pursue to maintain human welfare and the ecology indefinitely. This Chapter examines the scientific basis for sustainable development drawing heavily upon the work of some Russian researchers (Gorshkov *et al.*,1994; Gorshkov, 1995). In particular, this Chapter examines the environmental constraints within which the global economy must operate for development to be transformed into sustainable ways of living. The concept of sustainable corridors is suggested as one way of exploring both past historical paths of unsustainable development and future trajectories, some of which could be sustainable. Obviously, the theory of sustainable development corridors and the constraints operating upon the global economy have to be frankly recognised if we are to make development sustainable. Furthermore, these ideas have to be modelled so that we can gain some insight into the ways in which we can move towards a sustainable world.

Chapter 9 describes some of the approaches to model building. This review describes the basis of the modelling techniques and, where relevant, illustrates this with reference to examples of the methods being applied to sustainable development. Several approaches to modelling sustainable development have been developed including input–output; econometric approaches; dynamic

models and the application of geographical information systems and decision-support systems. Each of these approaches is described and the advantages and limitations in the methods are discussed. The need for integrating some of these methods is noted.

Models can be used both to explain a past path of development as well as to explore alternative future trajectories. In a real historical context, societies are much more complex and always use a variety of resources for their needs. Hence, in Chapter 10, a dynamic model of sustainable development is described using system dynamics methods. The model describes, in a highly simplified manner the links between global economic and demographic development, based upon the use of renewable resources, non-renewable resources and pollution. The model incorporates two measures of sustainability, namely the Human Appropriation of Net Primary Productivity and Environmental Impact, as the multiplication of population, consumption and technology (I = PCT) expressed as carbon dioxide in parts per million by volume. Using these two measures the base run gives some support to the model which is then used to explore several scenarios of sustainable development. At least one sustainable corridor or pathway is identified. It is acknowledged that further detailed research is required to develop this approach. Furthermore the links between the dynamic model and geographical information systems (GIS) are required.

The eleventh Chapter describes in detail an input–output model of the Scottish economy, highlighting the links with the natural resource base as a source of raw materials and as a sink for wastes. Unlike the broad-based and long-term dynamic model, the input–output model is, at present, static in its structure but has the major advantage of being disaggregated by economic and ecological sectors. It shows the ways in which these sectors actually impinge on pollution in Scotland. Several simulations exploring the impact of possible policies on the Scottish economy and environment are undertaken in this Chapter.

As Chapter 12 points out, our measures and models illustrate that on balance the current patterns of development are unsustainable. Some of the policies recommended by the European, UK and Scottish government and non-government groups may lead unwittingly to patterns of unsustainable development. Our own choice of policies, guided by an informed group of advisers, can lead to patterns of development which are first sustainable and, equally important, socially just. Obviously, the choice of one set of policies rather than another is reflected in the personal choice and political pressures that people operate under in Scotland. Ultimately, we believe that by exploring different options for a sustainable Scotland, the final choice, in a democracy, has to be undertaken by a well-educated and informed electorate. At present, however, the development of specific strategic policies together with more detailed modelling still needs to be undertaken. In this sense this text is a first step in the right direction. We note that further detailed research needs to be undertaken.

This book, based on the ESRC Global Environmental Change research programme, is a collaborative effort. Chapters 1, 2, 3, 4 and 6 were written by

Ian Moffatt, Chapter 5 was written by Nick Hanley, who also wrote Chapter 7 with major inputs from Ian, Robin Faichney and Mike Wilson. Ian wrote Chapter 8 on limits to development and the concept of sustainable corridors, after a productive meeting with Professor Kondratyev from Russia at the *Encyclopedia of Life-Support Systems* Bahamas workshop in Nassau. Chapter 9, on modelling sustainable development, was written by Ian, Nick and Mike. Ian was responsible for writing up the dynamic models in STELLA for Scotland in a global context in Chapter 10. Mike Wilson contributed substantially to a cut-down version of an input–output model of the Scottish economy in Chapter 11 which was written by Nick. The final Chapter was written by Ian but agreed by all of the research team. The final product is the result of this collaborative effort. Ian and Nick took responsibility for the final editing prior to handing the book over to the publisher.

