Sustainable Development in a Complex World

PhD Thesis

Alex Robert Trisoglio

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Abstract

The thesis examines the development of theoretical models and practical tools for understanding and making decisions regarding sustainable development (SD) in a complex world. It seeks to answer three questions:

- What is the meaning of SD in a complex world?
- What are the implications for our policies and institutions?
- What tools can we use to assist decision-making for SD in a complex world?

The thesis examines these issues by bringing together thinking and research within complex systems theory, cultural theory and management theory. It also draws on the environmental and SD literatures, which are in turn associated with several disciplines including geography, economics and environmental science. The thesis is in four parts:

The first part explores the diversity of SD definitions and the two main policy models for SD. It identifies the need for a theoretical explanation of the plurality of perspectives in the SD debate, and also for an integration of insights from complexity theory into SD definitions and policy models.

The second part introduces complexity theory and cultural theory, and examines how they can support development of an improved understanding of sustainability.

The third part applies complexity theory and cultural theory to analyse SD policies. It argues that these theories yield significant new insights about sustainability, including highlighting the importance of plurality and resilience in policy making for sustainability.

The final part explores how the theories and tools developed by management science can be applied to sustainability, especially in increasing the plurality and resilience of SD decision making. It demonstrates that scenarios can promote the organisational learning and institutional resilience needed for sustainability, and that cultural theory provides an appropriate theoretical basis for scenario-building. The thesis concludes by developing a set of SD scenarios and analysing the results from their application.

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Chapter 1: Introduction

1.1. Sustainable Development in a Complex World: An Overview

The was a mood of optimism in certain quarters in the months before the 1992 United Nations Conference on Environment and Development (UNCED) held at Rio. It appeared to some people that the pathway to sustainability was clear, and nearly everyone seemed to agree that the environment and the economy could be integrated. Environmental concern would revive a country's economic and competitive outlook, generating new jobs and reviving political fortunes, and eco-efficiency would be the basis of a new industrial revolution, providing a rich source of new markets and profits for business (Schmidheiny et al. 1992). The details still had to be worked out, but the required change of course seemed clear and attractive.

Today, as the sambas and caipirinhas have faded into distant memory, things seem rather less rosy. Although 103 of the 178 nations represented at UNCED have established national sustainable development commissions (Trisoglio 1994b), there is still little agreement on what a strategy for sustainable development might look like, and even less enthusiasm to implement one. Growing unemployment and faltering competitiveness have left industrialised countries with little appetite for costly environmental policy measures, and business is also feeling the pain. Environmental spending in the OECD region is some 1.5% of GNP and rising, while in environmentally-intensive industries such as chemicals, it is between 4-6% of turnover. According to Klaus Eigenmann, head of safety and environment at Ciba, 25% of the company's capital expenditure is on environment: "We can't repeat this - it may be feasible technically, but financially it's just not possible" (Trisoglio 1993). Leading environmental managers have tackled all their relatively easy environmental problems, and are realising that further progress will be much more difficult and expensive. Walley and Whitehead (1994) argue that the win-win rhetoric of Rio: ". . . [had] tremendous appeal. Unfortunately this popular idea is also unrealistic. Environmental costs at most companies are skyrocketing, with little economic payback in sight". They conclude that optimistic rhetoric about sustainability "is not just misleading; it is dangerous".

Faced with this "new realism", the debate on sustainability has lost momentum, returning to the old trade-off between the environment and the economy. For environmental managers and policy makers, this has led to retrenchment and short-termism, even though the need for effective policies and institutions is as strong as ever. Policy makers appear to lack the tools they need to move forward, or to resolve the central economic questions of cost and benefit. Environmental policy making is supposed to be based on sound science and cost-effectiveness, but in the face of large scientific uncertainty and significant disagreement over the costs and benefits of proposed policy alternatives, the process has got stuck. Policy makers cannot agree on what the future will look like, or whether nations are prepared to pay to get there.

This is perhaps clearest with climate policy. The Intergovernmental Panel on Climate Change (IPCC) forecasts used as the basis for economic and policy analysis estimate that a warming of 1.5° to 4.5°C will result from a doubling of the atmospheric carbon dioxide concentration. But climate modellers admit that their models are woefully inadequate, since they still do not understand the direction of many important atmospheric feedback processes, much less their magnitude. A typical debate took place during the US senate hearing on global warming on 24 May 1994, when Jerry Mahlman, director of the geophysical fluid dynamics laboratory at the National Oceanic and Atmospheric Administration argued that damage from global warming was "virtually certain". Richard Lindzen, Sloan professor of meteorology at MIT, countered that "man will most likely have no effect on the environment" (Trisoglio 1994b). In the face of such scientific disagreement, it is not surprising that agreement on a climate policy appears as distant as ever. Meanwhile, the US has abandoned plans for an energy tax, and the European Union's carbon/energy tax, the centrepiece of its strategy for sustainability, has sunk without a trace.

If this environmental impasse were temporary, it might perhaps be tolerable. There are, however, good reasons to think that we are witnessing a more fundamental change, and that we need a new approach to developing policies for sustainable development. Since the birth of modern environmental policy some 25 years ago, the scale and complexity of environmental issues has grown inexorably, from local to global. Decision making is important at all levels, from individual consumers, to corporations, to nations; the entire life-cycle of a product is relevant; and perhaps most importantly, the environment is tightly linked to the economy. Today, environmental policy makers must also think about cost-effectiveness, competitiveness, trade, employment, taxation policy and the financial markets, an agenda of sobering complexity.

Environmentalists have always insisted that global biogeochemical systems are just that: systems. Sustainable development policy-makers are finally starting to see that they too must operate in the world of complex systems, and not only in terms of the environment. They must also integrate economic, social and technological considerations, each of which taken alone is complex, and hence intrinsically unpredictable. Taken together, they signal the end of an era when policy makers could expect simple answers. This complexity suggests that new ways of thinking about sustainability are needed.

1.2. Introduction to the Thesis

> "We are the absolute masters of what the earth produces. We enjoy the mountains and the plains. The rivers are ours; we sow the seed and plant the trees. We fertilise the earth . . . We stop, direct, and turn the rivers. In short by our hands we endeavour, by our various operations on this world, to make, as it were, another nature".
>
> Cicero [106-43 BC], cited in Hughes (1975)

> "Now the country was in those days inhabited . . . The land was the best in the world, and was therefore able . . . to support a vast army, raised from the surrounding people. Even the remnant of Attica which now exists may compare with any region in the world for the variety and excellence of its fruits . . . but the earth has fallen away all round and sunk out of sight . . . in comparison of what then was, there are remaining only the bones of a wasted body."
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> Plato [427-347 BC], cited in Jowett (1892:531)

Even in classical times, there were differing opinions about whether the natural environment can be moulded by humanity to suit its purposes, or whether it must be protected from excessive human interference which would lead to its degradation and collapse (Ponting 1991, Wall 1994).

A stream of environmentalism has continued through the last two millennia, but over the last three decades, however, from the inauguration of the Club of Rome in 1967 to Margaret Thatcher's famous 'green' speech to the Royal Society in 1988, environmental concern has reached unprecedented heights. As Thatcher put it, "with all these enormous changes - population, agriculture, use of fossil fuels - concentrated into such a short period of time, we have unwittingly begun a massive experiment with the system of the planet itself" (Woodell 1989:647). This concern for the global environmental is at the heart of sustainable development (SD), a term that henceforth will be used interchangeably with sustainability.

Although sustainability is often seen as a recent idea, it has been with us since the beginnings of the modern environmental movement in the 1960s. It appears in Boulding's (1966) discussion of "Spaceship Earth", as well as in the Club of Rome's 1972 report on *The Limits to Growth* (Meadows et al. 1972). The outlines of a sustainable society were discussed by Pirages (1977) and Hayes (1978), and a series of books on sustainability appeared in the early 1980s (Brown 1981, Cleveland 1981, Coomer 1981), although it was not until the report of the Brundtland Commission (WCED 1987) that the term achieved broad prominence within the policy debate. In fact, its origins do not lie in industrial society at all, but rather with traditional societies and indigenous peoples, who have based their lives on the concept of sustainability for thousands of years. For example, the traditional teaching of Canadian indigenous peoples would not be out of place in a contemporary discussion of sustainability and intergenerational equity (Clarkson et al. 1992):

> "It is said that we are placed on the earth (our Mother) to be the caretakers of all that is here. The way in which we interact with the earth, how we utilise the plants, animals and the mineral gifts, should be carried out with the seventh generation in mind. We cannot simply think of ourselves and our survival; each generation has a responsibility to ensure the survival for the seventh generation"

It has been suggested that sustainability appears to command consensus as a policy objective within the environmental debate (Marien 1994a), but a casual observation of the continuing differences between industry and environmental groups suggests that people do not all mean the same thing when they say they are in favour of sustainability (Eden 1994). Now that the concept of sustainability has entered into international law, however, the lack of consensus over its meaning presents a problem. For example, the Framework Convention on Climate Change (FCCC) that was signed at Rio in 1992 sets as its objective:

> "The ultimate objective of this Convention . . . is to achieve . . . stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a *sustainable* manner"
>
> (IER 1992, FCCC Article 2. Emphasis added)

Implementation of the FCCC, for example through protocols, is eventually likely to require an interpretation of the meaning of 'sustainable', a requirement which will also become necessary for other agreements incorporating the term, such as the 1992 Convention on Biological Diversity. A similar need is arising within the business community, where there has been a rapid growth of interest in the measurement of sustainability and the development of sustainability management and audit tools, eco-labels and life-cycle assessments (Schmidheiny et al. 1992, Miller and Szekely 1994). In addition, there are attempts within the financial community to develop lending procedures and investment products that distinguish between 'sustainable' and 'unsustainable' companies (Rada and Trisoglio 1993), and there are many initiatives among international agencies, governments and non-governmental organisations to develop "national strategies for sustainable development" (IUCN and IIED 1994). All of these initiatives will require some kind of definition of sustainability and insights into its implications, and there is unlikely to be significant progress in the integration of sustainability into business strategies and economic policy making in the absence of a clearer understanding of SD.

One of the problems that this thesis seeks to examine is the question of the meaning, if any, of 'sustainability', in order to explore whether it is possible to develop any theoretical models or draw any conclusions which might support the evident need for greater definitional clarity in the worlds of business and government.

The FCCC objective quoted above also suggests a further issue, however, since in its use of concepts such as "a level that would prevent dangerous anthropogenic interference with the climate system", or the idea of "a time frame sufficient to allow ecosystems to adapt naturally", it implicitly assumes that these levels and time frames are knowable, and that they can be derived through scientific inquiry. This thesis argues that these modes of thinking belong to the Newtonian paradigm of a controllable, modellable and knowable world, a paradigm that is being questioned by the emerging sciences of complexity. A complex systems perspective suggests that our ability to predict and manage the world is intrinsically limited by the non-linearity and complexity of natural and social systems. If this perspective is valid, then we require a radically different approach to designing policies and institutions for sustainability.

This, then, is the central question of the thesis: what are the implications of complexity for sustainability? The question contains within it three issues that form the basis for the approach taken in the thesis:

- What is the meaning of sustainable development in a complex world?
- What are the implications for our policies and institutions?
- What tools can we use to assist decision-making for sustainability in a complex world?

The approach and methodology of the thesis in exploring these three issues is discussed in chapter 2, where there is also an introduction to the way that theoretical frameworks from complexity, cultural theory and management theory are used in the thesis.

Chapter 2: Methodology

2.1. Introduction

The evolution of the debate about sustainable development, including previous discussions of the meaning of sustainability, has emphasised theoretical inquiry and understanding. This thesis builds on this work, and makes an original contribution by developing new approaches to understanding sustainability. It advances an original synthesis of theoretical findings from disciplines that have not previously been brought together in an analysis of SD, and also develops and tests a practical tool for improving the resilience of SD decision making, namely a set of scenarios for sustainable development.

A PhD thesis is expected to form a distinct contribution to the knowledge of the subject and afford evidence of originality shown by the discovery of new facts or by the exercise of independent critical power. This thesis emphasises the second of these aspects, and is primarily theoretical. Although it does generate new material, such as the scenarios developed in chapter 14 and applied in chapter 15, its primary concern is to examine existing material in a new way, developing and applying new explanatory frameworks.

This chapter provides a summary of the methodology followed in the thesis, together with an outline of the structure of the argument.

2.2. The Three Theoretical Roots of the Thesis

Environmental degradation has been recorded for millennia, but the sustainability debate is relatively recent in origin, with roots in the rebirth of modern environmentalism in the 1960s. Similarly, the theories used in this thesis also have recent origins, and they are still being developed actively:

- *Complexity theory*: complex systems theory has emerged from the non-equilibrium thermodynamics and non-linear dynamical systems work of the 1970s, as well as cybernetics and computer science research, as described in chapter 5. It provides an alternative to the Newtonian paradigm that has dominated Western thinking for the last 300 years, not just in the physical sciences, but also in the economic and social sciences that have drawn on prevailing world views in the physical sciences. Complexity theory provides a model of stability, change and unpredictability, and also a new set of tools for analysis and simulation.

The thesis applies complexity theory to provide a basis for understanding why the highly complex and interconnected natural and social systems that are the concern of the SD debate cannot be understood using the traditional linear and equilibrium thinking of the Newtonian paradigm, and to glean insights into the types of policies and institutions that might be required for managing in a complex world.

- *Cultural theory*: cultural theory was developed starting in the 1970s by the anthropologist Mary Douglas, as described in chapter 7. It describes how cognition, culture and organisational choice are linked, and it proposes that institutional life may be understood in terms of the two dimensions *grid* and *group*, which may be combined to produce four distinct rationalities and ways of life. With its identification of four distinct 'myths of nature', cultural theory provides an explanatory framework for the sustainability which may be examined in the light of the policy debate. Cultural theory argues that institutional and policy resilience may be increased by ensuring plurality, namely the inclusion of all the myths of nature in policy design, although no tools are provided to operationalise this theoretical proposal.

  The thesis applies cultural theory to analyse the sustainability debate, and also develops a set of scenario-based tools that can be used to attain greater plurality.

- *Management theory*: theories of organisational learning first became prominent in management theory during the 1970s, when they were proposed as an alternative to mechanistic models of how businesses function and how they might most effectively be managed, as discussed in chapter 12. The 1970s also saw the refinement and application to business strategy of scenario based techniques, which provide a practical tool for enhancing organisational learning and resilience, as discussed in chapter 13. Despite the practical success of scenarios, however, there is no theory to support scenario development, which has reduced their potential impact in improving decision making.

The thesis applies management theory to provide insights into institutional design for SD in the face of complexity, and to set out how a scenario-based approach might be used to aid decision-making for sustainability.

The complex systems, cultural and management theories have all been applied at some level to understanding sustainability, but they have not previously been used together. This thesis uses them in a mutually supportive way, as follows:

- *Complexity theory*: provides a scientific basis and paradigm for the thesis, including the ideas of cognition and model-building in a complex world. Cultural theory builds on complexity theory by describing the emergence of patterns of organisation and cognition in social life, while management theory and organisational learning provide guidance on how to manage and develop institutions in a complex world.

- *Cultural theory*: provides a hypothesis to account for the interaction of world-views, organisational types and cognitive styles. Management theory builds on cultural theory by providing operational understanding of such ideas as plurality, clumsy institutions, organisational learning and resilience, while complexity theory provides an understanding of the origins of cultural theory's myths of nature and sheds light on the underlying ecological theory on which myths are based

- *Management theory*: provides a basis for designing strategies and institutions that can flourish in a complex world, and with scenario planning it also provides a practical tool to improve decision making. Cultural theory builds on scenario theory by providing a basis for developing scenarios that can take account of social and institutional behaviour, while complexity theory provides a basis for understanding the implications of a turbulent and uncertain world for management theory and practice, including organisational learning.

This thesis argues that the combination of these three approaches provides a rich theoretical framework that combines insights from diverse disciplines, and is able to shed light not only on the nature of the problem of SD, but also on the types of organisational structures and decision making tools that would help to improve decision making for SD. In addition to these three bodies of theory, the thesis also draws heavily on the literature of the environmental and sustainable development debates, which are in turn associated with several disciplines including geography, economics and environmental science.

2.3. Thesis Structure

The following chapters of the thesis are structured as follows:

3. *Typologies of Sustainable Development Definitions - A Review*: explores previous classifications and frameworks of SD definitions, and finds that previous work is diverse and fragmentary, and lacks a coherent theoretical basis.

4. *Two Policy Models for Sustainable Development*: introduces and explores the differences between two competing models of policy development for SD, the comprehensive/rational approach and the complex/adaptive approach.

5. *Complexity*: introduces complexity theory and explores the distinction between complex and non-complex systems, the types of behaviour demonstrated by complex systems, and new approaches to modelling and thinking about complex systems.

6. *Examples of Complexity in the Sustainable Development Debate*: examines the presence of complexity and uncertainty at both large and small scales in the SD debate, and the limitations of current scientific knowledge.

7. *Cultural Theory*: reviews the grid/group framework, the plural rationalities and myths of nature, the key hypotheses and results of cultural theory, and the previous application of cultural theory to the SD debate.

8. *Sustainable Development - An Analysis*: applies the theories introduced in earlier chapters to analyse and shed light on a diverse set of SD definitions and policy recommendations drawn widely from academic, business, governmental and non-governmental sources.

9. *Cultural Theory and Complexity*: evaluates the success of cultural theory as an explanatory framework for thinking about sustainability, and examines how insights from complexity theory could be used to strengthen cultural theory.

10. *Resilience, Learning and Sustainability*: compares and contrasts insights from complexity and cultural theory on the resilience and learning required for sustainability, and how they might be attained.

11. *Sustainable Development in a Complex World*: examines the status of the SD debate, including the implications for definitions and policy, in the light of the theoretical synthesis and insights developed in previous chapters.

12. *Managing in a Complex World*: reviews two principal approaches in management theory and the implications for management in a complex world, including their conclusions about organisational learning and strategic resilience.

13. *Scenario-Based Tools for Decision Making*: introduces the scenario planning technique and explores its strengths and shortcomings, as well as the absence of a theoretical basis to guide scenario development.

14. *Cultural Theory and Scenarios*: applies cultural theory to develop a theoretical basis for scenario planning, evaluates the strengths of this approach compared to previous sets of scenarios, and introduces a set of three SD scenarios developed using cultural theory.

15. *Sustainability Scenarios - Application and Results*: reviews the application of the SD scenarios developed in chapter 14 in different contexts, and draws conclusions about the theoretical and practical implications of using the scenarios.

16. *Conclusions*: summarises the findings of the thesis, draws conclusions, and suggests directions for future work.

The thesis also contains a set of references and four appendices.

Chapter 3: Typologies of Sustainable Development Definitions - A Review

3.1. Introduction

Since the publication of the Brundtland Report (WCED 1987), the term *sustainable development* (SD) has become prominent in environment and development policy. It has been enshrined as a basic objective of several international agreements, including the Maastricht Treaty on European Union; the European Union (EU) Fifth Environmental Action Programme; the Rio Declaration; Agenda 21; the Framework Convention on Climate Change; and the Convention on Biological Diversity (Grubb et al. 1993). SD is widely debated among environmental policy researchers and non-governmental organisations, and it also appears within numerous corporate mission statements and environmental charters, notably the *Business Charter for Sustainable Development* (ICC 1990a), which has been signed by over 1,500 companies.

SD was defined by the Brundtland Commission (WCED 1987:43) as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Yet despite numerous subsequent elaborations and uses of sustainability (OECD 1989), which were presented in a "gallery of definitions" by Pearce et al. (1989:173-185), the theoretical status of SD remains problematic. Some authors see the diversity as undesirable, for example Lélé (1991:613), who argues that:

> "[SD] is a 'metafix' that will unite everybody from the profit-minded industrialist and risk-minimising subsistence farmer to the equity-seeking social worker, the pollution-concerned or wildlife-loving First Worlder, the growth-maximising policy-maker, the goal-oriented bureaucrat and, therefore, the vote-counting politician".

Other authors argue that sustainability is not something to be defined but to be declared, since "it is an ethical guiding principle" (Viederman 1993). Yet others argue that the breadth of SD definitions has allowed the concept to succeed politically where narrower and clearer concepts such as limits to growth failed (Buttel et al. 1990, Bardwell 1991), not least because the limits to growth discussion forced the premature polarisation of opposing perspectives and thus prevented dialogue and policy development. Nevertheless, Brown et al. (1987) have shown that different SD definitions are incommensurable, while Pearce et al. (1989) argue that they lack rigour. Dasgupta and Mäler (1994) contend that "most writings on sustainable development start from scratch and some proceed to get things hopelessly wrong. It would be difficult to find another field of research endeavour in the social sciences that has displayed such intellectual regress". And in conclusion, Beckerman (1994) argues that sustainable development may not have any conceptual utility at all, since it "has been defined in such a way as to be either morally repugnant or logically redundant".

Despite the academic dissent, Brooks (1992) insists that policy makers require an operational definition of SD to inform choices between alternative policies, technologies and development strategies. To be useful, a definition must be operational, including objectives and decision criteria, and there is no excuse for delay, since investment and policy decisions made today can have consequences far into the future, many of which may be physically or economically irreversible (Meadows et al. 1973). Policy makers are beginning to grasp the importance of an operational definition, and have initiated discussions on the meaning of SD in the EU and elsewhere (ERM 1994a). Nevertheless, as this chapter confirms, the need for a unified theoretical definition remains as strong as ever.

3.2. Frameworks for Understanding Sustainability

As a starting point for understanding SD (Brown et al. 1987, Shearman 1990), we may consider the definitions in the *Oxford English Dictionary*:

> *To develop* is "to grow into a fuller, higher or maturer condition". Applied to human society, development indicates progress towards a set of desirable goals which might, for example, include meeting basic needs, increasing economic welfare and quality of life, or attaining spiritual enlightenment.

> *Sustainable* is "capable of being upheld; maintainable", and *to sustain* is "to keep a person, community etc. from falling or giving way; to keep in being, to maintain at the proper level; to support life in; to support life, nature etc. with needs".

On the basis of these definitions, sustainable development is "human progress that can be maintained into the future", an anthropocentric approach reminiscent of Brundtland's. This objective is hard to condemn in general (Solow 1991), although it is saved from being platitudinous by biocentrists who hold that it discriminates against non-human species (section 3.2.2). There is an additional debate about whether sustainability should be restricted to mean "able to be sustained" or "worthy of being sustained" (Dower 1992, Attfield and Wilkins 1994, Dower 1994), although since both these usages are commonplace, the following discussion will include them both.