IM/NH/MW
Stirling
4/07/00

CONTENTS

ACKNOWLEDGEMENTS viii

PREFACE ix

1. DEFINITIONS AND PRINCIPLES OF SUSTAINABLE DEVELOPMENT

Introduction 1
Definitions 1
Ethical principles 4
Economic perspectives 7
Social justice and equity 8
Environmental and ecological concerns 9
Predicting sustainable development 11
Summary 14

2. THE SCOTTISH CONTEXT

Introduction 17
Another new beginning? 17
The changing physical environment 18
Social and economic conditions in Scotland 21
Environmental problems 29
Sustainable Scottish landscapes? 32

3. MEASURING SUSTAINABLE DEVELOPMENT

Introduction 35
What makes a good indicator of sustainable development? 35
A framework for sustainable development indicators 36
Data for sustainable development indicators: sources and problems 38
Summary 42

4. ENVIRONMENTAL INDICATORS OF SUSTAINABLE DEVELOPMENT

Introduction 45
Environmental quality indicators 46
Environmental Space, Material Intensity and Environmental Rucsacs 50
Preliminary results of Environmental Space 52
Is the Environmental Space methodology sound? 55
Ecological Footprints 67
Is Environmental Space roughly right or precisely wrong? 71
Conclusion: the relevance of these indicators of sustainable development 73

5. ECONOMIC MEASURES OF SUSTAINABILITY

Introduction: definition, context and policy objectives 75
Green Net National Product 79
Stock-based measures 91
Conclusions 100

6. SOCIO-POLITICAL MEASURES

Introduction: what constitutes a just resource distribution? 103
The Level of Living index 105
The Human Development index 107
Criticisms of conventional economic measures of 'welfare' 110
The Index of Sustainable Economic Welfare 115
Discussion 127
Summary 129

7. A TIME SERIES ANALYSIS FOR SCOTLAND

Introduction 131
On indicators of sustainable development 131
A brief summary of the indicators used 134
Results 140
Discussion and conclusions 147
Appendix 7.1 Data sources and calculation methods 149

8. NATURAL LIMITS TO DEVELOPMENT, AND THE THEORY OF SUSTAINABLE CORRIDORS

Introduction 153
Some aspects of science and sustainable development 154
Environmental considerations for sustainable development: the real constraints 158
Sustainable corridors: towards a theory of ecological and economic welfare 175
Conclusions 181

9. ALTERNATIVE APPROACHES TO MODELLING SUSTAINABLE DEVELOPMENT

Introduction 185
System dynamics 187
Econometrics and other quantitative modelling approaches 190
Input–output and computable general equilibrium modelling 191
Optimisation 194
Geographical Information Systems 195
Decision-support systems 196
The need to integrate methods for modelling sustainable development 198

10. MODELLING SUSTAINABLE DEVELOPMENT USING SYSTEMS DYNAMICS

Measuring environmental impacts 203
Modelling sustainable development using systems dynamics 205
A dynamic global/national hierarchical model 207
National model 220
Scenario analysis 224
Analysis of possible future scenarios 231
Sustainable Scotland scenarios 238
Conclusions 241
Appendix 10.1 Global model 242
Appendix 10.2 National model 244

11. ECONOMIC MODELLING OF SUSTAINABLE DEVELOPMENT POLICIES

Introduction 247
Computable general equilibrium models 247
Input–output models 249
Choice of modelling strategy 260
An environmental input–output model for Scotland 261

12. TOWARDS SUSTAINABLE SOCIETIES

Introduction 271
Shades of green and sustainable societies 272
On the relevance of a 'small country' study 276
Further research 280
Concluding comments 284