Although general definitions of SD command wide acceptance, they are not operational, and cannot guide decision making. When attempts at operationalisation are made, alternative assumptions and differences in interpretation create a plurality of seemingly incompatible definitions. Business, governments and environmental groups may all be in favour of sustainability, but if they cannot agree on what it means, it is of little use as a guide to policy making. The extent of the definitional divergence is explored in the following sections.

3.2.1. Two-Fold Distinctions within Sustainability

(a) Technological Optimism and Pessimism

An early discussion of alternative perspectives of environmental quality in a growing economy was provided by Boulding (1966), who contrasted the "Cowboy economy" of a world without limits with the "Spaceship economy" of a world in which resources are scarce and waste sinks are limited. The related distinction between *technological optimism* and *technological pessimism* arose with the *Limits to Growth* debate of the early 1970s (Meadows et al. 1972, 1973, Cole et al. 1973), which questioned the effects of uncontrolled physical growth, and asked whether technological innovation could provide economically viable solutions to environmental problems indefinitely into the future. Optimists see man as powerful, ingenious, and able to solve any problems that may arise, while pessimists see nature as vulnerable, human institutions as fallible and slow-moving, and technology as the source of as many problems as it solves. Thus although optimists and pessimists would both support SD, in the sense of maintaining human progress into the future, they would recommend different policy responses to achieve this goal. Optimists would promote growth and innovation, pessimists would limit them, and both would argue that their favoured policies would further sustainability. The implacable opposition of these perspectives is summarised by Meadows et al. (1973:131):

> "We see no objective way of resolving these very different views of man and his role in the world. It seems to be possible for either side to look at the same world and find support for its view. Technological optimists see only rising life expectancies, more comfortable lives, the advance of human knowledge, and improved wheat strains. Malthusians see only rising populations, urban ugliness, and increasing gaps between the rich and the poor".

The US National Academy of Sciences draws a similar distinction, between *conservationist* and *possibilist* poles (NRC 1990). Conservationist thinking supports a 'better safe than sorry' prescription, based on an image of nature "in its original state perturbed by sporadic human blundering, while the possibilists see spaceship earth as the creation and responsibility of enlightened long-term engineering. In this perspective, mistakes are possible, even likely, but with sufficient alertness and wisdom we may detect and remedy them before their consequences are too serious. The same bipolar distinctions emerge as *ecocentrism* and *technocentrism* in Gladwin, Kennelly and Krause (1995), as *neo-Malthusian* and *cornucopian* in Ayres (1993), and in Goodwin (1994) as an axis of "predictions of the future of human civilisation", from future misery to future luxury (table 3.1). Mol and Spaargarten (1993) similarly find that the two poles of the post-modern environmental debate are *eco-alarmism* and *ecological modernisation.*

The same two-fold distinction appears elsewhere, for example in the question of whether traditional tribal people were more or less sustainable than humans today. Redclift (1988:646) argues that indigenous people made use of the environment in "ways that are sustainable, socially and ecologically", while Bossel (1987) provides criteria which argue

Optimism	Pessimism	Reference
Endless frontier / Cowboy economy	Spaceship economy	Boulding (1966)
Environmental optimism	Environmental pessimism	Meadows et al. (1972)
Technological optimism	Technological pessimism	Meadows et al. (1973)
Cornucopian	Neo-Malthusian	Kahn et al. (1976)
Cornucopia	Catastrophe	Cotgrove (1982)
Indigenous people were unsustainable	Indigenous people were sustainable	Bossel (1987), Redclift (1988)
Possibilist	Conservationist	NRC (1990)
Technological sustainability	Ecological sustainability	Orr (1992)
Ecological modernisation	Eco-alarmism	Mol and Spaargarten (1993)
Future luxury	Future misery	Goodwin (1994)
Technocentrist	Ecocentrist	Gladwin, Kennelly & Krause (1995)

Table 3.1. Technological Optimism / Pessimism and Related Bipolar Distinctions

they did not, and Rapport (1990) questions the implication that a "rediscovery of the past" holds lessons for sustainability today.

Many authors take the optimism / pessimism split as the primary, if not the only, fault line in definitions of SD, and argue that "reality probably lies intermediate between these two" (Brooks 1992). Lecomber (1975:42) argues that "everything hinges on the rate of technical progress and the possibilities of substitution. This is perhaps the main issue that separates resource optimists and resource pessimists", but he also notes that "the central feature of technical advance is indeed its uncertainty". This technological distinction is necessary in understanding alternative perspectives on SD, but it is not sufficient, since other authors propose different bipolar distinctions, as outlined below.

(b) <u>North-South and Rich-Poor</u>

A second important distinction is that between North / South or rich / poor, which has emerged from the developmental roots of SD (Brandt Commission 1980, 1983). The argument here is that the North's concern for sustainability is typically environmental, seeking to protect standards of living that have already been attained, while the South's is developmental, focusing on poverty alleviation, improving education and health, and socio-economic development (Redclift 1987, 1992). It should be noted that these distinction refer to the debate conducted within the SD policy community, which tends to comprise ministries of environment and overseas development. Among other government ministries in Northern countries, such as industry, transport or economics, the focus is still typically on promoting economic growth rather than protecting the environment, and sustainability is used in its economic context of "sustaining growth", or the "maximum sustainable growth rate" that can be attained without incurring adverse inflationary consequences, rather than to refer to the environment.

An alternative formulation locates the source of North's unsustainability in over-consumption, and the South's in excessive population growth (MacKellar 1995) (table 3.2). These divisions are not simply between nations, as Jasanoff (1993) demonstrates that even within India, there are sharply conflicting views on the 'causes' of environmental degradation, between those who blame the "reckless consumption" of the rich, and those who focus on population pressures. Jasanoff finds that here too both sides of the debate favour SD as the 'solution', since they invest it with very different meanings.

North	**South**	**Reference**
Rich (exploiter)	Poor (exploited)	Redclift (1987, 1992)
Environment-focused	Development-focused	WCED (1987)
Individual, moral problem	Collective, population problem	Jasanoff (1993)
Over-consumption	Excessive population growth	MacKellar (1995)

Table 3.2. North / South and Related Bipolar Distinctions

Apart from Jasanoff's observation that the consumption / population debate occurs even within a country, the North / South distinction is simplistic in other ways. For example, is it meaningful to classify Singapore as 'Southern', given that this high-technology city state has a higher per capita income, better education and lower infant mortality than 'Northern' Portugal? Similarly, UNDP (1991) has shown that human development is not simply correlated with economic development. Nevertheless, the North / South axis is another along which divergent policy priorities for SD may be analysed. Perhaps more importantly, Jasanoff (1993) argues that "political divisions previously identified with North-South cleavages are now more accurately seen as divisions between fundamentally opposing views about human claims on nature and their mediation by the state", thus pointing towards the importance of subjective cognitive distinctions in analysing sustainability, rather than definitions derived from supposedly objective or technical scientific and economic criteria. These approaches are investigated further below, and also in chapter 7.

(c) Responding to Malthusianism: Intervention and No-Growth

In the *Limits to Growth* debate, pessimists favoured interventionist no-growth policies, while optimists sought to liberalise markets and promote growth. In contrast, Goodland et al. (1991) and MacNeill et al. (1991) are both environmentally pessimistic, yet support different policies. The former recommend redistribution from rich to poor countries, redirecting investment towards improving environmental quality, and *limiting* economic growth. The latter advocate intervention, but in this case to support technological and economic development while *redirecting* them along less environmentally-intensive paths. There would therefore appear to be at least two forms of environmental pessimism, indicating that if is our objective is to provide a complete classification of perspectives on sustainability, we require a richer typology.

Similarly, Ayres (1993) notes that Boulding's "cowboy" / "spaceship" and Kahn's cornucopian / neo-Malthusian axes do not correspond exactly. Cowboys and cornucopians tend to be political conservatives, but cowboys see government as an active, interventionist ally, while cornucopians seek to limit the role of government to macroeconomic policy and defence. Equally, the emphasis in the spaceship is on mutual co-operation and conservation, while the neo-Malthusian world requires restraint, austerity and government-imposed equity.

These distinctions demonstrate that there are additional discriminations in sustainability beyond technological optimism / pessimism, and that a complete typology of SD must include more than two basic types. More sophisticated typologies are discussed below. At this point, concerns might legitimately be raised as to whether a richer typology will aid improved policy making, or simply result in greater complication and confusion. The response, which is addressed in chapters 4 and 7, is that a more complete understanding of reality can usually be translated into superior policies. The converse, of inferior understanding yielding superior policy, only arises by accident. Hence a more complete understanding of SD is desirable.

3.2.2. Multipolar Distinctions within Sustainability

Several authors expand the optimist / pessimist scale with additional categories. Kahn et al. (1976) acknowledge four "world views" ranging from the extreme neo-Malthusian to the extreme "technology / growth enthusiast", with two intermediate positions of guarded pessimism and guarded optimism. Carley and Christie (1992:78) provide a similar four-fold typology based on O'Riordan and Turner (1983) and Turner (1987) (table 3.3).

Deep Ecologist	"Bioethicist, extreme-preservationist, anti-growth".
Communalist	"Resource-preservationist, oriented to limited or zero growth".
Managerial	"Resource-conservationist, oriented to sustainable growth".
Technocentric	"Resource-exploitative, growth-oriented".

Table 3.3. Four Attitudes towards Sustainability

O'Riordan (1991) provides a similar set of four positions along a one-dimensional scale in his analysis of attitudes on biodiversity, in which the first three "world views" match those of Carley and Christie, although the 'technocentric' and 'Gaianist' perspectives have no equivalents (table 3.4).

Absolutist	"Any further species loss is a crime against creation"
Ecologist	"Endangered species and habitats should be protected"
Pragmatist	"Some crude cost-benefit analysis at each stage of [prospective] further loss"
Gaianist	"Earth is a creative force that will eventually establish its own equilibrium of species mix, *within which humans may become marginal*"

Table 3.4. Four Attitudes to Sustaining the Biosphere

MacKellar (1995) identifies three population-environment theories, based on a classification by Jolly (1994), which also fit the four-fold typology. The same structure appears in Pearce et al. (1993:18) in a chapter co-authored by Turner, in which labels are also attached for "weak" and "strong" sustainability, and each idea of sustainability is associated with a preferred view of economic policies, management strategies and ethics. Apart from O'Riordan's Gaianist, these four-fold typologies are seen to be derived from Kahn et al. (1976), and thus in turn from the original technological optimist / pessimist split first introduced by Boulding (1966) (table 3.5).

Colby (1991) proposes two perspectives corresponding to perspective 4 of table 3.5, "environmental protection" and "resource management". He also speculates on the evolution of definitions over the last three decades, arguing that 'frontier economics' and 'deep ecology', which originated with Boulding (1966), were subsequently integrated in the 'environmental protection' paradigm, which in turn spawned 'ecodevelopment'. Colby also mentions Gaiaism, but he does not attempt to classify it.

Proops (1989) also derives four perspectives, based on "paradigmatic images of the world" which he draws from literary sources. These are:

(i) *undisturbed nature*, the hunter-gatherer world where humans are intruders;
(ii) *humankind in nature*, the agricultural world in which nature embodies human presence;
(iii) *the human as creator*, the industrial world in which "nature is a tabula rasa" upon which humankind can write its destiny; and
(iv) *Gaia*, the creative and self-sustaining world.

Perspective 1	Perspective 2	Perspective 3	Perspective 4	Perspective 5	Reference
(no equivalent)	neo-Malthusian	Guarded pessimist	Guarded optimist	Cornucopian	Kahn et al. (1976)
(no equivalent)	Extreme ecocentrism	Communalist ecocentrism	Accommodating technocentrism	Extreme technocentrism	O'Riordan and Turner (1983)
(no equivalent)	Extensionist-preservationist	Naturalist-preservationist	Conservationist	Exploitationist	Norton (1989)
Gaia	Undisturbed nature	*(no equivalent)*	Humankind in nature	The human as creator	Proops (1989)
(no equivalent)	Deep ecology	Eco-Development	Environmental protection	Frontier economics	Colby (1991)
Gaianist	Absolutist	Ecologist	Pragmatist	*(no equivalent)*	O'Riordan (1991)
(no equivalent)	Deep ecologist	Communalist	Managerial	Technocentric	Carley and Christie (1992)
(no equivalent)	Deep ecology	Communalist	Accommodating	Cornucopian	Pearce et al. (1993)
(no equivalent)	Very strong sustainability	Strong sustainability	Weak sustainability	Very weak sustainability	Pearce et al. (1993)
(no equivalent)	*(no equivalent)*	Dependency	Classical / Natural science	Neo-classical	Jolly (1994), MacKellar (1995)

Table 3.5. Five-Fold Perspectives on Sustainability

Proops does not include a paradigm based on communal management, and although he convincingly establishes the identity of the other paradigms, he does not explain why these particular four exist, rather than any others.

Norton (1989) also presents four world-views, along with a detailed historical perspective, although he labels them differently (table 3.5). Unlike the previously mentioned authors, Norton provides a systematic explanation for the perspectives, which he bases on Rawls' (1971) idealised decision model. Rawls posits an "original position" in which free and rationally self-motivated individuals choose from behind a "veil of ignorance" the social arrangements they find acceptable as the basis for a just society. Such individuals in the hypothetical original position do not know what their fortune will be, either economically or in natural abilities, nor their social standing, nor the generation in which they will live.

Norton explains that the different perspectives emerge from a Rawlsian choice under different assumptions. An individual would choose an exploitationist society only if he accepted the Axiom of Abundance, namely that nature's goods are unlimited and infinitely substitutable. He would choose conservationism if he rejected that principle, but did not believe that earlier generations could preclude the existence of later generations. Naturalism-preservationism would follow the view that exploitation could endanger human life, while extensionism-preservationism would be associated with a moral concern that the legitimate interests of non-human species would not be adequately protected by policies to protect human interests.

Table 3.5 demonstrates that there are at least four distinct perspectives on sustainability, or five if the Gaian perspective is included. Some authors develop additional distinctions within these perspectives, such as Colby (1991) as noted above, and Jacob (1994), who provides a detailed comparison of deep ecology, sustainability and anthropocentrism. Redclift (1988) has three positions at the Malthusian end of the spectrum: (i) neo-Malthusianism, based on limits to growth (Meadows et al. 1972) and the tragedy of the commons (Hardin 1968), which could lead in turn to an authoritarian "ecofascist" approach (Pepper 1984), or a political impasse where institutional change does not keep up with environmental change (Commoner 1972, Ehrlich 1974, Myers 1979); (ii) a Marxist perspective that examines distributional issues left untouched by the neo-Malthusians (Redclift 1987); (iii) an "ecocentric" perspective that questions the ends of development, as well as the means (O'Riordan 1981). These more subtle distinctions are discussed in chapters 7 and 8, but they do not add any fundamentally different dimensions to the four-fold classification.

We may summarise these frameworks as follows:

1. Most two-fold and four-fold distinctions are developed along the axis between cornucopian / neo-Malthusianism (or technological optimism / pessimism), which is based on the distinction between cowboy / spaceship economies by Boulding (1966).

2. Some four-fold distinctions, notably those based on images of nature, include Gaianism. This perspective does not appear to be classifiable on an axis between anthropocentrism and biocentrism.

3. Few authors provide theoretical justifications for the classificatory typologies they propose. The exception is Norton (1989), who derives alternative perspectives by considering hypothetical rational responses under a Rawlsian veil of ignorance. Proops (1989) explains world views in terms of "utopias", or desired images of the future, and although he includes Gaianism, he does not explain why there should only be four utopias.

4. Differences between definitions of sustainability are associated with alternative assumptions regarding the stability and resourcefulness of the natural world, the potential for future technological innovation, and humanity's ethical responsibilities towards other species, future generations, and less privileged members of current generations. Many definitions of SD are restricted to scientific or economic criteria, but these are seen to be inadequate if we wish to develop a complete definition that includes social, cultural and ethical components.

The way in which several authors start from different positions and converge on a similar four-fold typology suggests that this framework reflects something fundamental about the sustainability debate, which is addressed in greater detail in subsequent chapters. The next two sections examine other frameworks for defining sustainability originating from systems and economic approaches.

3.2.3. Systems Approaches for Understanding Sustainability

The definitions of sustainability in section 3.2.2 are socio-economic or political in nature, but an alternative path towards understanding sustainability can be derived from ideas in systems theory. Since the social and environmental phenomena of SD comprise complex interrelated sets of elements and processes, they are systems phenomena. Furthermore, since human and natural systems are profoundly linked, no issue is purely human or purely environmental (Dovers and Handmer 1992, Redclift 1987). Human systems also have attributes that complicate analysis of sustainability (Checkland 1981):

(i) complexity: the human agents in the system are active participants, cognising and strategising reflexively (Soros 1994);

(ii) frequent non-repeatability plagues analysis;

(iii) there is a related difficulty in generating laws with any longevity in explaining system behaviour.

Systems approaches within sustainability arose from work in ecology, particularly the concept of *resilience* in populations and ecosystems. In his seminal work, Holling (1973) defined resilience, as opposed to *stability*, as the ability to persist by absorbing changes to key variables and parameters. Conway (1985, 1987) applied systems thinking to analysis of agricultural ecosystems, for which he identified four properties: (i) productivity: system output; (ii) stability: constancy of production of output; (iii) equity: evenness of distribution of output; and (iv) sustainability: system ability to maintain output after disturbance, which is equivalent to Holling's resilience. Building on Conway's work, Dovers and Handmer (1992) suggest that:

> "Sustainability is the ability of a human, natural or mixed system to withstand or adapt to endogenous or exogenous change indefinitely. Sustainable development is therefore a pathway of deliberate change and improvement which maintains or enhances this attribute of the system, while answering the needs of the present population".

Norgaard (1988) takes a similar approach towards a co-evolutionary view of SD, based on six key concepts: complexity, continuous evolution, reflexivity, culturally framed perception, learning through trial and error, and learning in organisations. Norgaard argues that the world's complexity ensures that no single way of understanding it is sufficient and, even with multiple ways, we will periodically be surprised. Definitional frameworks should therefore be plural and inclusive, and their success may be judged by whether they "reduce single-minded intransigence". O'Connor (1991) explores the implications of thermodynamic theory, entropy and far-from-equilibrium conditions, and draws similar conclusions about the need for multiple levels of explanation in SD. Other perspectives on systems approaches to sustainability are provided by Ayres

(1984), Bossel (1987), de Young and Kaplan (1988), Foy (1990), Shearman (1990), Common and Perrings (1992), Hourcade et al. (1992), Ayres (1993), Binswanger (1993), Dovers and Handmer (1993), Drepper and Månsson (1993), Perez-Trejo et al. (1993), Giampetro (1994), Holling (1994) and Clark et al. (1995). Although these authors lay out a broad range of theoretical approaches, they do not develop a unified perspective on the definitional or policy implications of complex systems approaches for SD. These issues are considered in more detail in chapter 5.

In summary, many authors sense the importance and potential of systems approaches in shedding light on the meaning of SD, but the ideas still need to be operationalised and set in a policy relevant context. Checkland (1993), cited by Roberts (1994), believes that "there is little evidence that policy making at the highest levels is ever affected by systems thinking", perhaps because most applications of systems approaches are lax or nebulous: "the apparently all-embracing scope of systems thinking offers to many people a heady elixir. We should decline to drink it". Nevertheless, systems approaches for understanding sustainability complement socio-political approaches, and should be integrated alongside them in an overall theoretical framework.

3.2.4. Economic Approaches for Understanding Sustainability

Economic definitions of sustainability have been developed within environmental and ecological economics, which provide an additional dimension to economic theory to deal with exhaustible and renewable natural resources. The mainstream approach of environmental economics (Dasgupta & Heal 1979), the history of which is explored by Klaasen and Opschoor (1991), is based squarely within the neo-classical paradigm, and is therefore subject to all the criticisms directed at neo-classical theory. In particular, the neo-classical assumptions of equilibrium, decreasing returns to scale, and rational economic actors are contested (Simon 1978, Anderson et al. 1988, Arthur 1994, Ormerod 1994, Parker and Stacey 1994, Trisoglio 1995b). These criticisms tend to be ignored, however, in economic discussions of sustainability.

A typical economic definition of sustainability is "non-declining utility of a representative member of society" for some long time period into the future (Pezzey 1989, 1992:323), which in turn requires that each generation should leave the next generation a stock of capital no less than it started with (Pearce et al. 1993). Since capital comprises both natural and man-made capital (Pearce et al. 1989), two further possibilities arise: (i) the constant capital rule may refer to any sort of capital; or (ii) natural capital must be conserved separately, to take account of ecological and biophysical uncertainty and irreversibility. Pearce et al. (1993) label these variants as weak / strong sustainability respectively, as noted in section 3.2.2. Apart from the strong criticism by Beckerman (1994) of this approach and its contradictions, another important critique of the neo-classical approach is directed at the valuation of natural capital stocks in terms of price.

Several techniques exist to assign monetary values to natural resources, for example in order to use these values in cost-benefit analysis or to 'correct' estimates of GNP and GDP in national accounts (Pearce et al. 1989, 1993). Apart from ethical and moral objections to this reduction of values, needs and welfare to monetary aggregates (Ekins 1986, Adams 1995), such valuation exercises say nothing about the complex behaviour of the biogeochemical systems that comprise the environment. They may, for example, reflect the opinions of laymen on the economic value of the ozone layer or the climate system. But they provide no policy-relevant information regarding the likely costs or benefits that might arise were such systems to be modified as a result of human activities, not least because the scientific basis for such predictions is not yet available (Jasanoff & Wynne 1995). Furthermore, green economic approaches are weak at explaining or evaluating entrepreneurship and technological innovation, especially the way information technology is revolutionising the global economy (Marien 1994a), which leaves them unable to explore the dynamics, and hence sustainability, of global economic change. These problems are discussed further in subsequent chapters.
An alternative approach to economic thinking is provided by 'green' or ecological economics. Pioneered in work such as Schumacher's *Small is Beautiful* (1973), green economics is less an attempt to describe economic behaviour than it is to propose a vision of what would constitute a more human-oriented, spiritual and ecologically harmonious economic system, which it would argue is the basis of a sustainable world. Its critique of neo-classical economics is therefore not that it fails to give a theoretically

convincing and experimentally verifiable account of economic decision making, but rather that it ignores fundamental human, social and environmental values in its calculus, and thus promotes unfairness, inequitable development, social decay and environmental degradation (Daly & Cobb 1990, Costanza 1991, Jacobs 1991). The case for including social concerns is that a system that is biophysically sustainable may nevertheless be socially unsustainable, for example due to growing divisions in society (Brooks 1992).

Although much of ecological economics takes a values-based critique, it also has a strong component that stresses thermodynamic and biophysical constraints on economic growth (Georgescu-Roegen 1971, Meadows et al. 1972, Daly 1992a), and argues for the transition to a steady-state economy in the face of fundamental limits to growth. The neo-classical rebuttal of this argument observes that neo-classical theory only speaks of growth in value, which says nothing about growth in physical scale of the economy (Pearce et al. 1993:5). In response, ecological economists point out that historically there has been a close correlation between economic growth and growth in physical scale of the economy (Daly 1992a:9). Since it is essentially about whether historical and technological trends can be extrapolated into the future, this *Limits to Growth* debate is likely to continue indefinitely. It is, in fact, simply restating in different language the technological optimism / pessimism dichotomy explored in section 3.2.1.

Another variant on this theme, and of the weak / strong distinction, is the idea of "critical natural capital" (Pearce et al. 1993:16), which includes environmental assets that are vital for human well-being or survival, for example biogeochemical cycles. Pearce argues that such critical capital, which is presumed to be non-substitutable, should be subject to the constraint of strong sustainability. The problem is that this criterion is non-operational, since we return to unanswerable questions such as: Are there limits? If so, in which biogeochemical systems? This takes us back to the fundamental environmental uncertainty and complexity, and the optimist / pessimist distinction. The underlying complexity means no one economic definition is "correct", thus rendering unsuccessful Pearce's attempts to reduce the definitional plurality.

Any economic approach which seeks to assign value to natural systems and their components must confront the basic scientific and technological uncertainties at the root of socio-political alternatives discussed in 3.2.2. In addition, reductionist economic approaches are not compatible with the non-reductionist systems approaches introduced in 3.2.3, while economics also makes no claim to illuminate the moral or ethical aspects of sustainability. Finally, both environmental and ecological economics are vulnerable to critiques directed at neo-classical economics, especially from complex systems, Austrian, game-theoretic and strategic perspectives. The economic definitions of sustainability thus have severe shortcomings, despite their high profile in SD policy discussions.

3.3. Summary and Ways Forward

The theoretical underpinning for sustainability is in disarray. As Section 3.2 demonstrated, there are several competing frameworks to classify definitions of SD, although none provides either a complete typology or a theoretical underpinning for the categorisation. Some authors seek to provide comprehensive interdisciplinary definitions, such as Brown et al. (1987), Liverman et al. (1988), Brooks (1992) and Pezzey (1992), but in their attempt to provide policy-relevant conclusions, they reduce the complexity and indeterminacy of the SD debate and become trapped in just one of the perspectives of table 3.5. Other authors claim to have produced integrated definitions of sustainability, for example Gladwin, Kennelly and Krause (1995) propose that a "sustaincentric" paradigm can be derived from a "Hegelian synthesis" of technocentrism and ecocentrism. In fact, these exercises do not consider the full diversity of definitional frameworks already present, and so merely regenerate existing perspectives. Environmental and ecological economics also propose several definitions of SD based on natural capital, but fail to provide an exhaustive typology or to explain any non-economic definitions, while themselves being limited in the face of complexity.

Developing a definitional framework remains a complex and unresolved issue, as recent analyses of SD confirm. Brooks (1992) observes that sustainability is "extremely difficult to apply unambiguously" in decision making, not least because it is a "highly interdisciplinary" concept, including technical, economic, social, environmental and cultural factors which interact in ways that are "complex, and often unpredictable and surprising". Heinen (1994) argues that the wide variety of ways in which sustainability has been used make "analyses of and broad conclusions from the existing literature difficult", although he also concludes that "there is a great need to develop a theoretical paradigm". Such a paradigm would not only have to provide a complete typology of definitions, but also an underlying theory to support the typology.

We might expect to find such a theory within the social sciences since their "principal claim" is their ability to explain and interpret human cognition and behaviour towards the environment (Benton and Redclift 1994), which would include questions of definition. Interpretative frameworks are provided by, among others, sociology (Buttel and Taylor 1994, Redclift and Woodgate 1994, Skair 1994), gender analysis (Jackson 1994) and social studies of science (Wynne 1994), although none of these theories offers a typology for SD definitions. By contrast, cultural theory (Thompson et al. 1990, Schwarz and Thompson 1990) sets out both a theoretical framework and a typology which appears to shed light on the typologies derived by other authors. Cultural theory's claims and insights are set out in chapter 7.

In addition to socio-economic and political approaches to understanding SD, several authors have begun to explore the potential of explanatory frameworks based on systems theory and complexity. Although they present tantalising theoretical insights, these have not been combined into a convincing whole (Simon 1989) and their application to operational questions of definition and policy making remains embryonic. Furthermore, the socio-economic and systems approaches appear to be following separate paths, and the potential insights from their integration remain untapped. The implications of a complex systems approach are presented in chapter 5, and then combined with social science approaches in analysing SD policies in chapters 8 to 12. These chapters demonstrate how cultural theory and complexity can form the basis of a coherent theoretical underpinning for sustainable development.

Chapter 4: Two Policy Models for Sustainable Development

4.1. Introduction

The issue of sustainability can be viewed in two ways, theoretical and operational. Chapter 3 found that there is no clear theoretical structure for SD, which is evidenced in the proliferation of incompatible definitions, and which has frustrated attempts to develop clear objectives and criteria to guide policy. Chapter 4 turns to the debate at the operational level of designing appropriate policy processes and institutional forms, and establishing the appropriate role for science and modelling in guiding policy.

Many in the SD policy debate contend that resolving theoretical and definitional problems has little relevance to the business of developing effective policies (Schmidheiny et al. 1992, Beckerman 1994). However, an analysis of the two principal policy paradigms confirms that not only is there an active debate about the best approach to policy, but also that this debate stems from the same theoretical lacunae that underlie the definitional confusion. In particular, the concepts of plurality and complexity play a pivotal role.

This chapter examines the two dominant *policy models* and their underlying theoretical assumptions, and explores why a policy approach based on plurality and complexity is becoming increasingly relevant in a complex and unpredictable world. The operational significance of policy models is illustrated with reference to the debate on climate change, and the chapter concludes by observing that analysis and policy design for SD at the operational level has the same need for new theoretical frameworks as was identified for SD definitional frameworks in the previous chapter.

4.2. The Comprehensive/Rational Policy Model

Although the details of environmental policies vary significantly among countries (Andersson et al. 1992), the dominant policy paradigm since the beginning of modern environmentalism in the 1960s has been based on a comprehensive/rational model (Briassoulis 1989), which has three key components: (i) objective and exhaustive analysis of the environmental and socio-economic problems under consideration; (ii) identification and formulation of alternative solutions; (iii) selection of the best solution using objective scientific criteria. Winsemius (1990) proposes a model of the policy life cycle with the four stages of problem recognition, policy formulation, implementation and control, in which there is a similar separation of analysis, policy choice and implementation.

The model is labelled 'rational' because of its analytical approach and reliance on supposedly objective scientific and technical decision criteria. Briassoulis observes that policy is not only guided by scientific criteria, since as awareness of the costs of environmental policies has grown, decision making has increasingly included cost-benefit type assessments and other economic criteria in the decision process (Pearce et al. 1989). Winsemius notes that while the policy formulation phase is characterised by results-orientation, in which effectiveness has a higher priority than concern over costs, policy measures are often refined during the implementation phase to reduce costs and improve efficiency, when the need for economic analysis becomes necessary. There are, however, counter-examples to this model, such as the way that IPCC Working Group III is focusing on cost-effectiveness early in the policy formulation process, or the rise of cost-effectiveness considerations in policy formulation more generally (Schmidheiny et al. 1992).

The term 'comprehensive' reflects a desire to be as complete as possible at each stage in the decision process, from building detailed models, to considering a wide range of potential solutions, to using a full set of scientific and economic criteria in selecting policies. The approach is summarised in former White House Chief of Staff John Sununu's tenet that "You do not establish policy on the basis of incomplete models" (*Newsweek* 1989).

Three observations may be made regarding this policy model:

(1) *Linearity*: decisions are made in a two-stage linear process, with analysis preceding action: first there is construction of models, assessment of alternatives and selection of the best solution. Then, when the solution has

been identified, the stage of implementation and action begins.

(2) *Analysability*: the system must be analysable, and enough information about must be obtainable through direct observation or modelling, in order to enable selection of the best solution.

(3) *Harmonisability*: it must be possible to reach agreement on what constitutes a 'good' solution, which is often achieved through decision criteria that are formulated in supposedly 'neutral' scientific and economic terms.

Briassoulis (1989) argues that the comprehensive/rational approach "has run into many obstacles" which reflect a tension between the characteristics of the environmental problems considered and the capacity of the decision system to handle them. The shortcomings are typically evident during implementation when, for example, the policy does not achieve its intended objectives, or the problem is seen to have been wrongly defined. These difficulties can be related to the characteristics of the policy model identified above:

(1) *Action Before Analysis*: political pressures typically prompt action before analysis is complete, especially with growing calls from media and public interest groups for 'solutions' and 'leadership' (Hourcade et al. 1992). Winsemius (1990) notes that a more realistic model has analysis overlapping with action, and Jasanoff and Wynne (1995) observe that in the case of the Montreal Protocol, political agreement actually predated scientific consensus regarding ozone depletion (Benedick 1991). Analysts have noted that this trend is being reinforced by calls for precautionary and anticipatory action ahead of scientific certainty in situations of significant environmental risk (Woodell 1989, O'Riordan and Cameron 1994, Adams 1995). Action may also precede complete analysis if the problem is too complex, if data and scientific results are unavailable, or in order to test hypotheses or experimental policy solutions.

(2) *Unanalysability*: it is becoming evident that many SD problems, which involve intricate interdependencies of social and natural systems that are themselves complex, are unanalysable in practice and perhaps also in principle. In such cases, Ravetz (1986) argues that when scientists are asked by policy makers "What will happen, and when?", they must in all honesty reply "We don't know, and we won't know, certainly not in time for your next decisions". In the face of unanalysability, policy makers may turn to *incrementalism*, concentrating on sub-problems in order to increase their tractability (Lindblom 1973), *contingency* planning to hedge against potential adverse conditions (Bolan 1967, O'Connor 1978), or *adaptive* planning that develops solutions to problems in an anticipatory manner on the basis of predictions of future events, and adapts the plan in the light of changes in goals, revised predictions of the future, or the availability of new evidence (Holling 1978, Daneke 1983).

(3) *Plurality*: there are divergent perceptions on the extent of environmental problems and the appropriate policy interventions to provide solutions, as chapter 3 illustrated. In the face of plurality, policy may enter into an *advocacy* mode characterised by "survival of the fittest", normally those with greatest political influence (Briassoulis 1989). Alternatively, a *participatory* process based on a pluralistic view of reality may be set up, with efforts directed to finding common ground among stakeholders, resolving differences and distributing costs and benefits equitably (Bacow and Wheeler 1984, Bingham 1986, Carley and Christie 1992, Sharp 1992). The call for increased plurality is consistent with the findings of decision theory that parties seeking agreements on actions should seek to include a wide range of dimensions in their negotiation, since this increases the possibility for win-win rather than zero-sum outcomes (Fisher and Ury 1981, Raiffa 1982).

For more complex problems, the scientific and economic assessment of options requires computer simulation modelling, which has assumed an important role in short-range policy guidance and long-range opinion formation (Ayres 1984), especially in the climate change debate (Boehmer-Christiansen 1994a, Jasanoff and Wynne 1995). The objective of such modelling is to determine the crucial "parameters" of "global change" and, if possible, its dynamics so as to make models predictive. These predictive assessments, in turn, lay the basis for elaborating policies and negotiating agreements (Jasanoff and Wynne 1995). The impact of the growing technical sophistication of decision processes is unclear, however, as governments continue to simplify problems in public debate (Pestel 1982), while the scientific and economic decision criteria are rarely adhered to strictly since, as Boehmer-Christiansen (1994a) points out, "political obstacles to rational solutions are usually overwhelming". The comprehensive/rational model is therefore perhaps better seen as a utopian 'myth' than a reflection of reality, although it is still worth inquiring whether this particular utopia is a sound basis for policy.

Slocombe (1993) contends that critical discussion of the comprehensive/rational policy model has questioned the process of developing policies, rather than their analytical foundations. This observation is especially true of environmental groups, whose policy objectives typically include securing a more open and democratic decision process (Bramwell 1994). Hence we see governments moving to make policy processes more plural and participatory, while at the same time building up the analytical and model-based approach at the centre of the comprehensive/rational model. This trend has been reinforced by the growing involvement of business and industry, whose lobbying calls for decisions to be based on "sound science" and cost-benefit analysis (Cairncross 1991, Schmidheiny et al. 1992, Robins and Trisoglio 1992, Trisoglio 1993, Eden 1994). Boehmer-Christiansen (1994a) suggests that scientists and modellers are likely to support the comprehensive/rational approach, since stimulating governmental interest in improved modelling to reduce uncertainty and enable more rational decision making is a rich source of research funding, although this interpretation is rejected as simplistic and misleading by Moss (1995) and Shackley and Skodvin (1995). Nevertheless, ambitions for predictive modelling are increasing (van den Bergh and Nijkamp 1991), notably with the US Global Change Research Programme's plan to develop a comprehensive predictive capacity to support SD policy (CEES 1992), and the growing role of modelling is giving a new lease of life to the comprehensive/rational policy model (Bella et al. 1994).

Despite this rising tide, increasing numbers of authors are questioning the validity of a comprehensive/rational policy process given the scarcity of information, controversies in science, difficulties in modelling, and sheer complexity of natural and social systems (Ravetz 1986, Briassoulis 1989, Carley and Christie 1992, Bella et al. 1994, Boehmer-

Christiansen 1994a, Jasanoff and Wynne 1995). There is growing awareness that an alternative policy model would be more appropriate, as explored in the following section.

4.3. The Complex/Adaptive Policy Model

The comprehensive/rational approach can be characterised by an assumption that the systems and policy issues under consideration are 'simple', and thus amenable to detailed analysis and predictive modelling to select the optimum policy. Those adhering to the 'simplicity' perspective continue to maintain that predictability is possible, and even that "accurate forecasting is a prerequisite for trouble-free civilisation" (Watt 1990).

In contrast, the complex/adaptive model assumes that policy issues are complex, with an irreducible unpredictability and uncertainty, as well as limits to analysability that preclude the search for optimal policies. If we cannot analyse the system and predict its behaviour under alternative policy regimes, then the comprehensive/rational model cannot be applied, since we cannot evaluate alternative courses of action or select an optimum. We therefore require another policy model, the outlines of which are identified below. The question of whether SD issues are 'simple' or 'complex', and the importance of complexity theory in studying natural and social systems, is explored in chapters 5 and 6.

The first step beyond predictability is the introduction of ideas of uncertainty and risk. In the face of uncertainty, maintaining the comprehensive/rational notion of an optimal policy requires reducing the indeterminacy and complexity of the world to the more quantifiable idea of uncertainty (Shackley and Wynne 1995). Selecting optimally then implies a choice between a limited number of knowable outcomes of differing probability, using tools such as risk assessment (Adams 1995), cost-benefit assessment (Pearce et al. 1989), stochastic optimisation (Ermoliev 1995), and numerous variants of decision theory (Carley 1981, Clark and Munn 1986, Morgan and Henrion 1990, Carley and Christie 1992).

While this approach is undoubtedly attractive for decision makers who wish to project an image of control and optimisation (Grzybowski and Slocombe 1988), such quantification of the non-quantifiable camouflages, rather than resolves, the underlying indeterminacy. An example is provided by the Nobel prize-winning economist Herbert Simon, who recalls his experience as chairman of a National Academy of Sciences committee whose job it was to advise Congress on the control of automobile emissions (NAS 1974, Simon 1978). Simon (1978:13) summarises the problem:

> "It is easy to formulate an SEU (subjective expected utility) model to conceptualise the problem. There is a production function for automobiles that associates different costs with different levels of emissions. The laws governing the chemistry of the atmosphere determine the concentrations of polluting substances in the air as a function of the levels of emissions. Biomedical science tells us what effects on life and health can be expected from various concentrations of pollutants. All we need to do is attach a price tag to life and health, and we can calculate the optimum level of pollution control. There is only one hitch . . . None of the relevant parameters of the various 'production functions' are known - except, within half an order of magnitude, the cost of reducing the emissions themselves . . . The physics and chemistry of the atmosphere presents a series of unsolved problems . . . Medical science is barely able to detect that there *are* health effects from pollutants . . . What constitutes procedural rationality in such circumstances?"

Sonntag (1986) similarly argues that the comprehensive/rational approach fails to shed useful insights on the issue of sustainability, which is complex, dynamic and full of surprises that "defy the principles of optimality", while Macrae (1994) contends that the "sport" of business or government economic planning is in any case "a pastime of rapidly declining self-importance". Instead, policy making in a complex world requires us to end the pretence of optimisation, and adapt a complex/adaptive model (Brewer 1986, Clark 1986, Norgaard 1988, Schwarz and Thompson 1990, Brooks 1992), some of the features of which are:

(1) *Incompleteness*: the world is more complex than can be represented in any model or taken account of in any decision-making process, as chapter 5 discusses. As a result, any model or decision is necessarily incomplete. Since some of the things that are left out are likely to be important, models and

policies will be incorrect or inapplicable in certain respects, and will need to be changed when these errors are discovered.

(2) *Non-Optimised*: since it is impossible to build a complete model or test all options, an optimal policy cannot be discovered, although it may still be possible to differentiate between better and worse decisions. In the face of uncertainty, unpredictability and surprise, however, it may not even be clear what constitutes a better decision, since it may not be possible to assign "value" until the decision outcomes are understood and evaluated (di Castri 1986, Ravetz 1986, Allen 1990, Bella et al. 1994). Moreover, as Sagoff (1994) argues, a universal metric of optimality is unattainable since "every important decision, policy, or institution is path-dependent, and must be understood in terms of values that resonate locally and historically".

(3) *Non-Predictive*: Holling (1986) concludes that the inevitability of surprise and non-linear behaviour in complex natural and social systems means that "there is now less of a priority to develop predictive tools than to design systems with enough flexibility to allow recovery and renewal in the face of unexpected events". The objective of modelling is therefore no longer seen as prediction, but as assisting exploration and simulation in complex decision environments (Clark et al. 1995, van Asselt and Rotmans 1995), while tools other than computer models, such as policy exercises, scenarios and games, are also seen to have a role in assisting policy making (Brewer 1986).

(4) *Learning*: a policy model and its supporting institutional structures must be based on learning and ongoing adaptation since models are inevitably incomplete, prediction is impossible, and natural and social systems are constantly changing. A successful learning environment typically encourages experimentation, tolerates failure and nurtures mental map-building, while being structured enough to support the generation of options and ideas (Cantley 1986, Norgaard 1989a, Bardwell 1991, Brooks 1992, Carley and Christie 1992), although some environments will not be suitable for learning since failure could have catastrophic consequences. Rayner (1986) also argues that we must examine the social roots of ignorance, since we recognise, select

and 'edit' problems on the basis of their societal implications.

(5) *Experimentation*: since solutions cannot be found purely analytically, learning implies taking action rather than simply collecting knowledge (Brooks 1992), and it becomes a question of "courting surprise" and encountering "appropriate events" to learn from (di Castri 1986, Timmerman 1986, Allen 1990). Thompson (1986) argues that all knowledge of a complex reality is inevitably partial, so that we must proceed on the basis of our diverse understandings of the world: "There is no final solution; there is no complete knowledge. All we can do is learn and tinker, tinker and learn. Diversity, contradiction, contention and criticism are our finest resources".

(6) *Resilience*: in the face of unpredictability and potentially unpleasant surprises, policies and institutions should be designed so as to be resilient (Holling 1978, 1986, Norgaard 1989a). Resilience includes the ability to retain form and function in the face of changing external conditions, and to tolerate mistakes and errors. It requires flexibility (Dovers and Handmer 1992) and usually a degree of redundancy and spare capacity which the comprehensive/rational model would consider non-optimal. Resilient institutions also permit bolder exploration, which encourages more innovative solutions and promotes learning (De Young and Kaplan 1988). Sonntag (1986) argues that to secure resilience, we need new adaptive and flexible tools that seek to improve decision processes in the face of complexity, rather than focusing narrowly on securing supposedly 'optimal' outcomes.

(7) *Plurality*: in addition to the political benefits of including many points of view, a plural process is advisable in a complex world since it is likely that a more diverse group will be able to bring more insights, experiences and world views, and thus improve the resilience of policies and institutions (Norgaard 1988, 1989a, Söderbaum 1994), although the resulting *clumsy institution* (Schwarz and Thompson 1990) will not be optimal from any one point of view (Shrivastava 1994). Brewer (1986) argues that any model "embodies a single perspective", and games, scenarios and policy exercises are better ways of including plurality and stimulating the critical imagination needed for

"thinking complex" and developing polices for sustainability in a complex world.

(8) *Reflexivity*: human actors are reflexive, that is they respond to their changing environment, including changes that are introduced by policy interventions and the actions of other agents, and also to their changing perceptions of future environments, and they modify their behaviour accordingly (Soros 1994, Adams 1995). A complex/adaptive approach to policy needs to be sensitive to the inevitability of this compensating behaviour, and its implications for policy and institutional design.

These eight features form a set of 'design principles' for policies and institutions suited to a complex world, but the sustainability literature does not generally explain how these principles can be translated into practice. For example, there is no advice on how to create a clumsy institution, nor on the precise nature of resilience, nor on the most effective structures for learning. Where there are exceptions, they tend to emphasise plurality and participation in the decision process without addressing the policy outcomes. For example, Carley and Christie (1992) explain how to create *action-centred networks* as the appropriate institutional response to complexity, which "emphasise the role of partnership between government, business and community groups, and consensus-building as a precondition to action" on issues relevant to SD. Yet even a participatory process may produce policies and institutions that are non-resilient and poor at learning, so participation alone does not guarantee success in a complex world.