REFERENCES 287

INDEX 301

CHAPTER 1

DEFINITIONS AND PRINCIPLES OF SUSTAINABLE DEVELOPMENT

INTRODUCTION

The concept of sustainable development evolved from earlier ideas concerning the effects of human activities on the environment. Concern about our impacts on the environment and on the health and welfare of people has grown into a major internationally recognised political movement and was first expressed internationally at the Stockholm Conference on the Human Environment in 1972 (Ward and Dubos, 1972). It was also reflected in the recognition of the growing disparity between the rich and poor nations in the North–South Brandt Report (Brandt, 1980) and the Report to the President (Barney, 1980). By 1987 the publication of *Our Common Future* (WCED, 1987), known as the Brundtland Report, introduced sustainable development as a key concept that different groups could use to discuss the intimate relationships between economic activity and ecology. This international concern with sustainable development found its most recent expression at the 1992 UN Earth Summit agreements signed at Rio de Janeiro. From significant international concern about the relationship between economic activity and ecology there has grown up a massive literature on sustainable development (Moffatt, 1996a).

This chapter examines some of the ideas underpinning the concept of sustainable development and discusses the implications of some of the many definitions. It will be argued that many of the definitions can be sub-divided into ethical, economic, socio-economic and environmental categories. These definitions do not, of course, exist in isolation from principles other than those by which they are categorised, but the different definitions do often imply that different ethical principles underpin them.

DEFINITIONS

There are numerous definitions of the term 'sustainable development'. Some researchers believe that economic growth is sustainable whilst others believe that although this is not the case, sustainable development is possible. Daly, for example, suggests that we can have economic growth or economic development, both, one or none (Daly, 1991). Clearly, continued economic growth on a finite planet is not sustainable: the planet cannot continue to accept the exploitation of its natural resources or the poisoning of its assimilative resources, such as water, land or the atmosphere (Peet, 1992). For some researchers sustainable

development is not something that needs to be defined but is to be declared as an ethical principle. Whilst one might agree with this view it is clear that there is a need to define sustainable development before examining the underlying ethical principles.

One of the most quoted definitions of sustainable development is given in the text *Our Common Future* (WCED, 1987), often referred to as the Brundtland Report after its chairperson the (then) Prime Minister of Norway, Gros Brundtland. This definition is: 'sustainable development requires meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life . . . sustainable development requires that promotion of values that encourage consumption standards that are within the bounds of the ecologically possible and to which all can reasonably aspire . . . at a minimum, sustainable development must not endanger the natural systems that support life on Earth: the atmosphere, the waters, the soils, and the living beings' (WCED, 1987).

This lengthy definition stresses various *inter-related* aspects of sustainable development. First, it acknowledges that the 'basic needs' of all people be met subject to some conditions. The basic needs would include the survival needs of food, water, energy for cooking and keeping warm (or cool), clothing and shelter. It is a sad reflection on the current global economy that many of these basic needs are not met today. Even in so-called advanced nations there are large numbers of homeless people and many living close to or beneath the societally determined poverty line (Townsend, 1979). Obviously, basic needs are often met for most people in many societies but higher order needs are also important. These would include worthwhile employment, caring for each other, education, good health care and a feeling of belonging and worth. Again, in many nations there are increasing signs of alienation at work and, more generally, in society as a whole. The stresses and strains of life 'in the fast-lane' are, for increasing numbers of people, not worth the promise of the rewards such a system can confer to those who are sufficiently lucky and/or hardworking to reap them. Increasingly, many people are finding the lifestyle of global capitalism far from satisfactory, but the alternatives are often either unclear or too difficult to contemplate. To try to achieve a better life is, for a substantial and growing minority of people, a dream that cannot be fulfilled under the rules of engagement of contemporary capitalism. In a sense the optimist believes that this is the best of all worlds and the pessimist fears that he is right.