It is clear, therefore, that the complex/adaptive model must focus not only on the policy *process*, but also the *outcomes* in terms of policies, strategies and institutional structures, and the specific tools that can guide decision making towards more appropriate outcomes. The sustainability literature discusses the overall directions and design principles, but has little advice on how to create appropriate institutions and strategies. These operational issues, however, are the concern of management scientists and organisational theorists, who have studied organisational learning and the design of resilient strategies and institutions, although they have not applied their insights to the SD debate. These parallel lines of inquiry provide the basis for a fruitful synthesis, which is taken up in chapter 12.

4.4. Science and Policy

The complex/adaptive policy model also has implications for the relationship between science and policy (Clark and Munn 1986). O'Riordan and Rayner (1991) call for "a new interdisciplinary science" to manage the large, non-linear systems of global environmental change, while Slocombe (1993) proposes that the approach should be systems-oriented, plural, adaptive, long-term and participatory. Wahlström (1992) also calls for a pluralistic learning process given his concern that "the utilisation of complex technologies involves the dilemma of a need for better predictability at the same time as technical development is decreasing it". Wiman (1991) suggests repositioning science as an early warning system for impending ominous non-linearities rather than as a management guide, while Bella et al. (1994) see the role of science as a more exploratory investigation of how "order and disorder act over time". While some authors continue to expect clear answers from science (Speth 1989), a more widely shared conclusion is that the status of scientific knowledge will shift with growing complexity (Hunt 1994, Wynne 1994, Jasanoff and Wynne 1995).

With this change, the political aspects of decision making may become more important. O'Riordan (1992) argues that neither causalities nor probabilities are understood for major environmental problem, and Boehmer-Christiansen (1994b) builds on this to propose that political ability to motivate attitudinal and behavioural change in society may be more important than science in attaining sustainability. Bruce et al. (1995) point out that cost-benefit analysis is not useful for questions involving equity, such as how the costs and benefits of climate change should be shared. Sardar and Ravetz (1994) believe that once our predictive powers are seen to be inadequate in the face of complexity, "the burden of proof (assigned by essentially political means) may turn out to be more important than the arguments on either side". Redclift (1992) goes further, and argues that sustainability will be built not on "the uncertain predictions of natural scientists . . . [but] upon the daily lives of human subjects". Others argue that human values can enrich an ethically and culturally limited Western science (Carley and Christie 1992) or, more critically, that the 'new' sciences of complexity may simply be the latest post-colonialist appropriation of non-Western ideas (Sardar 1994).

Further insights about the changing role of science and knowledge in the face of complexity arise outside the sustainable development debate, within philosophy and postmodernism (Lyotard 1984, Popper 1965, Harvey 1990, Prigogine 1989). These ideas are explored further in chapter 5.

4.5. The Role of Modelling

Computer modelling, whether intended for prediction or simulation, plays an important role in policy formulation. Clark (1986) shows that it is the most common synthetic method for handling scientific knowledge with policy implications, and observes that a substantial literature has emerged regarding its strengths and weaknesses. Reviewing this literature, Brewer (1986) concludes that large computer models are now part of the SD problem rather than part of the solution, a conclusion shared by Jasanoff and Wynne (1995). A central criticism is that formal models take a single approach to a problem, and usually reflect a single set of underlying assumptions, not least because of the time and expense required for experimenting with alternative perspectives. The model thus reflects just one of many perspectives, and typically ignores "the most interesting aspect of any analysis . . . the set of assumptions used to fashion it" (Brewer 1986). In the light of the plural definitions of SD uncovered in chapter 3, it is clear that any single perspective only represents a partial view of the underlying reality, which undermines the proposed status of modelling as a comprehensive/rational tool. Recent climate models have attempted to overcome this shortcoming (van Asselt and Rotmans 1995), although any dynamical model that is dependent on a fixed parametrised structure remains inherently limited in this respect (Allen 1987, 1990, 1994).

The significance of assumptions in model building can be illustrated with reference to the IIASA study *Energy in a Finite World* (Häfele 1981). This study of world energy futures used three large interlinked computer models, comprising several thousand variables, that purported to represent the relationship between energy supply, energy demand and economic impacts. The model outputs were a set of scenarios which showed a growing gap between energy supply and demand in the future, and the policy analysis based on these results was influential in shaping the national energy policies of, among others, the

Soviet Union, West Germany and the UK. Although the model was presented as a rational and scientific tool, an analysis of the model structure (Keepin and Wynne 1984, Keepin et al. 1984) found that the 4,000 variables of the three computer models were essentially playing no role in affecting the model outputs. Instead, the output scenarios were directly linked to the input assumptions "that provided the cultural cohesion for the project" among its 250 research scientists (Schwarz and Thompson 1990). Despite the enormous intricacy of the model, its outputs were essentially determined by the input assumptions and, far from being a neutral scientific tool, the model produced results reflecting the cognitive and cultural assumptions built into its structure.

Modellers like to present their methodologies as neutrally technocratic (Shackley and Wynne 1995), yet there are numerous decisions in model building that constrain a model's behaviour. These include the selection of variables of interest, the definition of system boundaries, the choice between parameters and variables, the choice of model structure, and the suppression of chaotic or unstable model behaviour (Søgaard 1993, Clark et al. 1995, Jasanoff and Wynne 1995). During testing, a model's outputs typically do not match reality, so the further problem arises of which part of the model to change. Few modellers nowadays hold that their models are predictive, with most arguing that they seek instead to illustrate the basic dynamic tendencies of the system under consideration (Van Asselt and Rotmans 1995), which Meadows et al. (1973) argued for the World3 model used in the *Limits to Growth* study. This argument must still contend with the critique that such tendencies will reflect the numerous assumptions that are built into models (Robinson 1990, MacKellar 1995), while facing the additional problem that the idea of "basic tendencies" is meaningless, since a non-linear dynamical model with more than five parameters can display essentially any behaviour depending on the choice of parameter values (Ayres 1984). For example, Boyd (1972) demonstrated that World3 could be modified to yield optimistic results, rather than the collapse predicted by Meadows et al. (1972), by the addition of one more dependent variable, "technology", and some plausible parametric assumptions about the relationship between technology and the other variables.

Bella et al. (1994) and Jasanoff and Wynne (1995) conclude that modellers are generating expectations of prediction and control that simply cannot be met, while at the same time limiting plurality by excluding perspectives, framing issues in ways that are non-transparent, and generating results that are of ambiguous scientific meaning. Noting these critiques, Clark (1986) argues that improved decision tools are "badly needed", while Grzybowski and Slocombe (1988) argue that cybernetisation is "a trap". For example, Clark favours informal, non-mathematical techniques such as scenarios and "policy exercises" based on writing "future histories" to capture alternative perspectives and knowledge in a policy relevant context and support decision making. The potential of these and other tools is explored further in chapter 13.

4.6. The Comprehensive/Rational Policy Model in the Climate Change Debate

The climate change debate since the late 1980s provides an example of the comprehensive/rational policy model in action. The climate system is extremely complex, and scientific understanding of it is highly incomplete. McElroy (1986) and Crutzen and Graedel (1986) find that the Earth's atmosphere, oceans, soils and biota are intricately linked by material flows, energy flows, and flows of major chemical compounds such as carbon, nitrogen, oxygen, sulphur and phosphorous. Clark (1986:15) argues that "these interactions are complex, often non-linear, and . . . give the biosphere a propensity for discontinuous change, characterised by threshold responses and multiple domains of stability".

There are at least 21 major sources of uncertainty in ocean dynamics, Biospheric processes, atmospheric chemistry and climatology (den Elzen 1993, Van Asselt and Rotmans 1995). Of these processes, six exhibit positive feedback, seven are negative feedback, and eight are unknown. The magnitude of all but two is unknown to within ±30%, with seven having uncertainty of at least 50% (IPCC 1990, Gates et al. 1992, IPCC 1992, Wigley 1994). Lovelock (1986) evaluates our current scientific knowledge of these biogeochemical cycles and biogeophysical processes as "a vast ignorance, illuminated only by an instinct that warns us not to act precipitately", while also noting that "in the complex and non-linear real world, theory is often the *post hoc* explanation of a practical success".

These processes are modelled in large computer-based Global Circulation Models (GCMs) and Integrated Assessment Models (IAMs), which are not only limited by scientific uncertainty, but also by technical modelling issues such as ocean flux corrections and inadequate representation of clouds (Jasanoff and Wynne 1995). In 'resolving' such difficulties, arbitrary technical 'fixes' are introduced into the models, while poorly understood feedbacks are simply left out (Leggett 1990). Of the five major world GCMs, only the US NCAR group has refrained from such fixes, since they contaminate a model in unknown ways and seriously undermine its use in understanding climate, but NCAR has paid the price of having an unstable model which cannot produce long-term predications (Jasanoff and Wynne 1995). Dickinson (1986:281) argues that even if there were large improvements in climate modelling and monitoring, "serious constraints would still remain in the creation of 'usable knowledge'", while Parry (1986) finds that although models to assess the impacts of climate change are becoming more complex, our knowledge is still at the stage of "naiveté".

The Intergovernmental Panel on Climate Change (IPCC) confirms that integration of all significant complexities and uncertainties into integrated assessment models remains a distant goal, since today it is still "impossible to know what to focus on and which methodology to employ" (Weyant et al. 1995:18). Summarising the debate over the last 15 years, Nierenberg (1993) points to large inconsistencies in scientific findings and predictions, and notes that "Almost all climatologists agree that they cannot relate the observed temperature rise to the 'greenhouse effect', and some even feel that the observed rise [of about 0.5°C] is part of a normal expression of natural variability. In further fact, satellite measurements of surface temperatures over the last 14 years show no rise, in contradiction to the century-old series derived from ground-based weather stations". Adams (1995) also comments on these satellite results, noting that the most recent data from NASA actually reveal a slight cooling trend.

Despite the evident complexity and indeterminacy of the climate system and the inadequacy of current models, the modelling community continues to hold that meaningful predictive modelling will be possible in the near future (Boehmer-Christiansen 1994a). In the absence of reliable model results today, however, the climate community has responded to a need for policy-relevant information by agreeing that a warming of 1.5° to 4.5°C will result from a doubling of the atmospheric carbon dioxide concentration, a figure which can then be used in impact assessments and economic analyses. Jasanoff and Wynne (1995) note that this 'result' arises not from formal modelling, but from subjective and informal negotiations among climate scientists, prompting one GCM scientist to note that "the range is nothing to do with probability. It is not a normal distribution or a skewed distribution. Who knows what it is?".

Apart from such arbitrary quantitative limitations, the debate within the IPCC is also plagued by qualitative assumptions, especially the idea that climate change is smooth, predictable and hence manageable. Jasanoff and Wynne (1995) report how this politically institutionalised limitation of the scientific framing was inadvertently reflected in 1994 by the chair of the scientific work group of IPCC, Sir John Houghton:

> "There are those who home in on surprises as their main argument for action. I think that this is a weak case. No politician can be expected to take on board the unlikely though possible event of disintegration of the West Antarctic ice sheet. What the IPCC scientists have been doing is providing a best estimate of future climate change under increased greenhouse gases - rather like a weather forecast is a best estimate. Within the range of possibility no change of climate is very unlikely. Sensible planning, I would argue, needs to be based on the best estimate, not on fear of global catastrophe or collapse".

It is hard to reconcile this approach of excluding possible futures and introducing arbitrary constraints with a comprehensive/rational policy model, although the IPCC's unwillingness to confront the complexity of the climate system and the need for adaptive policies is even less consistent with a complex/adaptive model. Despite arbitrary model fixes, the meaningless warming estimate of 1.5° to 4.5°C, and the exclusion of uncomfortable perspectives from the debate, the climate community continues to present itself as supporting comprehensive/rational policy, and argues that "without more research rational policy could not be made" (Boehmer-Christiansen 1994a, Jasanoff and Wynne 1995).

Despite the evidently provisional nature of the IPCC's scientific findings, they have been widely seized upon by economists seeking to promote 'more rational' policy making by performing economic analyses of climate change, perhaps the most notable of which is the

300-year cost benefit analysis by Cline (1992). The IPCC emphasises the difficulties of economic analysis of climate change, including "the sensitivity of the climate system to changes in greenhouse gas concentrations, the physical and economic impacts of any climate changes that occur, the choice of discount rate and assumptions regarding the cost and availability of future energy technologies" (Bruce et al. 1995:14). Although IPCC is seemingly aware of the complex and unpredictable behaviour of natural and social systems, its Working Group 3 assesses the appropriateness of policy responses primarily in economic terms (Arrow et al. 1995, Banuri et al. 1995, Goldemberg et al. 1995, Jepma et al. 1995, Pearce et al. 1995). The IPCC admits that "it is difficult in practice to apply cost-benefit analysis . . . at this time" (Bruce et al. 1995:7), but the implication remains that an economics-based approach may in time bear fruit. The potential limitations of this approach in the face of complexity are not considered by IPCC.

The difficulties of economic forecasts over even ten years are well known, and over longer periods the complex, evolving nature of society and technology make forecasting completely impossible (Tonn 1986, Alexander 1988, Ormerod 1994, Parker and Stacey 1994). As Adams (1995) comments, asking for a 300-year cost benefit analysis of global warming is equivalent to asking the North American Indians in 1693, when the US dollar did not even exist, to calculate the net present value of the European conquest of North America in 1693 wampum. The problems of economic forecasting in a complex world are discussed in chapter 5, but we may note at this stage that the growing influence of economists in the IPCC process is further evidence of the paradigmatic grip of the comprehensive/rational model.

Several authors argue that the complexity, uncertainty and indeterminacy associated with climate change is so great that climate policy can only be based on a complex/adaptive model (Foy 1990, Brooks 1992, Waterstone 1993, Bella et al. 1994). Yet the issue of complexity is barely even discussed in the present climate debate, which is still conducted within a conceptual paradigm of manageability and predictability, in contrast to the policy conclusions of Clark and Munn (1986), which emphasise the shortcomings of policy making based on scientific or economic modelling of complex systems, and instead recommend flexibility, resilience and societal learning. The lack of plurality in the climate debate, and the arbitrary exclusion of inconvenient or uncomfortable scenarios and perspectives, has already been observed. Given the rejection of complexity and plurality among the mainstream climate policy makers, it is evident that climate debate can be classified squarely within the comprehensive/rational model.

4.7. Conclusions

This chapter has argued that complexity and plurality are important themes in discussing SD policy. The two dominant models for SD policy may be distinguished using the simple / complex dichotomy, and both models have identified the importance of plural and participatory processes. These findings from the policy domain are parallel to the two principal findings regarding SD definitional frameworks in chapter 3, namely that there is an irreducible plurality of incompatible and mutually contradictory definitions of sustainability, and that the socio-political approach to understanding sustainability has not been integrated with the complex systems approach.

The need to improve plurality in the policy process is widely recognised, but there is no theoretical framework to identify how many perspectives or stakeholders should be included, nor the diversity that is desirable for organisational learning or resilience. If policy makers seek to create a plural and adaptive institution that includes all major perspectives, they require a theory explaining how many perspectives there are and where they come from. Similarly, a theory is required to explain the multiple definitions of SD. These theoretical questions are closely related.

The absence of a complex/adaptive approach in IPCC working group III is indicative of the low awareness of complexity in the SD debate more generally. This result was also observed in chapter 3, where it was found that none of the most popular four-fold definitional frameworks for SD explicitly include complexity, and that complex systems based definitions are restricted to a separate, smaller group of SD definitions which are relatively scarce and rarely discussed by the policy mainstream. The significance of this omission is confirmed by this chapter's demonstration that complexity provides the fundamental basis for evaluating the relative merits and applicability of the comprehensive/rational and the complex/adaptive policy models. In the light of the relationship between policy models and SD definitions, this observation further suggests that complexity should play a much more important role in definitions of sustainability than has been the case until now. The theories of complexity and plurality are explored in the following three chapters, and their utility as theoretical frameworks for understanding and supporting decision making for sustainability is assessed in the subsequent chapters.

Chapter 5: Complexity

5.1. Introduction

The previous chapters have argued that the concept of complexity is of great relevance to sustainability, both in understanding the meaning of SD as a policy objective and in developing appropriate policy processes, strategies and institutional structures to move towards this goal. Chapter 3 found that there are complex systems approaches to defining sustainability, but that these need to be further developed and integrated with socio-political definitions of SD. Chapter 4 surveyed the debate on policy models for sustainability, and found that the emerging complex/adaptive policy model emphasises the complex and uncertain nature of the world and suggests that an adaptive response would be based on concepts such as learning, resilience and plurality.

Chapter 5 explores the meaning of complexity, and why it implies a new approach to understanding and acting in the world. The chapter begins by surveying the scope of complexity theory, and contrasting it with the dominant Newtonian/Cartesian view of the world that has dominated Western thinking for the last 300 years. It then examines the nature of cognition and modelling in a complex world, and outlines the inherent limitations of mental and computer models of a complex reality. The chapter continues with an overview of the behaviour and structure of complex systems and the relationship between these behaviours and our ways of understanding such systems. It concludes with a summary of these theoretical results and their implications for SD definitions and policy making.

5.1.1. The Scope of Complexity Theory

Complex systems theory is not a single discipline, but rather an approach taken in a number of different disciplines that are all working on different aspects or different types of complex systems. Indeed, it is perhaps misleading to refer to it as a theory, since it is not formulated in a compact and falsifiable form, and the term paradigm might be more appropriate. The words theory and paradigm are used interchangeably in this thesis when referring to complexity.

Complexity research is interdisciplinary: it seeks to discover the common characteristics shared by all complex systems, by cross-fertilising ideas, approaches, and examples between different disciplines (Langton et al. 1992, Langton 1994, Levy 1992, Lewin 1992, Waldrop 1992, Gell-Mann 1994, Kelly 1994, Gell-Mann 1995). The core disciplines include:

- *Ecology*: The study of structure, behaviour and interaction in the biological world, their relationship with the external biophysical and geochemical environment, and the efficiency, resilience and diversity of complex living systems.

- *Evolution & Genetics*: The study of how genes, species and ecosystems evolve and change over time; adaptability, inheritance, rates of change, emergence of structures and behaviours from evolution; simulation of evolutionary processes of change and adaptation in computers.

- *Cognitive Science, Artificial Intelligence & Computer Science*: The study of the neurological, physiological and computational roots of intelligence, and approaches to simulate and recreate intelligence inside hardware and software; theory of computation, cybernetics, information and communications; development of programming tools and computational techniques, including new software and hardware architectures, including highly parallel and neural computing.

- *Mathematics*: The study of mathematical description and analysis of non-linear and complex systems, including chaos, catastrophe theory and general systems theory; modelling, including dynamical systems modelling and statistical theory.

- *Economics, Linguistics, Social Science and Philosophy*: Complex systems theory is based not only on the above fields, particularly evolution, intelligence and computation, but also on applications in areas like economics, social science, linguistics, postmodernism and philosophy. Applications not only provide a source of ideas, approaches and examples, but also provide a real world test of the relevance and appropriateness of complex systems theories.

It is difficult to provide a brief summary of complex systems theory, as it is a synthesis of relevant results from all these fields. The workshops of the Santa Fe Institute, a leading centre of complexity research, provide an illustration. In the second workshop on *Artificial Life* held at Santa Fe, papers were presented in a wide variety of areas, including: self-organisation, metabolism, algorithmic chemistry, pre-biotic evolution, the edge of chaos, neural systems, learning, genetic algorithms, genetic programming, communication, culture, computer viruses, emergence and philosophy (Langton et al. 1992).

This example also clarifies the distinction between chaos theory, which is a specialised branch of mathematics, and the wide-ranging, interdisciplinary study that makes up complexity theory. A second difference, which is of greater significance to the application of these ideas to sustainability, is that chaos theorists must argue by analogy when they speak of the implications for SD, since chaos theorists only study the abstract world of mathematics. Complexity, on the other hand, is directly concerned with the emergence, behaviour and evolution of complex structures in nature, society and the economy, and their explanation in terms of theoretical insights from evolution, ecology and cognitive science in addition to those from mathematics. The definition of complexity is returned to in section 5.6.

5.2. The Newtonian Revolution

The elements of mechanistic theory first appear in the ideas of the Greek "atomists" of the fifth to third centuries BC, such as Democritus and Leucippus. They believed that the world was composed of indivisible particles in motion in an infinite void, and that all form, movement and change could be explained in terms of the form and movement of these atoms. Subsequent philosophers used mechanistic principles to understand natural phenomena, such as Aristotle's (1937) study of animal movement, and the physical and mathematical work of Archimedes and Galileo (Heath 1897, Galileo 1968).

Popper (1960a, 1965) argues that the beginning of the scientific age can be marked with Newton's theory of gravitation, since it was the "first really successful scientific theory in human history" , as it explained not only the movements of all the stars in their courses, but also the movements of bodies on earth, such as projectiles, pendulum clocks or falling apples. Newton's theory, together with the intellectual-rational philosophy of Descartes and Laplace, set in place the foundational elements of the Western scientific world view. Descartes, like Galileo and Newton, built his views on the principles of atomism, believing that the material world was to be understood in terms of mechanical interaction and movement of corpuscles originally created and set in motion by God. He saw humans as similar to machines, but distinguished by their great capacity to use words and signs as a basis for discourse and by their capacity to reason (Descartes 1968). His logic was taken to the extreme by LaMettrie (1748), who argued in *L'Homme Machine* that man is a machine, and that all human behaviour is reducible to laws of matter in motion.

These theories established a paradigm for thinking about complex systems which has lasted 300 years, and which is essentially based on a reductionist and mechanical view of the view. The Newtonian paradigm may be illustrated by considering the difference between the paradigmatic structures of 'clouds' and 'clocks', where 'clouds' represent physical systems which, like gases, are irregular, disorderly and more or less unpredictable, while 'clocks' are regular, orderly and highly predictable in their behaviour. Popper (1965) points out that the Newtonian revolution suggested that all 'clouds' are 'clocks', and that if we could obtain detailed knowledge about the interaction of the components of any system, we should find that gas clouds or organisms are as clock-like as our solar system.

Explanation, under the Newtonian paradigm, is equivalent to describing a system in machine-like terms and understanding its functioning in terms of the interaction of its parts (Allen 1990). The universe is viewed as a kind of giant 'clockwork' mechanism, although the presence of dissipative forces such as friction mean that it is 'winding down' in an irreversible, deterministic progression towards thermodynamic equilibrium.

Newtonian physics and thermodynamics provided a theory that was couched in mathematical terms, allowing predictive calculation and empirical testing, and application to the solution of practical engineering problems. The success of Newtonian theory, which was vindicated in the technological triumphs of the industrial revolution, made it a tempting theoretical framework for all complex systems, including those in biology, economics and anthropology (Allen 1990). The framework includes the following principles:

- *Reductionism*: A system is the sum of its component parts. If the whole is too complex, we may study the parts to determine their behaviour and interaction, and recombine them to understand the whole (Langton 1995).

- *Prediction*: Systems are physically deterministic. The future state of a system can, in principle, be predicted once its components and their behaviour are understood in sufficient detail (Popper 1965).

- *Equilibrium*: A system's evolution is governed by an appropriate potential function, such as entropy in physics, utility in economics and fitness in biology (Allen 1990). Systems evolve towards equilibrium, where the potential function is maximised.

The ideas of reductionism, prediction and equilibrium are the essence of 'simple' systems, and they have had a strong influence on subsequent theories and world views in management and economics (Trisoglio 1995a, 1995b), and also on policy models for sustainability, as chapter 4 demonstrated. Yet even as they were being applied with great practical success, Newton's ideas were seen to be philosophically problematic, since they lead to what Prigogine (1989) describes as a cosmological bifurcation. An inconsistency arises if we, like Leibniz, see the universe around us as a regulated automaton in eternal motion, while at the same time understand ourselves to be creative in the way described by Bergson (1975): "I believe I experience creativity at every moment of my life". Since we are part of the universe, we must conclude that either the universe is able to show creative behaviour, in which case it is not a deterministic automaton, or that human perception of free will, creativity and reflexivity is an illusion (Popper 1965). The division of art and science into C. P. Snow's 'Two Cultures' may even be traceable to this bifurcation.

As well as challenging determinism, the existence of creativity also provides a problem for theories based on equilibrium. If the world is at equilibrium, we can explain neither creative, evolutionary change in natural, social and technological systems, nor the emergence of new species, ideas and innovations (Allen 1990). This problem arises prominently within neo-classical economics, where technical innovation must be treated as emerging exogenously, since it cannot be explained as a consequence of the behaviour of an economic system at equilibrium (Parker and Stacey 1994, Ormerod 1994).

Complexity theory provides the basis for new insights in economics, management and sustainability by contributing a new understanding of the creative and evolutionary behaviour of complex natural, social and economic systems, which is explored in section 5.5. The following section examines how complexity theory also sheds light onto the limitations of reductionism and reification, which are central to current thinking on SD, and which are an inevitable consequence of describing, discussing or modelling the world.

5.3. Reductionism in Modelling, Thought and Language

Reductionism is ubiquitous since even to think about reality or to invent words and concepts with which to discuss it, we are forced to reduce its complexity. As Allen (1987) explains, neither our minds nor our computers can represent the trillions of molecules, living cells, organisms, individuals and events that surround us, each in its own place and with its own history. We therefore reduce the complexity by making a model, with a taxonomic classification and spatial aggregation that describes typical elements of the system and their interactions, and in so doing inevitably reduce the information content and hence behavioural richness of the system. The use of words and concepts in language and thought proceeds in the same way. This is illustrated in Figure 5.1, where complex reality is represented as a cloud, and our reduced description as a set of interacting categories of different types.

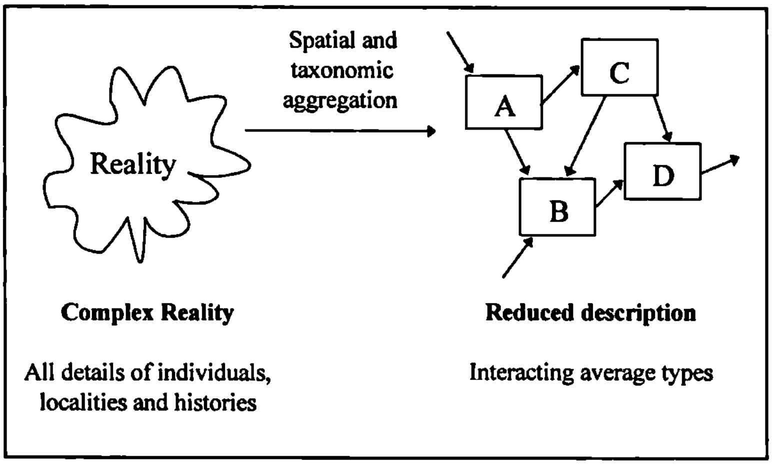


Figure 5.1. Modelling Necessitates Reducing Complexity

This process of simplifying the complex is particularly evident in formal scientific, mathematical and computer models, but has also been studied in language and thought. One of the central concerns of literary theory and postmodernism has been to examine how reduced symbolic, conceptual or linguistic descriptions encode complex and plural ideas and thereby simplify reality (Empson 1930, Frye 1957, Norris 1982, Eagleton 1983, Lyotard 1984, Harvey 1990), a discussion which is unfortunately beyond the scope of this thesis. This inquiry is closely parallel to the question of modelling in complex systems, and is especially relevant when studying how humans form mental models of a complex reality, and the way that they relate to social and cultural settings, which is discussed in chapter 7.

Returning to models, we see that however good our choice of variables, parameters and interaction mechanisms, these only concern average behaviour. If we compare a model's behaviour with reality, we shall necessarily find that variables and parameters fluctuate around average values, and that reality has much greater microscopic diversity than is described by our model (Allen 1994). This non-average behaviour, far from being statistical 'noise', is vital in generating complex emergent and evolutionary behaviour, as explained in section 5.5.

If we observe the system at a later time, performing the taxonomy again, we may find changes in the elements and their relationships, and there may be the emergence of entirely new elements, corresponding to new species in biological systems or new technologies in economic systems (Figure 5.2).

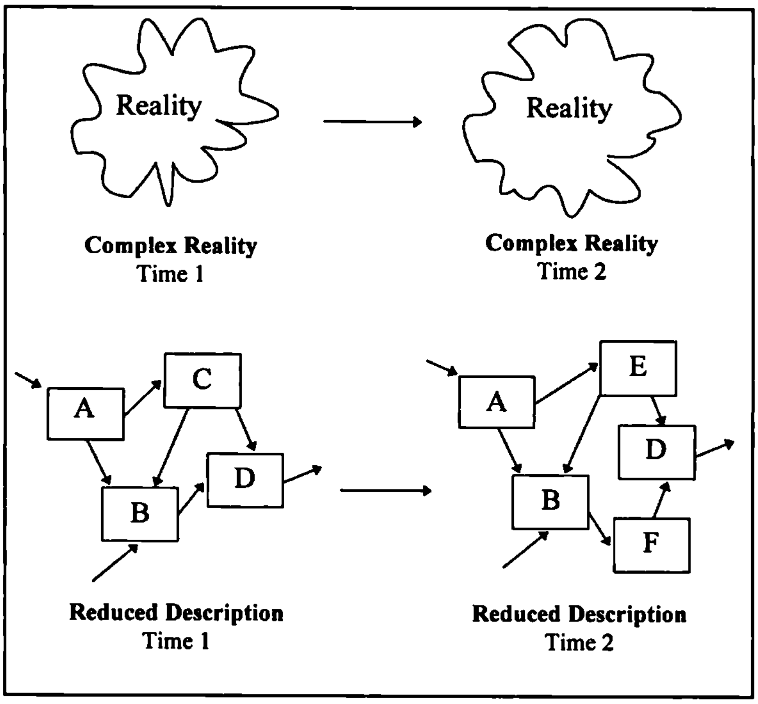


Figure 5.2. Models of a Changing Complex Reality

In mathematical terms, the reduced description of figure 5.1 can be represented as a linked set of dynamical equations, although such a model can only function, like a machine, not evolve. It cannot restructure itself, nor insert new relationships or variables, and as the system evolves, we need new models (figure 5.2). As Allen (1994) summarises, the predictions from a mechanical model can only be correct for as long as the taxonomy of the system remains unchanged. Since the model cannot produce new types of objects or new variables, its 'predictions' will only be valid until some moment, unpredictable within the model, when there is an adaptation or innovation, and new behaviour emerges. A model is therefore seen to be simply a frozen snapshot of, rather than an explanation of, the evolutionary behaviour of the system (figure 5.3).

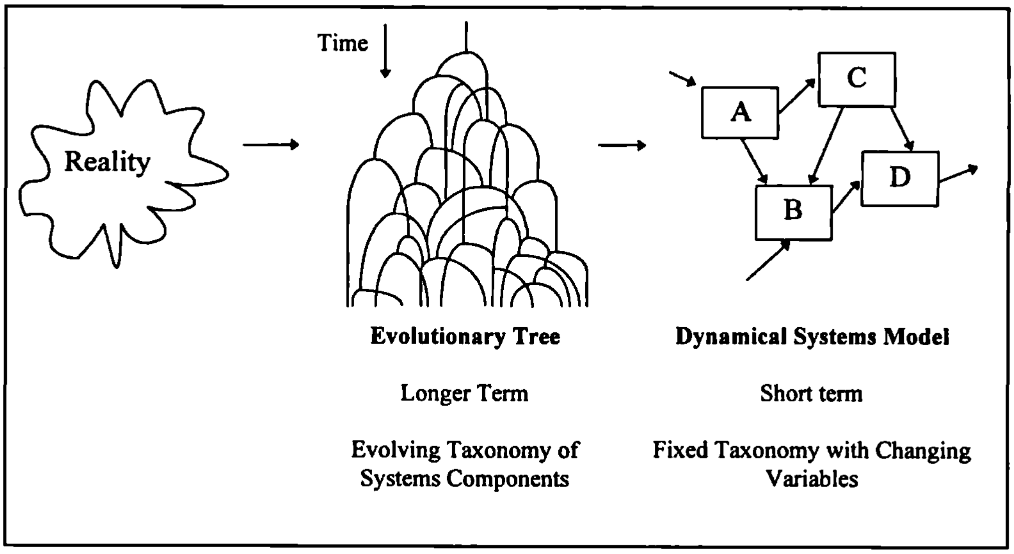


Figure 5.3. A Model as a Frozen Snapshot of Evolutionary Change

The modelling process exemplifies the general problem of representing change that dates back to Heraclitus, Anaximander and the Presocratics (Popper 1958), and the different descriptions in figure 5.2 also recall the paradox posed by Parmenides and Zeno: if a thing remains the same, it does not change; yet if it loses its identity then it is no longer that thing which has changed. How then is change logically possible? This question is discussed in section 5.6.

The preceding discussion has demonstrated that reductionist models are fundamentally limited in their ability to explain evolutionary change. The modelling process also gives rise to two further problems, which were noted above in section 4.3:

- *Incompleteness*: Except for simple systems, a complete description of a complex reality is impossible, as illustrated in the story by Borges (1972) of an emperor who requests a perfectly accurate map of the empire and thereby leads his country to ruin, as the entire population devotes all its energy to cartography.

- *Subjective Categorisation*: Any abstraction of complex reality to a limited set of concepts or categories necessarily involves subjective choices regarding the similarities and differences underlying taxonomic choices, the scale and extent of hierarchical units of study, and the connections that are important to the study at hand (Schneider and Kay 1994, Clark et al. 1995). Alternative models or descriptions will therefore refer to different aspects of reality, and we may argue that the system is in the eye of the beholder (Locker and Coulter 1977, Robinson 1990, Wynne 1992). Such choices are usually functional, related to the purpose of the model or conceptual system, much in the way that Icelanders have dozens of different words to discriminate between different types of snow.

Any designation of parts and wholes is seen to be a temporary expedient, a result of choosing a particular "observation set", a "particular way of viewing the natural world" (O'Neill et al. 1986, Allen and Starr 1982). As Popper warned, it is not even possible to look around and record what one sees without an initial hypothesis (Williams 1994). We should not forget, therefore, that any model of reality is only an artefact generated by an incomplete description, and that the entirety of the complex world is beyond our ability to describe or comprehend in a reductionist manner. This result is consistent with one of the central teachings of Eastern philosophies (Watts 1957), namely that attachment to any single set of forms and concepts about reality will result in delusion about the nature of the world.

Different subjective interpretations of the same complex reality will produce different models or conceptual systems, which behave in different ways. Progress in science itself follows a similar process of alternative theoretical and paradigmatic perspectives on the same set of phenomena that constitute complex reality (Popper 1957, 1960b, Kuhn 1970). The issues of subjective categorisation and incompleteness also have important implications for social and cultural systems, as discussed in Chapter 7.

In summary, the reductionist approach at the heart of almost all mainstream scientific and economic models used in sustainability has two shortcomings in a complex world:

- *Creativity and Change*: It cannot explain adaptive, innovative or evolutionary change, all of which are related to the notion of sustainable development.

- *Subjectivity and Incompleteness*: Reductive taxonomy and description is unavoidably subjective and incomplete, except in trivially simple systems. As a result, many alternative descriptions of reality are possible, both in formal models and in mental models.

In order to evaluate the significance of these shortcomings of traditional modelling, we require some insight into the behaviour of non-linear systems. The description of reality illustrated in figure 5.3 gives rise to two questions, namely what types of dynamics may be shown by the system over the short term, and how does the taxonomy change in an evolutionary manner over the longer term? The question of dynamics is discussed in section 5.4, and that of evolution in section 5.5.

5.4. The Behaviour of Non-linear Systems

In the Newtonian world based on linear equations, system dynamics comprise rest, periodic motion or smooth change. By contrast, complex systems typically exhibit highly non-linear behaviour. A simple example of non-linearity is provided by a thermostat's response to a smooth fall in temperature: the thermostat responds discontinuously, initially doing nothing, then suddenly turning on a heater when the temperate falls below a certain level. The relationship between the input and the output is non-linear, as it cannot be described mathematically by a straight line. Non-linear systems also exhibit such phenomena as catastrophe and chaos, which have been referred to by several authors in exploring issues of sustainability (Brooks 1986, O'Connor 1991, Binswanger 1993, Drepper and Månsson 1993, Clark et al. 1995).

Catastrophe Theory was developed beginning in the late 1960s (Thom 1975, Zeeman 1977, Woodcock and Davis 1978), and unlike traditional science, which describes change as smooth, continuous and quantitative, catastrophe theory explains how non-linear physical and natural systems can undergo sudden and discontinuous change. For example, the theory brings valuable insights to how a bubble bursts or a bridge collapses. A common catastrophe is illustrated in figure 5.4, where the path with arrows represents an evolutionary trajectory for the system.

Catastrophic change occurs at point X in figure 5.4, when the system suddenly moves from one state, represented by the upper surface, to another represented by the lower surface. The theory's applications in management and economics have been less convincing, since the mathematical formalisation required to cast problems in the form of catastrophes proves overly restrictive. Although interest in catastrophe theory faded after a period of public prominence in the 1970s, it stimulated interest in chaos research by illustrating the interesting and unexpected behaviour of non-linear systems, and it may still prove to hold vital clues to embryology and the development of shape and form in plants and animals (Casti 1991). The discontinuous behaviour and multiple equilibria demonstrated by catastrophic systems are illustrative of these types of behaviour among non-linear systems more generally.

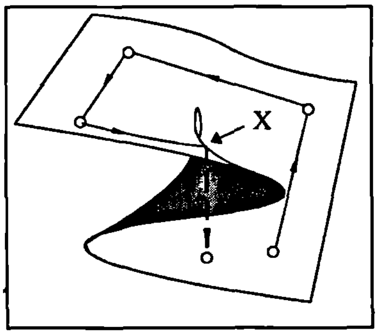


Figure 5.4. The Cusp Catastrophe

Chaos Theory describes how a system can be sensitively dependent on initial conditions, such that two initially very similar system states may evolve into completely different states over time (Hall 1992). Although chaotic systems are deterministic, their sensitivity renders them unpredictable, since it is only a matter of time before differences below the threshold of scientific measurability or the resolution of models accumulate and are magnified to create large errors in model outputs. An everyday example of chaos arises in weather forecasting. Lorenz (1963a, 1963b, 1964) had already shown in the 1960s that the non-linear equations governing the temperature and humidity of the atmosphere create totally unpredictable weather patterns, since the equations show sensitive dependence on initial conditions, and the atmosphere's evolution from states that are initially indistinguishable soon diverges to give completely different behaviour. Although supercomputers now allow reasonably good forecasts three or four days into the future, we now know that even with a perfect model and perfect data we will never be able to predict the weather more than two weeks ahead (Gleick 1987, Casti 1991, Hall 1992). Economic prediction is similarly constrained by the non-linearities of the economy (Bass 1985, Peters 1991, Kelly 1994, Ormerod 1994, Parker and Stacey 1994, Vaga 1994). In terms of the reductionist modelling described in section 5.3, seemingly unimportant information or system components can play a decisive role in the evolution of a non-linear system, but no model can include all such components, or include them to the required level of accuracy. This is a fundamental limitation in modelling non-linear systems.

Non-linear systems can display highly disordered and unpredictable behaviour, as explained in theories of catastrophe and chaos, but they can also demonstrate the emergence of ordered structures and behaviour. An example is provided by work on fractals, which began in the 1970s with Mandelbrot's investigation of symmetry of scale in systems as diverse as cotton prices and earthquake sizes. Statistical theory predicts that large systems of independent actors or parts should obey a Gaussian distribution, the familiar bell-shaped curve. Instead, the systems Mandelbrot studied exhibited behaviour he called *fractal*, where the events or structures at large scales have the same pattern as at small scales. For example, figure 5.5 shows two graphs of price changes in financial markets, one covering a period of a few days, the other spanning a few months.

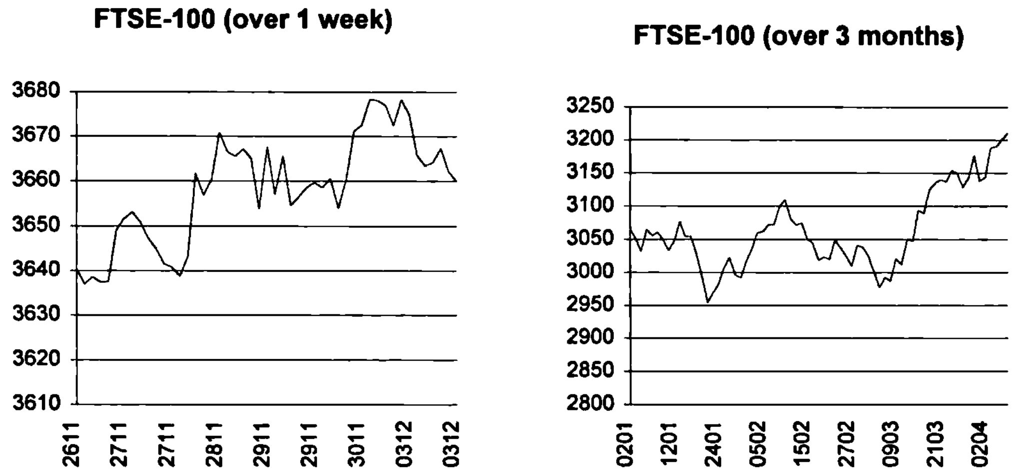


Figure 5.5. Fractal Behaviour in the Financial Markets

The behaviour is fractal: unless the time dimension is labelled, it is impossible to tell whether the graphs refer to hourly, daily or monthly price movements. Mandelbrot (1977) found that fractal forms occur throughout nature, from the shapes of trees, coastlines and mountains, to the structure of blood vessels and lungs.

Work on non-linear systems has confirmed that linear systems simply cannot show the kinds of creation and destruction of order seen in everyday life, and which only non-linear systems exhibit (table 5.1).

	Theory	**Example**	**Reference**
Creation of order	Fractals	The intricate structure and symmetry of a snowflake.	Mandelbrot (1977)
	Dissipative systems	Formation of a whirlwind to dissipate the energy of a storm.	Prigogine & Stengers (1984)
Creation of disorder	Chaos	Unpredictability of the weather.	Gleick (1987)
	Catastrophe	Sudden, unpredictable change, like a bubble bursting.	Thom (1975)

Table 5.1. Creation of Order and Disorder in Non-linear Systems

Apart from the behaviours listed in table 5.1, linear systems also fail to exhibit other aspects of non-linear behaviour seen in the real world, such as:

- *Historical Dependence*: Several equilibria or system states may be possible for a given set of control parameters, and the actual state of the system is determined by its previous history, and not only by its current environment (Prigogine and Stengers 1984, Prigogine 1989, Allen 1990). An example is the direction of the spiral of water draining into the plughole of a bath.

- *Spontaneous emergence of structure and holistic behaviour*: the system elements may interact and become organised to create structure whose form cannot be predicted using the system's equations. Examples include a breaking wave or the intricate beauty of a snowflake. Such emergent properties mean that the behaviour of the whole system is more than the sum of its parts, which is also not the case in linear systems (Kauffman 1991, Lewin 1992, Waldrop 1992, Kauffman 1993, Inayatullah 1994).

Chaotic and catastrophic behaviour are well-known examples of non-linear behaviour, but these are a small subset of the types of behaviour that non-linear systems may display (Kreysig 1983). A generalised non-linear system will have various domains of stable behaviour connected by regions of instability, and these domains will change over space and time. Stable behaviours correspond to various types of attractor: point attractors yield stable equilibrium solutions, cyclic attractors yield oscillatory behaviour and strange attractors produce chaos. In certain special cases of a point attractor, there is a global potential function that can be drawn as a surface, and such cases correspond to those of catastrophe theory.

The dynamics of a general non-linear system may contain elements of all these processes, resulting in a rich combination of stable, unstable, oscillatory and chaotic behaviours in different domains and under different conditions. Non-linear systems, including natural and social systems, are therefore characterised by sudden discontinuous change, unpredictability, and multiple equilibria.

Mathematical representation is an important step in modelling and theorising, but it is important to bear in mind that chaos and catastrophe are only a small subset of the non-linear dynamical behaviours described by differential equations, and these in turn are only approximate representations of the still larger set of complex systems (Allen 1990). Applications of non-linear theories in business and economics have usually failed to make the distinction between chaos and complexity (Peters 1987, Stacey 1993, Parker and Stacey 1994, Trisoglio 1995a), and there is the additional difficulty that many authors use the words chaotic and complex in their everyday sense of "disorganised" and "complicated" rather than their precise scientific and mathematical sense. As a result, there are signs of a backlash brewing against the confused claims made about complexity theory (Horgan 1995). These issues are discussed further in section 5.6, following an examination of the role of non-linearity in economics and an overview of evolution in complex systems.