Next, the definition notes that new patterns of consumption are to be held within the ecologically possible. Jacobs has developed this argument in his study of the green economy (Jacobs, 1991) that describes the current global economic system of resource consumption as attempting to live beyond the limits of sustainability and even attempting to reach beyond the boundaries of the ecologically possible (Figure 1.1). He suggests that the transition to a sustainable form of development requires that the economy is a subset of the ecology and that the former also lies well within the sustainable development

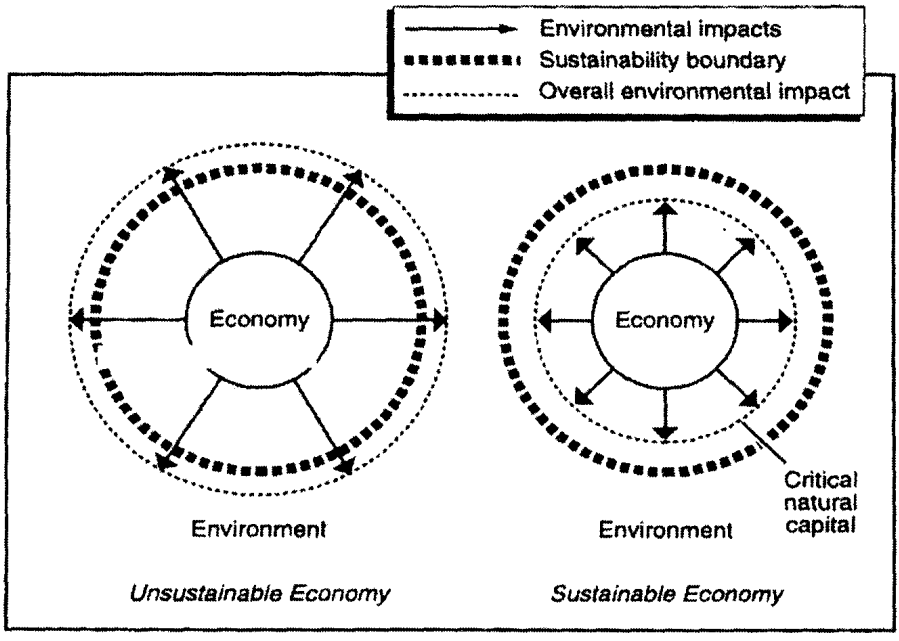

Figure 1.1 Environmental impacts, welfare and the sustainability boundary (after Jacobs, 1991 with permission from Pluto Press)

boundary. The move towards lifestyles that are richer in their social relationships, economically satisfying and that are well within the bounds of sustainability is part of the global quest to make development sustainable (Coombs, 1990).

The WCED definition underlines the importance of ensuring that the life-support systems of the planet (in terms of air and water quality) and the land, including soil fertility, together with the essential ecological functions performed by living organisms (plants, birds, fish and other animals), should be maintained. This implies that the assimilative capacity of a receiving environment should not be exceeded and that all life on the planet (whether of economic value or not) should be respected. Clearly, this definition of sustainable development raises ethical, social, ecological and economic questions.

At the risk of oversimplifying the complex concept of sustainable development, Ekins and Max-Neef (1992) have suggested that it can be thought of as a regular tetrahedron in which ethical, economic, social and ecological aspects are represented at the vertices. No priority is given to any one of these four factors; thus sustainable development is an attempt to integrate all four aspects into one coherent view of the world so that current and future generations of people and other living organisms can continue indefinitely. In Figure 1.2 each vertex represents a major factor in the sustainable development debate. The four factors interact to form different patterns of potential development each of which is sustainable. There are, of course, other ways of portraying the