5.4.1. The Economy as a Non-linear System

The reason Mandelbrot found fractal behaviour in financial markets is that the assumption of independence, or non-interaction, does not hold in non-linear systems. Systems such as financial markets and tectonic plates have strong connections between their component parts which ensure that the actions of the parts are not independent, but rather they are correlated, as may be seen in 'herd' behaviour of financial speculators (Soros 1994). In mathematical terms, such correlations can only be modelled with non-linear equations, although it is worth emphasising that the ability to build a computer model of such systems does not imply that the model will have any predictive value.

Despite the evidence that economic systems are non-linear, linear equations have been at the centre of scientific and economic explanation because, until very recently, non-linear theories were intractable (Ormerod 1994). Before the advent of powerful computers, solutions to non-linear equations could not be found, predictions could not be made, and non-linear theories were therefore unusable. Physics and chemistry have been successful because linear theories happen to be a good approximation to the behaviour of many physical systems, but this is not true for economic systems.

Many economists have been aware of the limitations of neo-classical theory for some time, and there is a rapidly growing body of work on the implications of non-linear theories, especially chaos, in economics, management and financial markets (Enzensberger 1982, Anderson et al. 1988, Drucker 1989, Peters 1991, Hall 1992, Nichols 1993, Parker and Stacey 1994, Trisoglio 1995a, 1995b). In evaluating the application of non-linear theories to economics and business, we may recall that the mathematical work on chaos and non linear dynamics has been based on modelling physical and chemical systems. In contrast to this inanimate world, economists, like biologists, must deal with a world of wilful living beings that show complex and elusive behaviour and, as Gleick (1987:85) puts it, the creatures studied by economists are "the most elusive of all".

Chaos and catastrophe theory take us the first step by showing that non-linear systems are capable of new types of behaviour not exhibited by linear systems (table 5.1). But truly complex systems can show even more interesting types of behaviour: computation, life and intelligence (table 5.2) (Allen 1990, Lewin 1992, Waldrop 1992, Kelly 1994).

System	Theory	Characteristics	Scientific Disciplines	Examples	Behaviour
A	Classical	Linear, Equilibrium	Classical science	Solar system, pendulum	Equilibrium
B	Chaos / Non-linearity	Non-linear, Non-equilibrium	Chaos, Catastrophe theory, Non-equilibrium thermodynamics	Sand piles, Weather, Climate, Waves, Snowflakes, Roulette	Unpredictable
C	Complexity	Non-linear, Non-equilibrium + Computation	Mathematics, Computer science, Information theory, Linguistics	Language, Computer software, Artificial intelligence, DNA?	Computation and Information Processing
D	Complexity	Non-linear, Non-equilibrium + Life	Biology, Ecology, Evolution, Artificial life	Plants, Viruses, Ecosystems	Creative, Adaptive, Evolving
E	Complexity	Non-linear, Non-equilibrium + Life + Intelligence	Cultural theory, Game theory, Economics, Management	Humans, markets, Economies, society Companies, Technology	Intelligent, Strategic

Table 5.2. The Emergence of Complex Behaviour in Five Types of System

Chaos theory can help us to understand the shape of a leaf or the unpredictability of the weather, but it cannot take us the next step forward to explaining or describing the processes of life or intelligence. We can write a set of equations to describe the physical and chemical processes behind the formation of a snowflake or the changes in the weather, although even here 'the map is not the territory', but we cannot reduce life or intelligence to the functioning of a machine that can be described by a set of equations. As section 5.3 argued, a set of equations is a mathematical system that is only capable of 'functioning', not evolving. It cannot restructure itself or insert new relationships, yet this kind of innovation and evolutionary change is central to living systems.

Economic and social systems are not only evolving, for example because of technological innovation, but are also governed by the actions of intelligent, cognising, strategy-forming individuals and organisations. In seeking a new basis for understanding and making decisions about sustainability, we should therefore look not to theories of chaos and non-linear systems, but rather to complexity theory, and its insights into the role of creativity, evolution and strategic behaviour.

5.5. Surprise, Creativity and Evolutionary Change

The complex/adaptive policy model outlined in chapter 4 highlights the inevitability of surprise, unpredictability and complex behaviour, and seeks to build policies and institutions that are resilient in the face of such complexity. A system's resilience is related to its ability to handle surprising events and conditions, so in seeking to understand resilience it is useful to explore the nature of surprise. Timmerman (1986) argues that an analysis of surprise must take account of the surprising event itself, the perceptions of that event, and the basic frame of reference which may accept or reject the implications of any particular surprise. Whether an event is considered surprising depends on the model being used to make sense of the system, or as Thompson et al. (1990:70) put it, the observer's "particular set of convictions about the way the world is". A surprise is something unexpected, unpredictable or otherwise incompatible with a given world view. Referring to figure 5.2, we may distinguish between three types of surprise:

- *Unpredictability*: The dynamical change over time of non-linear and chaotic systems is surprising, since these systems are largely unpredictable, as demonstrated in section 5.4.

- *Evolutionary change*: Innovation, creativity and evolutionary change is inevitably surprising, since it creates new processes, structures and relationships that were not previously present in the system, the emergence of which is unpredictable. Social and economic systems in particular are unpredictable as they create their own future (Godard 1992, Soros 1994)

- *Incompleteness*: Since models are necessarily incomplete, surprises can also arise when the system demonstrates an aspect of its behaviour or explores a domain of activity that is beyond the scope of the current model. It can be problematic to distinguish surprises due to incompleteness from those due to unpredictability or evolutionary change.

A system's resilience may be improved by tackling any of these sources of surprise. Our ability to perform predictive modelling on highly non-linear systems is strictly limited, and although supercomputers are improving forecasts in applications such as weather forecasting, we will eventually reach a limit of predictability (Casti 1991). In the short term, however, application of non-linear mathematical techniques can provide valuable insights and guidance for technical prediction problems.

Surprises due to incompleteness can be tackled with innovative decision tools, including building improved mental and computer models, as discussed in chapter 13. Cultural theory provides an alternative model of surprise based on a four-fold typology of myths of nature, arguing that an individual is surprised if he thinks the world is one of these four ways and it turns out to be another. This model is discussed in chapter 7 and evaluated in chapter 9.

Evolutionary change, which is the third source of surprise, has traditionally been beyond the scope of economic or environmental modelling. One of the central themes of complexity research, however, is the development of explanatory models of behaviour and evolutionary change in complex adaptive systems in nature and society. If an improved understanding of these processes can be attained, it may provide a basis for improving the resilience of policies and institutions.

5.5.1. Models of Evolutionary Change

In order to develop models of evolution across biological, social and technological domains, it is helpful to summarise some of the common types of behaviour shown by these different systems. This overview is based on studies of evolutionary change in biological systems (Colinvaux 1980, 1986, Dawkins 1986, Dawkins 1989, Gould 1989, Ridley 1993), technological and economic systems (Boulding 1981, Nelson and Winter 1982, Clark and Juma 1987, Anderson et al. 1988, Arthur 1989, Arthur 1990, Mokyr 1990, Mazlish 1993, Arthur 1994, Lane 1995), artificial and computational systems (Langton 1991, Koza 1992, Langton et al. 1992, Levy 1992, Langton 1994) and theoretical models of evolutionary change (Prigogine and Stengers 1984, Allen 1987, 1990, Holland 1992a, 1992b, Kauffman 1993, Holland 1995). Some of the common types of evolutionary behaviour which seem to apply across all complex adaptive systems include:

- *Creativity:* Evolution results in the creation of new structures, forms and types of behaviour that did not exist before. It is not a matter of the discovery of pre-existing niches, but the continual creation of new structures and opportunities for further creativity and interaction.

- *Irreversibility:* Evolution is an irreversible, historical process. Structures may cease to exist or become extinct, but a system does not evolve 'backwards' to a previous state, although aspects of social and cultural evolution, including fashions, do sometimes appear to repeat the events of an earlier cycle in a new social or historical context.

- *Self-organisation:* In evolution, ordered structures and patterns of behaviour emerge spontaneously from within the system, rather than through an external ordering influence. For example, Prigogine and Stengers (1984:146) comment that in order for 'chemical clocks' to produce their synchronous colour-changes, "to change . . . all at once, molecules must have a way to communicate". Despite lacking intelligence or teleology, such systems can communicate and generate order from randomness. As a result, bottom-up processes can give rise to increasingly complex structures at a hierarchically higher level, which can in turn interact to create emergent phenomena at yet higher levels (Prigogine et al. 1972, Nicolis and Prigogine 1977, Jantsch 1980, Prigogine and Stengers 1984, Grzybowski and Slocombe 1988, Hollick 1993).

- *Punctuated equilibria:* Evolution occurs in fits and starts. There are long periods of slow change and quasi-stability followed by rapid periods of innovation and change. These non-linear periods of change may be triggered by internal processes reaching a critical state, by changes in the external environment, or by emergence of new structures.

- *Path dependence and Lock-in:* The present state of a complex biological or technological system is determined by its previous history. Arthur (1990) observes that some medieval clocks in Florence had 24-hour faces and hands that went anti-clockwise, illustrating that clocks could easily have proceeded down a different technological trajectory. But once the majority of clocks were built with 12-hour clockwise faces, the technology locked in to that path. Other examples include the QWERTY keyboard and VHS / Betamax video recorders. Gould (1989) points out that at the time of the Cambrian Explosion, living creatures showed a much greater diversity than today of body designs, and it could be largely by chance that the dominant life-forms on Earth have taken their particular designs, rather than any of the others available.

- *Chance, not Optimisation*: Evolutionary history is driven by chance, accident and historical coincidence. The design that wins or survives is not necessarily the best, whether in biological or technological systems. Similarly, there is no reason to put man above mouse in evolutionary terms.

- *Co-evolution*: An organism does not evolve to fit a niche in the environment. Instead, an organism's 'environment' is largely determined by the other organisms around it, so predators and prey, organisms and niches co-evolve. The same applies to the business world, where the business 'environment' is determined by customers, suppliers, stakeholders, investors and competitors, all of whom are continually devising and implementing their own strategies, and hence the environment of all actors is continually changing.

Two models of evolutionary change which display these characteristics are Holland's (1992a, 1992b, 1995) development of genetic algorithms, artificial life and classifier systems, and Allen's (1987, 1990, 1994) work on spatial models. Artificial life techniques, which function analogously to natural selection, have been used to develop models of structure, behaviour, self-organisation and evolutionary change in complex biological, chemical, ecological, social and technological systems (Levy 1992, Mitchell and Forrest 1994, Ray 1994, Sims 1995). The spatial approach to modelling developed by Allen and his co-workers has been applied to decision making for sustainable development in fisheries management, urban development and rural migration (Allen and McGlade 1986, 1987a, 1987b , Allen and Sanglier 1979, 1981, Perez-Trejo et al. 1993), while a related approach based on self-organisation has been used to study land use in Canada (Grzybowski and Slocombe 1988).

It is worth observing that although theories of evolution have been with us since Darwin, detailed understanding of the dynamics of evolution over large diverse populations and thousands of generations has had to await high performance computer simulation. An example is provided by the prisoner's dilemma, where the 'rational' strategy in a single game is to defect, but where the best strategy for an infinitely iterated game cannot be derived analytically. It was only with Axelrod's work using a massively parallel computer tournament among competing strategies, which was subsequently complemented with a genetic algorithm based approach to identifying strategies, that the resilient tit-for-tat strategy was identified (Axelrod 1984, 1995). This example demonstrates that complex phenomena derived from multiple iterations or highly parallel processes can be counter-intuitive, which underscores the growing importance of computer-based approaches to investigating complexity, and which is an important reason that work on complexity has only emerged over the last decade (Trisoglio 1995a). The essence of Allen's and Holland's work may be summarised as follows:

- *Genetic Rules*: The fundamental unit of biological evolution is the gene, and the set of genes comprising the genome encodes a set of rules that determine the final phenotypic form of the organism, subject to environmental influences during growth and development. One may similarly view an economic agent or company as possessing a number of cultural and behavioural rules and strategies that are used to determine economic decisions. In both cases, low-level rules encode information and their interaction determines the biological, economic or institutional outcome.

Such rules may be modelled using genetic algorithms.

- *Fitness and Selection*: In complex environments, there are usually large numbers of agents competing for limited resources, which might include food or energy in biological terms, and capital or employees in economic terms. The ability of the agent to secure resources to sustain itself and reproduce is a measure of its fitness. In economic terms, fitness might be measured by profitability. Fitness cannot be determined in an absolute sense, but is rather a function of the other agents that form the 'environment'. Similarly in business or game-theoretic terms, the best strategy depends on the strategies of the other actors, or on changing customer demands. Since there is competition for resources, those agents that are least able to secure resources become unable to sustain themselves or reproduce, and their sets of strategies are therefore eliminated by a process of 'natural selection'.

- *Evolution*: The biological or strategic rule sets are modified over time, through mechanisms of mutation and crossover, or the social and technological equivalents of creativity and innovation. The biological processes appear to have their origins in thermodynamic, quantum or radioactive fluctuations, while the origins of human creativity are unknown; both processes are effectively random. It is noteworthy that most new ideas in business and technology arise through putting together existing ideas and technologies in new combinations, a process that is closely parallel to the recombination that arises through genetic crossover. Evolutionary change is seen to be a consequence of such creative non-average behaviour.

  Some of these new rule sets may result in organisms of increased fitness, in which case they will spread through the environment, thereby changing it. Equally, old rules that are now ill-adapted to the environment are more likely to decrease fitness and will tend to die out. Similar processes of fluctuations and positive feedbacks provide the basis for change in complex physical and chemical systems. These environmental changes will in turn change the fitness of other strategies and organisms, opening up new niches and opportunities, setting in motion an ongoing process of co-evolutionary change. Because the link between genotype and phenotype is highly non-linear, small genotypic changes may give rise to very rapid phenotypic and hence environmental changes, so evolution proceeds with the complicated dynamics of a non-linear system rather than the smooth progression of a linear system.

- *Models and Encodings*: Genomes, mental models and strategies are effectively implicit models of the world, built upon the experience in the world of previous rule sets, which provide the basis for action. As evolution proceeds, the rule sets and the models they encode for also evolve. They are not complete models of reality, but instead provide historically accumulated information on particular behaviours and structures that give rise to locally viable organisms or businesses in particular niches, where a niche is defined by a spatial and temporal coexistence of agents whose behaviours are phenotypic expressions of other genotypic rule sets.

A number of conclusions may be derived from this model of evolutionary change:

- *Non-Equilibrium*: while certain sets of rules and strategies may dominate for periods and give the semblance of local equilibrium, evolution is a continuous ongoing process of change that operates far from equilibrium. There is no 'best' strategy, since strategies are fit only relative to their environments, and these are constantly changing.

- *No Fixed Environment*: there is no fixed and unchanging 'environment' that we can protect and conserve. Instead, the environment is a process comprising and driven by many organisms engaged in co-evolutionary change. Equally, the future environment is made up of the creative actions of all present agents, and is therefore intrinsically unpredictable. As Lovelock (1979, 1988) points out, the oxygen that now comprises 20% of our atmosphere was a highly toxic trace gas for organisms of an earlier era. Had the organisms then alive been able to preserve their environment, our current oxygen-based life-forms would never have emerged.

- *Rules and Strategies*: the fundamental units of evolutionary change are the rules and strategies encoded in genes. Emerging results from complex systems research indicate that rules and strategies may play a similar role in the evolution of cultural practices, technologies, language or mental models. From the perspective of SD decision making, this implies that the centre of attention should be the cognitive level: the policies and strategies used by decision making agents, and their underlying assumptions, mental models, and use of language.

- *Efficiency and Learning*: two fundamental behaviours are required of complex adaptive systems. An agent cannot survive unless it has a minimum level of fitness or efficiency for its environment, but equally it and its descendants cannot prosper in a changing environment unless they have the capacity to learn through mutation, experimentation, innovation and evolutionary change. Since genetic structures, rules and strategies are based on encoded historical experience, an important part of learning is discarding the rules that are no longer relevant.

- *Resilience and Redundancy*: because the rule sets evolve in a bottom up, historical manner, they are not optimised. Instead they represent a series of hypotheses that have been tested and found to be useful in some way, although over evolutionary time, the parallelism of repeated trials and tests provide phenotypic 'solutions' that can be very efficient, to the extent that genetic algorithms are now used in multidimensional non-linear optimisation problems, such as designing turbines for jet engines (Holland 1992a, 1992b, 1995, Kauffman 1993, 1995). The rule sets often contain high redundancy, including old rules that are no longer relevant, duplicate rules and parallel ways of solving problems. But they are also very resilient, since the rules evolve by exposure to a wide set of 'problems', rather than being optimised for a single task. As a result, the rule sets will be able to generate adaptive responses in a wide variety of situations, even those not previously encountered. Computational systems based on genetic algorithms and neural networks are able to show similar learning, generalisation and resilience

(Hertz et al. 1991, DTI 1994). In general, resilience is seen to be closely related to redundancy and plurality, to having a large pool of possible behaviours, rules and response strategies from which to select an appropriate response for any given situation. This is an alternative derivation of the idea of requisite variety from cybernetics (Ashby 1952, 1960). In decision making terms, resilience corresponds to taking a plural approach to problem formulation and cognition (Bardwell 1991), and having a plural, and possibly parallel, approach to devising and implementing policies and strategies. The implications of this approach are considered further in chapter 12.

- *Local Understanding and Action*: the evolutionary process produces strategies that are adapted to a certain environment, or set of co-evolving strategies, at a given place and time, and will not necessarily be well-adapted to other environments in other places and times. The benefit of using models and strategies derived through a local, bottom-up process is that adaptive action does not require a complete description of the system. Lower animals and plants, for example, do not need to develop rich cognitive maps of reality in order to survive and evolve.

These conclusions present a number of challenges to simplistic notions of environmental protection and sustainability, especially reifications that present the environment as timeless and unchanging. The ideas of 'no fixed environment' and 'no equilibrium' make it clear that SD must be understood as sustaining an evolving process, the ecological, social and economic aspects of which are discussed in more detail in chapter 11. From a policy and management perspective, the complex/adaptive policy model's focus on resilience and learning is seen to be more consistent with survival in a complex evolving environment than the comprehensive/rational model's focus on optimisation and prediction. Section 5.3 observed that reductionist models are incomplete and fail to account for creativity and change. By contrast, the model of evolutionary change is dynamic and creative, and does not require complete cognition and exhaustive analysis before action is possible. Valéry argued "that which is simple is wrong, that which is complex is unusable" (Godet 1990), but the genetic algorithm style of bottom-up cognition and action overcomes this opposition by providing a radical break with the top-down approach to analysis and optimisation that has characterised the majority of decision making for SD.

The significance of theories of evolution in complex adaptive systems for sustainability are explored in more detail in chapters 9 and 11, while chapters 12 and 13 explores how institutional structures, strategies and decision making tools can support resilience and learning. The next section builds on the previous sections to shed more light on the meaning and relevance of complexity

5.6. Complexity

Zeno's paradox about the possibility of change, which was raised in section 5.3, also poses a question about identity in complex adaptive systems. Since such systems are adaptive, they can change their form and component parts while maintaining their identity, in the way that most cells in a human body are replaced several times during a lifetime. At the level of pure reductionism, there is no paradox, as the body of an adult is clearly not the same body as that of a child. But at the level of the human system, or person, the problem remains. Although their cells change, humans maintain a sense of personal history and identity over time. Part of the paradox is the deeply-rooted Western habit of reification, of thinking about the world in terms of objects rather than processes and patterns of interaction. A complex systems approach can provide insights into the limitations of such reductionism, and encourage a more evolutionary, process-based understanding.

Another aspect of the paradox is the nature of life, intelligence and identity. Among the characteristics of life and intelligence is that they cannot be described using the tools of reductionist science, as a living creature is more than its bodily components, and intelligence is more than the sum of the neurones in the human brain (Hofstadter 1979, Davis and Hersh 1983, Stewart 1987, Penrose 1989, Casti 1991, Kelly 1994). This holistic behaviour is also referred to as *emergence*, which denotes the appearance of structures and processes at a higher hierarchical level that cannot be predicted in terms of the laws governing the component elements of a system (O'Connor 1994, Sardar and Ravetz 1994, Schneider and Kay 1994, Stewart and Cohen 1994). For example, the laws of chemistry emerge from physics, and those of biology from chemistry. Although a living creature must *obey* the laws of physics, its structure and behaviour cannot be *predicted* from the laws of physics (Gell-Mann 1995). Similarly, the identity of a person is an emergent property of their physical and mental characteristics. Emergence is closely related to self-organisation in chemical and physical systems, which was introduced above.

The exact nature of emergence is still unresolved, and forms one of the central issues within complex systems research, although it has been suggested that interconnected positive feedback processes and autocatalytic sets have an important role to play (Allen 1990, Kauffman 1993, 1995, Holland 1995). The phenomenon of emergence is however promoting growing consensus among complexity researchers that a complex system cannot be judged simply in terms of what it *is*, but also by what it *does*. In other words, behaviour is at least as important as structure. For example, although the difference between a living creature and a dead creature is easy to detect, it is harder to describe in scientific terms. An instant after death, the organs and structures of the body are still the same as they were before death. What has changed is behaviour rather than structure; for example, the heart has stopped beating and breathing has stopped. Similarly, although the structures that underlie or emerge from complex behaviour are of great interest to complexity researchers, their primary concern is to describe the *behaviour* of complex systems, including their change and evolution over time.

There have been attempts to provide objective and quantitative measures of complexity, such as algorithmic complexity. Under this definition, a Sachertorte is more complex than a chocolate cupcake, because the shortest possible recipe (i.e. algorithm) for a cupcake is far shorter than the shortest possible recipe for a Sachertorte (Campbell 1982, Casti 1991). Other definitions are based on thermodynamics, computation and information theory (Horgan 1995), but such one-dimensional measures tend to obscure more than they reveal. An alternative approach to definition is to explore the types of behaviour which differentiate complex from non-complex systems:

- *Non-linear -vs.- Linear*: Although non-linear systems may be non-complex, no complex system behaves according to linear dynamics. Complexity therefore implies non-linear behaviour, including surprise, discontinuity and unpredictability, as discussed in section 5.4.

- *Evolving -vs.- Equilibrium*: Complex systems are characterised by ongoing co-evolutionary change, including creative and far from equilibrium behaviour, as discussed in section 5.5. Theories based on equilibrium cannot account for such behaviour.

- *Adaptive -vs.- Entropic*: Complex systems adaptively maintain their identity and functioning over time, by using information to control energy flows and thereby avoid an increase of entropy within their boundaries. An example is homeostasis, by which animals maintain a fixed bodily temperature in a changing environment.

- *Emergence -vs.- Reductionism*: The behaviour of a complex system cannot be analysed in a reductionist manner, that is, the behaviour of the whole cannot be predicted simply by studying the behaviour of the parts, or by building a reductionist model of the system, as discussed in section 5.3.

- *Reflexive -vs.- Non-Reflexive*: The behaviour of a complex system is reflexive, that is, the behaviour of the agents in the system is intrinsically unpredictable since they are continually responding to their changing environment, including the behaviour of the other agents that make up their environment.

These distinctions also help clarify the difference between complex systems, and those which are merely complicated, for example because they contain a large number of component parts, such as a pile of sand or an intricate Swiss watch. The ecological, social and economic systems that make up the SD debate all display non-linear, evolving, adaptive and emergent behaviour. They are therefore complex systems. The extent of the uncertainty that this complexity gives rise to is explored in chapter 6.

5.7. Conclusions

This chapter has presented an overview of reductionist modelling, non-linear behaviour, evolutionary change and complexity. Much as chapter 4 has differentiated between two policy models that do and do not take account of complexity, chapter 5 has discussed the approaches to understanding and types of behaviour of complex and non-complex systems, especially emergence, adaptiveness, evolution and non-linearity. Non-linearity is seen to yield discontinuous and unpredictable behaviour, while evolution adds creativity, innovation and adaptive change. The mechanisms of evolution, which are being explored through new forms of computer modelling such as artificial life, shed new light on adaptive behaviour and co-evolutionary change, as well as confirming the importance of innovation and experimentation in securing resilience. The traditional top-down, reductionist way of the understanding world is seen to be complemented by an adaptive, bottom-up and emergent process that appears to be typical of evolutionary development in complex systems.

The implications of these results for SD definitions and policies will be explored in subsequent chapters, but certain observations may already be made. In particular, the assumptions underlying the complex/adaptive policy model outlined in chapter 4 are seen to be consistent with an understanding of complexity, and the emphases on learning and resilience are seen to be appropriate responses. In addition, the fundamental role of strategies, rules, models and cognition in determining action and evolution suggests that this level of analysis is relevant to developing effective policies for SD. In the light of this insight, the definitional and cognitive problem at the heart of the SD debate is revealed to be central to pragmatic policy making, rather than simply an academic diversion.

At the level of SD definitions themselves, a complex systems perspective suggests that the polarisation of the debate into multiple perspectives is predictable given the partial nature of modelling and cognition, and yet unhelpful in shedding light on the co-evolutionary processes within natural and social systems. Moreover, by implying a false choice between hypothetical alternatives, such typologies encourage reductionist analysis to pick the 'right' definition, rather than the learning and resilience-based approach most appropriate to a complex world. That is not to say that the typologies do not describe views which may be deeply rooted, but rather that resilient policies for SD need to be able to synthesise the opposed perspectives and move beyond their implacable confrontation.

Complexity also sheds light on the nature of resilience in complex adaptive systems, which is seen to be related to the diversity and plurality of possible behaviours, which are in turn encoded in plural and redundant rules sets. In SD policy terms, resilience implies plurality at the level of mental models, problem definitions, solutions, technologies, policies and institutions. Theories of evolution and adaptiveness in complex systems also suggest models for policy processes and institutional forms that might promote such parallel, bottom-up and plural approaches. The practical implications of these insights are explored further in chapter 12, and also in the discussion of cultural theory in chapter 7. The next chapter examines the extent to which complexity and unpredictability have emerged as issues within the SD policy debate.

Chapter 6: Examples of Complexity in the Sustainable Development Debate

6.1. Introduction

Chapter 5 introduced some of the key concepts underlying a complex adaptive systems perspective of the world, and suggested that natural and social systems are complex, and are therefore likely to be marked by significant uncertainty and unpredictability. The purpose of chapter 6 is to provide an illustration of the extent of uncertainty in various aspects of the sustainability debate, in order to build a case for using complex systems approaches when tackling issues of SD.

6.2. The Prevalence of Uncertainty

Analysts of SD have concluded that uncertainty is prevalent in Biospheric and social systems (Clark and Munn 1986). For example, Ayres (1993) observes the non-equilibrium behaviour of the biosphere as a whole, as evidenced by an oxygen-nitrogen atmosphere, and concludes that the system is highly non-linear, complex and possibly chaotic in certain domains. He argues that the unpredictability of biogeochemical systems is such that "we may not be able to ascertain the limits of safety for human interference, even in principle".

O'Riordan and Rayner (1991) examine uncertainty associated with four types of potential global change: Biospheric catastrophe, climate perturbation, undermining basic needs provision, and micropollutants with long-term consequences. They argue that these issues present managers with irreducible complexity and uncertainty due to two key difficulties. First, human action and systemic reaction act interchangeably, leading to "wholesale unpredictability", yet they are treated as analytically separable during analysis and modelling. Second, policy makers are unable or perhaps unwilling to contemplate the complex interconnections among the component processes of these issues. Fosberg (1991:3) observes that for even the simplest biological or geographical systems:

"The more one learns, the more complexity becomes evident. Attempts to deal with this by a reductionist or analytical approach reveal more and more facts; but how these function together gets lost in the chaos of separate components. Few really controlling factors are found, and these turn out to be conditioned by other factors and combinations of factors; as a result, the mechanism comes to appear more and more complicated - often to the extent of being virtually unmanageable".

Other analysts reach similar conclusions, noting the complexity of ecological and social systems, and the challenges for policy and management (Clark 1986, Norgaard 1988, Brooks 1992, Dovers and Handmer 1992, Wahlström 1992, Slocombe 1993, Bella 1994, Holling 1994, Sardar and Ravetz 1994, Clark et al. 1995, Van Asselt and Rotmans 1995). Rather than performing an exhaustive analysis of complexity and uncertainty in the SD debate, which has already been demonstrated convincingly by other authors, the next section of this chapter will provide illustrative examples of the implications of complexity at all levels of the debate, from the global to the microscopic.

6.3. The Presence of Complexity at All Levels

The complexity of social and economic systems has already been explored in chapter 5. While a lingering belief in social engineering and central planning persists in certain quarters, most policy makers would now accept that social, cultural and technological change is essentially unpredictable over the generational timescales of SD, depending as it does on the actions of creative, strategising human individuals (Mason et al. 1984, Waldrop 1992, Kelly 1994). Biospheric complexity is of a different order, since it combines creative human actions with non-linearity and evolutionary responses of biogeochemical systems, and may be observed at many levels:

- *Global*: The uncertainty in climate science was explored in section 4.5, notably the existence of at least 21 different feedback processes of unknown magnitude and, in some cases, direction. Since the system is highly non-linear, there is no scientific way of predicting any points of discontinuous change or transition to a new behaviour domain that may be encountered due to anthropogenic interference

(Ayres 1993). Palmer (1992) argues that if we view the climate as a non-linear system with complex attractor dynamics, it is essentially impossible to tell whether any particular sequence of hot and cold annual mean temperatures is representative of a long-term shift in climate, or whether it is simply the result of the system's non-linear attractor exploring various parts of the system's phase space. The fundamental impossibility of predicting when, or whether, a chaotic or highly non-linear attractor will enter into a different behaviour domain was explored in chapter 5. Such analyses conclude that the long-term outlook for climate change and its implications for other parts of the biosphere may thus be completely unpredictable.

- The policy implications of non-linearity are illustrated by the discovery of the ozone hole. Initial work by Rowland and Molina in the 1970s proposed a mechanism for CFC-induced ozone depletion, but it was not until 1985 that 40% ozone losses were finally detected over Antarctica by Farman et al. (1985). NASA's Nimbus-7 satellite had in fact been recording the losses since 1978, but the computers analysing the satellite data had been programmed to reject such extreme variations as anomalous noise or errors, since they were outside the range of possible depletion accepted by the mainstream scientific establishment, whose models were based on linear assumptions about the depletion mechanism (Roan 1989, Benedick 1991, Zehr 1994). The ozone story provides a familiar example of how linear models are used in policy making because they are simpler to build and understand, even though their outputs may bear very little relationship to the real world. This practice is particularly prominent in economic modelling and analysis, as noted in chapter 5. Given the problems of constructing reliable models of highly non-linear systems, it is likely that further surprises like the ozone hole will emerge in other SD issues.

- *Regional*: Hourcade et al. (1992) analyse the problem of acid rain and forest die-back in Europe, which they argue is an archetypal environmental issue marked by demands for political action despite scientific uncertainty. Indeed, the proliferation of scientific hypothesis suggests that additional research has increased uncertainty, rather than decreased it. In the 1970s, the problems were thought to be due to transboundary transport of NO_x and SO_2 emissions. By 1985, there were three hypotheses: soil acidity due mainly to SO_2; the level of tropospheric photooxidants due to NO_x and VOC; and a synergetic combination of the two. By 1990, the number of competing hypothesis had risen to five: soil acidity; acid fog affecting leaves and needles; photo-oxidation; some forestry practices, especially spruce monoculture; and some climatic events (Pearce 1990). Most scientists now believe that the real reason is due to some complex interrelationship among these five, and possibly other, causative factors. Hourcade et al. propose that in the face of this evident complexity, we should treat such issues as *undecidable*, since experimental data and theoretical tools are lacking and are expected to remain lacking for the foreseeable future. They argue that since we cannot isolate 'the' problem, we cannot devise an optimal policy to tackle it through scientific and economic analysis, and so learning and resilience emerge as the only viable decision making approaches.

- *Local*: Miller (1993) analyses the spruce budworm controversy in New Brunswick, Canada, which concerns the interrelationship between the use of pesticides to control budworm, the effects of toxic runoffs into salmon rivers and the increased incidence of Reye's syndrome among local children. Miller demonstrates that reductionist epidemiological and toxicological studies have been unable to analyse the complex interactions of multiple chemical agents and their health and ecological impacts. He argues that in attempting to make such a complex issue amenable to scientific investigation, the extent of simplification and reductionism produced a "greatly reduced and inconsequential version of the problem . . . [which] virtually guaranteed that nothing would be found". This example demonstrates Fosberg's conclusion noted above, that the complex interdependency of natural and human systems eludes rational reductionist analysis.

6.4. Conclusions

Experience of environmental issues at global, regional and local scales has demonstrated that the extent of complexity and non-linearity is exceeding the present ability of reductionist science and modelling to provide meaningful guidance for policy. While additional research is undoubtedly needed to tackle the lacunae of data, theoretical models and understanding, the non-linearities of biogeochemical systems essentially preclude accurate prediction of important thresholds and sensitivities, and the extent of uncertainty is such that scientific consensus may not be attained for several decades, if ever. When the analysis is broadened to include social, technological and economic change and impacts, as with integrated assessment modelling, the complexity is such that the possibility of accurate prediction vanishes completely, and even simulations are of highly questionable utility (Jasanoff and Wynne 1995).

While this result is perhaps not surprising in the light of the nature of complex systems explored in chapter 5, it is sobering to reflect on Boehmer-Christiansen's (1994) analysis of the extent to which it is not accepted in the climate change debate. She found that the traditional view of science as a tool for the "science-planner" to control future states of society still dominates governmental thinking, with only one exception, a government official and IPCC participant who argued that "We increasingly live in a world of uncertainties and . . . should concentrate on learning to cope and deal better with uncertainties rather than try to reduce them. Science will always resolve some questions while revealing others". Boehmer-Christiansen observes that knowledge relating to the very complex systems that underlie SD issues is "intrinsically more indeterminate than policy would like", and that progress in policy making depends on a new model that recognises the limits of knowledge in the face of complexity.

The tools and approaches that might facilitate such thinking are explored from chapter 12 onwards, while the next chapter turns to the question of how policy makers and managers develop pluralistic mental models and world views in the face of such complexity, and the implications of these conceptual approaches for policy choice and institutional design.

Chapter 7: Cultural Theory

7.1. Introduction

Chapter 5 demonstrated that mental or computer models of a complex reality are inevitably partial, and also that resilience in complex adaptive systems typically arises through plural and diverse behaviours. A complex systems interpretation would argue that since behaviours are based on an underlying set of 'rules', which are encoded genetically, culturally, conceptually, linguistically or in other ways, a more resilient strategy may be attained by building a richer and more plural rule set or mental model.

These same results may be derived beginning from a completely different disciplinary starting point, namely that of cultural theory, which asserts that individuals have partial views of reality based on one of four fundamental world views or myths of nature which underpin their plural rationalities. Cultural theory argues that a more resilient strategy for sustainability may be attained through building a plural decision process that takes account of all four world views, which it refers to as a clumsy institution.

Both complexity and cultural theory see human agents as possessing partial models of reality, and both see greater plurality as the key to building resilient policies and institutions. The main difference is that cultural theory argues that there are only four basic perspectives, whereas the bottom-up evolution of rule sets in complex systems generates an unlimited diversity of perspectives. These two results are not necessarily inconsistent, however, since the four fold cultural typology may be an emergent property of social and cultural evolution, as discussed in chapter 10.

The particular attractiveness of cultural theory from a pragmatic policy perspective is that it provides a simple heuristic for developing resilient policies and institutions for SD, namely the inclusion of the four perspectives into the decision process and the resulting policies and institutions. Furthermore, unlike the participatory models discussed in chapter 4, it specifies a simple test for assessing whether adequate plurality or requisite variety has been attained, namely whether all four perspectives are present. Chapter 7 presents an overview of cultural theory, introducing the grid / group systems and the four myths of nature, and their previous application to the SD debate. It also explores cultural theory's recommendations on attaining resilience, and evaluates cultural theory's compatibility with the typologies of SD definitions examined in chapter 3.

7.2. An Overview of Cultural Theory

The following discussion of cultural theory is based on Douglas and Wildavsky (1982), Thompson et al. (1986), Schwarz and Thompson (1990), Thompson et al. (1990), Douglas (1992) and Rayner (1994). In summary, cultural theory holds that:

- The traditional dichotomous (i.e. one-dimensional) distinction between hierarchies and markets is an inadequate framework for discussing the full range of political cultures and preferred organisational forms of society.

- Instead, cultural theory proposes a four-fold system (i.e. two-dimensional) based on the two axes of grid and group. By crossing these two axes, we obtain four quadrants containing four distinctive political cultures: individualism, hierarchy, egalitarianism and fatalism. Any individual or group of individuals in the form of an institution will be organised according to one of these cultures.

- Each of these four political cultures has a preferred myth of nature which describes the general characteristics of the world. These are, following the above order of the political cultures, nature benign, nature perverse-tolerant, nature ephemeral and nature capricious. There are only four stable combinations of myths and cultures; individualism corresponds to nature benign, and so on.

- The myths and the cultures together can be used to derive the preferred policies, management regimes, technological solutions, consumption styles and attitudes to risk and fairness that are associated with different institutions corresponding to the different cultural types. Cultural theory thus offers a powerful and compact theory of political culture, political choice and technological disputes, among others.

At the heart of cultural theory is the grid-group typology of social relationships, which derives from the work of Basil Bernstein as described in Douglas (1973), and was developed by Douglas and her co-workers (Douglas 1975, 1978, 1982, Thompson 1983a, 1983b, Gross and Rayner 1985). It argues that the variability of an individual's involvement in social life can be explained using two dimensions:

- *Grid*, which measures the degree to which an individual's behaviour is circumscribed by externally imposed prescriptions and controls. A higher value of grid corresponds to a greater level of external constraint on individual choice.

- *Group*, which refers to the extent to which an individual's life is absorbed in and sustained by group membership. A higher value of group denotes a greater level of incorporation into bounded units, and a higher level of group determination of individual choice. It also corresponds to tighter controls over admission into the group, and higher boundaries separating members from non-members.

Cultural theory broadens the conventional two-fold distinction between hierarchies and markets (Williamson 1975, Lindblom 1977) to discriminate between four institutional types. By observing that markets institute equality and promote competition, whilst hierarchies institute inequality (i.e. status distinctions) and set limits on competition (i.e. free bidding and bargaining), cultural theory argues that there are two parameters in the description, so the complete typology must include the other two permutations (Price and Thompson 1995:4). These are equality without competition (which cultural theory refers to as egalitarianism), and inequality with competition (fatalism). The four-fold typology of ways of life provides a richer description than the two-fold differentiation between hierarchies and markets, and yields several advantages in understanding social systems. Cultural theory also argues that each way of life is associated with a distinct rationality which forms the basis of decision-making (Schwarz and Thompson 1990:6). The ways of life and their associated rationalities may be summarised by four archetypal examples (figure 7.1):

- *Individualist*: the 'self-made' Victorian manufacturer, a pragmatist who measures success in material terms and has a substantive rationality that focuses on the 'bottom line'. He follows a personal strategy that is defiantly individualistic and unashamedly manipulative, supports the free operation of the market as a means for increasing wealth, and sees human skill, enterprise and risk-taking as the keys to success.

- *Hierarchist*: the high-caste Hindu villager, who has considerable rights to land, water, priestly duties and the deference of his fellow villagers, and a corresponding set of duties and allowable behaviours. Everyone in his society has a place, and there are heavy prescriptions to ensure that social order and stability are maintained. Attention to observing the rules creates a procedural rationality that is more concerned with the correctness of procedure and behaviour than with trying to evaluate any outcome that may arise. Soldiers of all ranks and civil servants are other exemplars of this category.

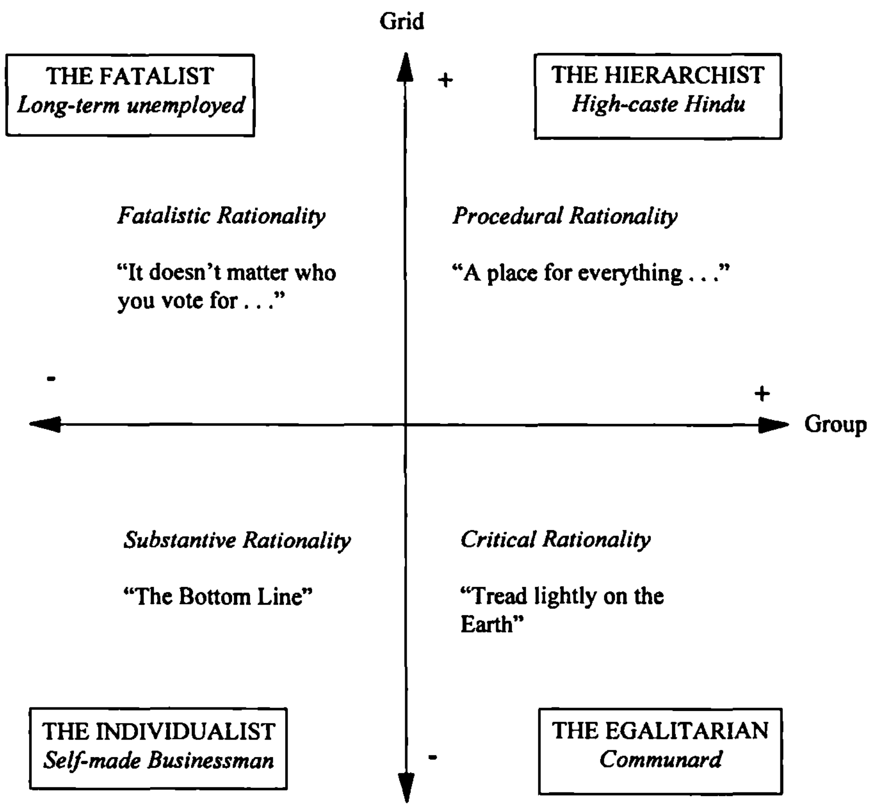


Figure 7.1. The Four Political Cultures, Rationalities, and Ways of Life

- *Egalitarian*: the member of a self-sufficient Western commune, whose critical rationality rejects the inequality, coerciveness and harshness of the outside world in favour of voluntaristic fraternal and sororal co-operation. He has strong group loyalties, but little respect for externally imposed rules, other than those of nature. Group decisions are arrived at democratically, but the group tends to expend more energy in criticising the world outside its 'wall of virtue' than in delivering solutions. This rationality was historically the driving force of socialism, and can be seen today in religious sects and environmental pressure groups.

- *Fatalist*: the long-term unemployed, on the margins of society, who is excluded from the group that makes the decisions that govern his life, and sees no way to influence events. For his fatalistic rationality, good or bad outcomes are to be enjoyed or endured, but never achieved. Examples include non-unionised workers, outcasts and untouchables.

The fatalist does not attempt to become involved in society, so there are only three active ways of life that participate in policy debates: individualists, hierarchists and egalitarians. Rayner (1994) proposes an alternative derivation of these three active ways of life by contrasting various dichotomous distinctions from classical social theory, and noting that two dimensions are needed to describe them exhaustively (table 7.1 and figure 7.2).

There is also a fifth "non-engaged" way of life described by cultural theory: the *hermit*, who "withdraws from all coercive social involvement", and hence plays no role in policy debates (Schwarz and Thompson 1990:78). Schwarz and Thompson argue that this way of life is followed by some individuals in industrial societies, and by whole communities in the Himalayas, but that its non-engagement means that it does not merit further analysis when considering policy debates.

A detailed comparison of cultural theory with previous typologies of social relations (such as those of Montesquieu, Spencer, Marx, Durkheim and Weber) is made by Thompson et al. (1990:103), wherein the cultural theorists assert the superiority of their typology. Although the details of this argument are beyond the scope of this chapter, it is instructive to examine the reasons given (Thompson et al. 1990:104, Rayner 1994:10) to support cultural theory's claim to superiority:

Market / Individualist	Hierarchist	Egalitarian	Reference
geselleschaft (social bonds created by individualistic competition and contract)	*gemeinschaft* (societies bound by ties of kinship, friendship, local tradition)	*gemeinschaft*	Tönnies (1887)
Organic solidarity (agents bound together by inter-dependence of specialised social roles)	*Organic solidarity*	*Mechanical solidarity* (agents bind themselves on basis of sameness)	Durkheim (1893)
Specialised roles (typical of industrial society)	*Specialised roles*	*Multifunctional roles* (typical of pre-industrial society)	Bennett and Dahlberg (1990)
Personal authority (families where behaviour is regulated by appeals based on individual preferences)	*Positional authority* (families where behaviour is regulated by appeals to hierarchical authority)	*Personal authority*	Bernstein (1971)
Contract relations (agents freely associate by negotiated agreement)	*Status relations* (actors know place in hierarchical structures based on idiom of the family)	*Status relations*	Maine (1861)

Table 7.1. Three Kinds of Social Solidarity in Classic Social Science Literature

- *Robustness*: the typology is logically superior because it is derived from common social dimensions (both grid and group measure social restrictions on individual autonomy) that generate an exhaustive and mutually exclusive set of categories, unlike other typologies. For example, Max Weber's threefold categorisation of tradition, legal-rational and charisma is formed from completely different sorts of dimensions. Tradition is a historical criterion, legal-rational refers to a mode of rationality and charisma is a leadership quality (Thompson et al. 1990:104). Thompson et al. also argue that their typology is more variegated than the traditional/modern dichotomy, which overlooks egalitarianism and fatalism, and explains neither the occurrence of competitive individualism in technologically primitive areas nor the role of hierarchy in industrialised societies. Cultural theorists also contend that the three active ways of life are fairly robust, since they systematically encompass the distinctions that have informed a century and a half of empirical social science.