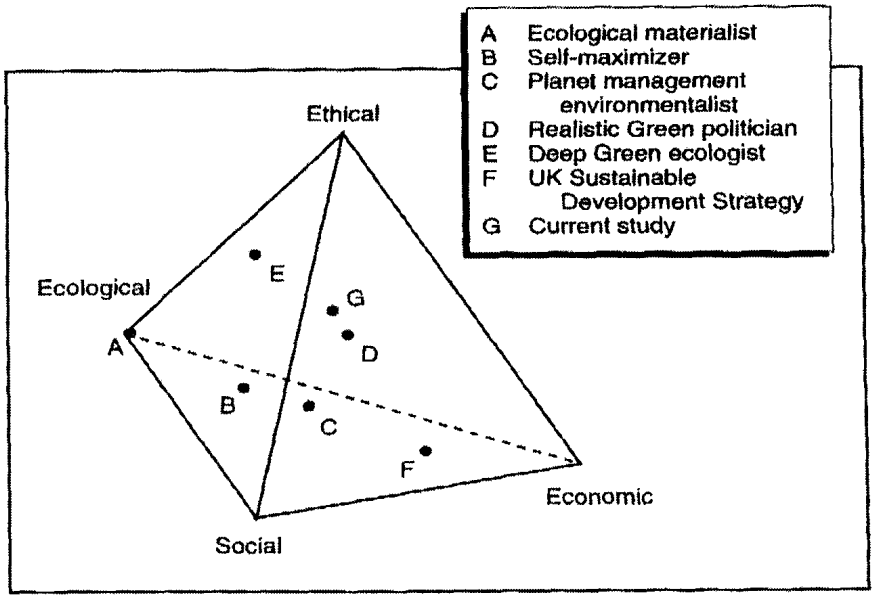

Figure 1.2 Sustainable development tetrahedron (printed with permission from Ekins and Max-Neef, 1992)

complex nature of the sustainable development debate but the regular tetrahedron model is a good representation of the major forces at work in making development sustainable.

There has been much ink spilt over definitions of sustainable development and over 100 definitions can be found in the literature. Some themes run throughout these, most notably equality of opportunity, both intra- and inter-temporally; protection of ecological systems and biodiversity; improvements in human health and welfare; and the restructuring of economic systems to reflect human needs not greed. Whilst the clarification of definitions of the concept of sustainable development is important, much of the criticism of vague definitions is misdirected because (1) it casts the problem as one of definition when in fact it is more one of prediction of what will last, and of achieving consensus on what we want to last, and (2) it fails to take account of the range of interrelated temporal and spatial scales over which the concept must apply (Costanza and Patten, 1995). We will return to these issues later.

ETHICAL PRINCIPLES

The 1972 Stockholm Conference on the Human Environment produced several ethical principles concerning the ways in which humankind ought to relate to and use the resources of the planet (Ward and Dubos, 1972). Similar ethical statements can be found in the World Conservation Strategy (IUCN, 1980) and the more recent Earth Summit held in Rio de Janeiro in 1992 (UNCED, 1992).

From these deliberations it would appear that many of the delegates attending these major international and influential meetings acknowledge the need for ethical principles to guide our activities to produce a sustainable world. Obviously, these claims for a frank recognition and application of ethical principles concerning the environment are not new. Many ethical principles have been enunciated centuries ago, as in Aristotle's *Ethics*, what is perhaps new in this restatement of ethics is the need to develop a set of principles to govern our actions. The Rio meeting produced 27 principles and several writers have noted the ways in which the work of Rawls (1971) on social justice arguments and the work of Taylor (1986) on the Rights of Nature can be applied to environmental concerns (Moffatt, 1996a). The recent literature on sustainable development has also recognised the need to develop and apply an appropriate environmental ethic.

Many of these ethical principles have already been used in the Friends of the Earth's (FoE) studies of sustainable development in Europe and in several nations making up Europe (FoE Europe, 1995; FoE Scotland, 1996; Carley and Spapens, 1998). The underlying principles upon which their methodology for a sustainable Europe is based are clearly described. This is good practice as it informs the reader why certain concepts such as environmental space, material intensity and environmental rucsacs are developed in the Reports on Sustainable Europe and the other national studies. Six key principles are invoked in these studies.

The precautionary principle

This principle, one of the 27 principles named at the Rio Earth Summit, has various definitions. The Earth Summit, for example, stated that 'where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation' (UNCED, 1992). Whilst many people may debate the meaning of the term 'cost-effective', a sensible view adopted by Friends of the Earth Scotland is that a decision to take action should be made on the appropriate scientific information available before deciding on the appropriate types of measure to determine cost-effectiveness. As one report puts it, 'Where reasonable doubts are raised about the risks or the impact of a development proposal, unless it is demonstrated that a significant impact will not happen, measures should be taken to safeguard against such an event' (FoE Scotland, 1996).

Equity

Equity is based on the ethically sound notion of a fair division of access to global resources. As Agenda 21 notes 'the major cause of the continued deterioration of the global environmental is the unsustainable pattern of consumption and production, particularly in the industrialised countries, which