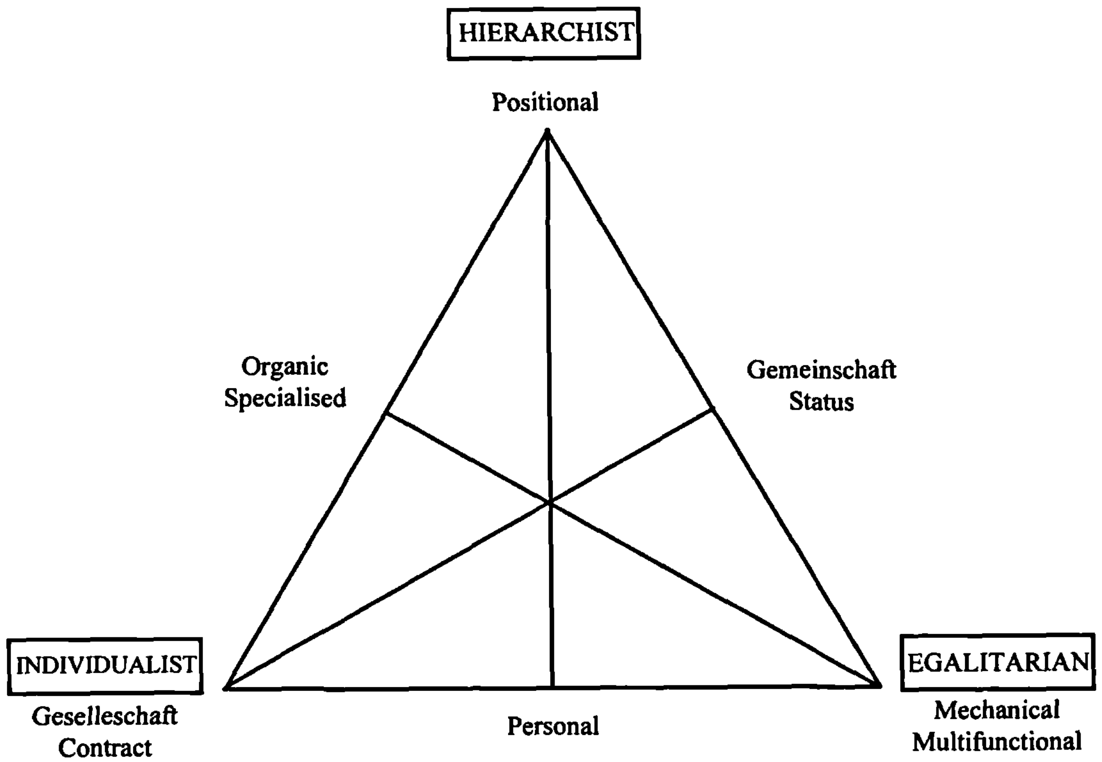


Figure 7.2. A Two-Dimensional Map of Social Solidarity and Ways of Life

- *Endogenous Change*: can be exhibited by the typology, since each type of solidarity only exists in distinction from the other two, and so instability and conflict are inherent to the framework. Changes in social organisation or values do not therefore necessarily require exogenous causes, which Rayner (1994) suggests may have important implications for policy modelling of societal preference functions such as the demographic transition.

- *Non-Deterministic Change*: unlike traditional dichotomous systems, in which a transition from one state can only be to the other state, a four-fold typology has three possible end-states and therefore allows non-deterministic change.

- *Predictive*: cultural theory is able to predict what specific new perspectives appear when a social position is changed, when "new foregrounds emerge and old worries are backgrounded" (Douglas 1992:xi).

- *Systematic*: the cultural framework, by explicitly focusing on the modes by which bind themselves to each other in social institutions, also explains how they: define their basic needs; develop principles for distributional equity, fairness and intergenerational equity; and shape their epistemological and moral relationship with nature.

These claims are evaluated when cultural theory is applied to SD in chapters 8 and 9.

7.2.1. Myths of Nature

Cultural theory holds that it is our institutions that analyse the inchoate, and allow us to make sense of the complex and multifaceted reality surrounding us. They are the repositories of our myths: the structures which frame individual awareness and perception (Douglas 1986). Thompson has extended cultural theory to understand how each of the four institutional types organises and makes sense of the natural world through a corresponding 'myth of nature' (Thompson et al. 1990), which, he argues, "brings natural and social scientists together in a new and interesting way" (Schwarz and Thompson 1990:4).

Social science is familiar with the idea that our perception of nature is socially constructed, at least in part, but this theme has received less attention in natural science. An exception is the work of the ecologist C. S. Holling, who has studied how institutions intervene in managed ecosystems such as forests, fisheries and grasslands. Holling finds that different managing institutions, when faced with the same kinds of situation, adopt very different management strategies based on different 'myths of nature', their assumptions about ecosystem behaviour. He describes such myths as "distinct viewpoints [or] metaphors . . . [that] have dominated perceptions of ecological causation, behaviour, and management" (Holling 1986:294).

Thompson et al., referring to Holling's work, list the following four myths of nature (Thompson et al. 1990:27, Schwarz and Thompson 1990:4), and represent them pictorially with icons of a ball in a landscape (figure 7.3):

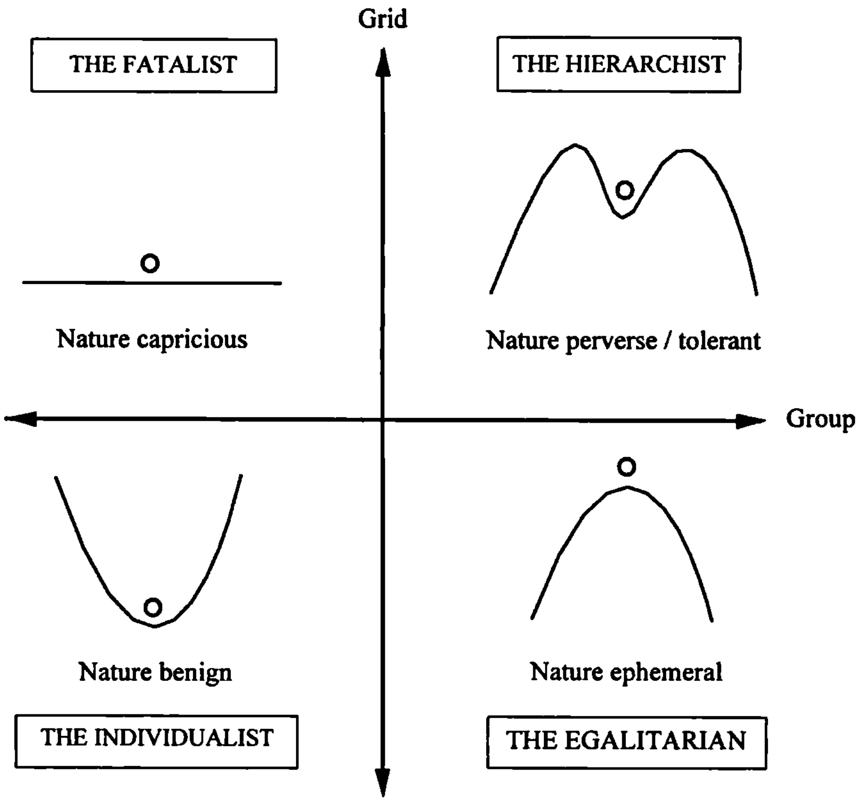


Figure 7.3. The Political Cultures and their Four Myths of Nature

- *Nature benign*: is a state of global equilibrium, represented by a ball in the bottom of an infinite bowl. Since the ball will always return to rest if displaced, an institution managing such an ecosystem can have a laissez-faire attitude.

- *Nature ephemeral*: is a precariously balanced state, in which the least jolt might cause catastrophic collapse. People must tread lightly in such a world, and observe the precautionary principle.

- *Nature perverse/tolerant*: is forgiving of most occurrences, but vulnerable to extreme events that could knock the ball over the rim. The managing institutions must therefore regulate against unusual incidents, but need not worry about minor matters.

- *Nature capricious*: is a random world, in which institutions cannot learn or manage, but must simply cope.

Thompson et al. argue that the ways of life will be subject to social influences on their cognition of ecosystem behaviour, such that they will grant credibility to different myths of nature. The individualist is predisposed to see nature as benign, since this allows him to rationalise the laissez-faire policies he favours; a fragile world supports the egalitarian's call for precaution; nature perverse/ tolerant justifies the hierarchist's reliance on expertise to map the zone of safety, and on regulation to keep the system there; while a random world confirms the fatalist in his belief that there is no point trying to manage anything at all (figure 7.3).

Schwarz and Thompson (1990:8) conclude that this homology reveals "how each of the myths of nature . . . legitimates and reproduces certain kinds of institutional relationships (the anthropologist's cultural categories)". This hypothetical parallel constitutes a falsifiable hypothesis (Schwarz and Thompson 1990:11), which has been examined with reference to real-world examples from environmental policy, as outlined below.

7.3. Applications of Cultural Theory to Environmental Policy

The cultural synthesis of ways of life and myths of nature has been used in environmental policy analysis and environmental modelling, although most of this work involves applying the theory rather than attempting to test it.

- Douglas and Wildavsky (1982): study US environmental groups using grid-group analysis but not the myths of nature (op. cit.:138-139), and differentiate between the 'centre' (hierarchy and individualism) and the 'border" (egalitarianism, here called sectarianism). They find that Friends of the Earth is sectarian in structure, has a world view of "a carefully balanced ecosystem that is being blindly upset by man with potentially disastrous social and physical consequences", and a single aim to "bring man back into balance with the environment on a world-wide scale". By contrast, the Sierra Club is hierarchical in organisation and approach, is prepared to make compromises with economic demands in its campaigns, and sees conservation as only one among a number of legitimate concerns (op. cit.:137). This example vindicates the cultural approach, as do their studies of carcinogenic chemicals and the antinuclear movement.

- Caputo (1984): analyses the debate on energy policy, noting that opposing "conclusions turned out to be the starting places, followed by assumptions, followed by analysis which always reached the same conclusions that were the starting point". Naming the three perspectives 'entrepreneur', 'survivalist' and 'hierarchist', he argues that all sides "apparently were making social predictions and then used their technical calculation of approximate resource potential to verify their vision of future societies" (op. cit.:237)

- Thompson et al. (1986): study theories of environmental degradation in the Himalayas, and the ways of life and environmental perceptions of local people, using the centre-border distinction, but not grid-group or myths of nature. They identify five socially viable conjunctions of problem definition, solution and way of life: the "irate administrator", "sceptical observer", "cautious cultivator" and "adventurous trader" (op. cit.:64), and the Chipko movement (op. cit.:144). These correspond to hierarchist, hermit, hierarchist, individualist and egalitarian. The authors also note an example of an individualist approach to policy combined with environmental concern: "the entrepreneurial style of WWF/IUCN is summed up in a staff member's remark: 'As far as biological conservation is concerned, we don't care how we get there; it's the bottom line that counts. We have to go after openings where we find them'" (op. cit.:153). The authors admit that they are applying, rather than testing, cultural theory, noting that management strategies in Himalayan villages can be classified, but that "we will not attempt to do much of that here" (op. cit.:39)

- Schwarz and Thompson (1990): analyse five studies of energy futures carried out between 1975 and 1980, and find that each study distinguishes between essentially the same three futures (table 7.2):

Reference	Approach	Individualist Myth	Hierarchist Myth	Egalitarian Myth
Harman et al. (1977)	engineering perceptions	'onward and upward'	'gradual smooth descent'	'sudden discontinuous descent'
Schanz (1987)	oil and gas supplies	optimist (reservoir engineer)	moderate (government bureaucrat)	conservative (economist)
Chapman (1975)	resource estimation	'business as usual' (future is same)	'technical fix' (future is different, but not close)	'low growth' (future is different, but close)
Humphrey and Buttel (1980)	environmental debate	liberal	conservative	radical
Orr (1977)	energy policy	'supply' (breeder / fusion technology)	'conservation' (conversation in near term, then breeder / fusion)	'energetics' (wind, decentralised solar and biomass technology)

Table 7.2. Five Threefold Myths of Energy and Environmental Futures

- O'Riordan and Rayner (1991): argue that the three active cultural myths choose three different strategies for global environmental change: egalitarians favour 'prevention', individualists prefer 'adaptation', and hierarchists endorse 'sustainable development' (op. cit.:99). They do not attempt to prove this assertion, but instead suggest which specific strategic institutional responses would be 'adaptive' for four sustainable development issues (table 7.3). Their argument applies cultural theory rather than tests it, while their selection of a single institutional solution for each issue rejects cultural theory's call for clumsy institutions. They argue that clumsy institutions are impractical, since "there appear to be institutional obstacles to each type of institution developing and retaining sensitivity to all aspects of global environmental risks", so if we wish to promote societal learning we should instead cultivate "institutional pluralism (the cultural equivalent of biodiversity)" (op. cit.:104-105).

Issue	**Decision Criteria**	**Decision-Making Approach**	**Adaptive Institution**
Biospheric catastrophe	Faith > Science	Gaianistic - holistic	Egalitarian
Climate perturbation	Faith = Science	Argument over evidence - pragmatic	Individualist
Basic needs provision	Faith < Science	Evidence and experiment - reductionist	Hierarchist
Micro-pollutants	Both Faith and Science	Intuition and foresight - pragmatic	Mixed

Table 7.3. Management Strategies for Global Environmental Change

- Dake and Thompson (1993): apply cultural theory to the sustainable development issue of needs and consumption styles, arguing that since both are culturally determined (table 7.4), policies based on the assumption that they are societally homogenous are likely to fail.

Way of Life	**Needs and Resources**	**Consumption Style**	**Lifestyle**
Individualist	Can manage both needs and resources.	*Conspicuous consumption* - manage needs and resources up (individualistically) as high as possible.	Cosmopolitan
Hierarchist	Can manage resources but not needs.	Manage resources up (collectively) to meet socially fixed (and hierarchically varied) needs.	Traditionalist
Egalitarian	Can manage needs but not resources.	*Voluntary simplicity* - manage needs down (collectively) to meet naturally fixed resources.	Naturalist
Fatalist	Cannot manage either needs or resources.	Enjoy time of plenty, endure times of scarcity.	Isolated

Table 7.4. Needs, Resources and Consumption Styles (Dake and Thompson 1993)

- Rayner (1994): points out that the climate change issue is associated with high levels of scientific uncertainty and high decision stakes, including not only the technical assessment of benefits and costs, but also judgements about what is fair and even what should be valued. He argues that the work of IPCC Working Group III and the current debate about CO_2 reduction targets and emissions rights is one-dimensional, since it assumes that all humans share the same basic motivations and procedural preferences, and will respond in the same way to the same incentives. He introduces, but does not attempt to prove, cultural theory's institutional types and myths of nature to demonstrate that there is no consensus on a 'best' equity principle. He therefore recommends that the IPCC "should shift its sights from a technocratic goal of providing decision makers with the best possible prescription for fairness towards the more modest goal of providing decision makers with the best tools for essentially political negotiation among competing prescriptions" (op. cit.:29).

- Trisoglio et al. (1994): apply the cultural perspectives to demonstrate that the IPCC scenarios only reflect the hierarchist world view, and not those of the individualist and egalitarian. The scenarios therefore lack the requisite variety to adequately describe the climate change debate and the full range of technology and policy options. The authors develop a set of scenarios of climate change to demonstrate how the inclusion of cultural perspectives would broaden the scope of the debate.

- Adams (1995): identifies examples of each myth of nature at play in the climate change debate: James Lovelock holds to the fatalist myth: "Gaia will look after herself. And the best way for her to do that might well be to get rid of us"; Greenpeace argues for precaution with egalitarian urgency; Richard Lindzen of MIT has an individualist faith in the "immense robustness" of the Earth's atmosphere; and the hierarchists in the UK government see cause for concern but not panic (op. cit.:167-170). Adams does not attempt to show that these are the only possible myths, nor to test the cultural hypothesis that they are associated with particular political cultures.

* Van Asselt and Rotmans (1995): apply the cultural perspectives in a preliminary manner in the population sub-model of the RIVM integrated assessment model TARGETS, and demonstrate that different policy assumptions and world views have a significant result on model results. They also analyse the sources of scientific uncertainty over climate change processes, and the RIVM biogeochemical cycles sub-model, and propose how the model parameters could be adjusted to reflect the different myths of nature within the accepted bounds of scientific uncertainty. They report that the RIVM models are being updated in the light of this work, but results are not yet available.

The various applications of cultural theory demonstrate that the theory appears to offer a useful typology of alternative perspectives towards environment and SD, which suggests a comparison with the typologies analysed in chapter 3. Referring to figure 3.5, we may draw the following links with cultural theory's myths of nature (table 7.5):

Perspective from table 3.5	Gaia	Neo-Malthusian, Deep Ecology	Ecocentrism, Communalism	Conservationist, Managerial	Cornucopian, Technocentrist
Cultural theory myth of nature	Nature Capricious?	Nature Ephemeral	Nature Ephemeral	Nature Perverse/ Tolerant	Nature Benign
Rationality	Fatalist ?	Egalitarian	Egalitarian	Hierarchist	Individualist

Table 7.5. Perspectives on Sustainability Compared with Cultural Theory

The following observations may be made regarding table 7.5:

* *Two Egalitarian Myths*: Cultural theory appears to be unable to differentiate between the 'light' and 'dark' greens, the communalist-ecocentrist and extreme ecocentrism-deep ecology perspectives identified by O'Riordan and Turner (1983). This is perhaps because the biocentrism / anthropocentrism bifurcation that separates these perspectives has very little to do with either the myth of nature, which both perspectives see as vulnerable, or the preferred institutional

form, which is typically communal and egalitarian (Redclift 1988, Jacob 1994).

- *Gaianism-Fatalism*: The Gaian perspective, as noted in the comments on Adams (1995) above, may be correlated with fatalism, since nature appears to be capricious as far as humanity is concerned, and humans are not wise enough to decide (Brooks 1992). The convergence is not exact, however, since fatalists see no inner logic to the workings of nature, whereas Gaianists see nature as an intricate self-organising and homeostatic system (Lovelock 1979, 1988). One can also argue that the Gaian model in fact holds that nature is highly resilient, and might therefore better fit the individualist myth of nature benign (Smil 1987). The problematic nature of this classification is discussed further in chapter 9.

With the exception of these two difficulties, however, cultural theory provides a good classification of the perspectives identified in table 3.5. Unlike the typologies discussed in chapter 3, cultural theory has the benefit that it is derived from a theoretically grounded, logically consistent two dimensional system, whereas the other typologies are essentially arbitrary classifications derived from 'experimental' observation of the SD debate. The correspondence between cultural theory and other typologies does not, however, constitute a test of cultural theory, since cultural theory's claim is not only that there are only four myths of nature, but that each myth is only ever held in conjunction with a given institutional preference. The success of cultural theory is evaluated in chapters 8 and 9.

7.4. Resilience and Plural Institutions

Cultural theory has several implications with respect to SD policy making. Firstly, whereas traditional models of decision making assume the separability of facts and values, implying a single rationality (Briassoulis 1989, Brewer 1986), cultural theory argues that facts and values cannot be separated, and that uncertainty is never just 'technical'. More generally, cultural theory supports the widespread conclusion noted in chapter 4 that plurality is an essential component of a successful policy process.

Plurality is vital during problem definition to ensure that all perspectives are included (Rayner 1986, Bardwell 1991), to allow a wider variety of solutions to be considered (Bowonder 1987), and to support processes that allow solutions to arise bottom-up (Wynne 1993). Thompson (1986) argues that taking account of all four perspectives is essential, since the various myths of nature are contradictory and therefore cannot be synthesised into a unified perspective.

Schwarz and Thompson (1990) demonstrate that the absence of the four-fold plurality leads to social and technological inflexibility, unpleasant surprises that could have been avoided through a better policy or decision making process, and disputes between experts and between holders of alternative perspectives within the SD debate that arise from the plural nature of problem definitions. The solution proposed by cultural theory is greater plurality, which may be attained through what it calls clumsy institutions. This recommendation is consistent with calls for a more open, pluralistic and learning-oriented policy process from other authors (Cantley 1986, Ravetz 1986, Winsemius 1990, Carley and Christie 1992, Jasanoff 1993), and with ideas of clumsiness, incrementalism, procedural rationality and "muddling through" in the policy process (Simon 1957, 1957, Lindblom 1959, Braybrooke and Lindblom 1963, Simon 1978, Lindblom and Cohen 1979, de Young and Kaplan 1988, Briassoulis 1989). The shortcoming of all such generic arguments in favour of institutional learning and plurality is that they rarely provide concrete means of ensuring that plurality is attained in practice. Cultural theory's call for inclusion of all four perspectives provides a starting point, but even here there is no further detail on how 'clumsiness' might be attained in practice.

One of the tools that has been successfully applied to ensure the inclusion of multiple perspectives in decision making is the use of scenarios to develop more plural and resilient mental models. Such approaches provide a natural vehicle for operationalising cultural theory's call for plurality, and chapters 13 and 14 discuss how this may be done.

7.5. Conclusions

Cultural theory provides an explanation of the origins of the four-fold typologies of SD definitions in the plural rationalities and myths of nature held by the different actors in the policy debate. The cultural hypothesis does not provide a satisfactory explanation of the difference between 'light' and 'dark' green forms of environmentalism, however, nor the Gaian perspective. Furthermore, although cultural theory has been applied as a heuristic by numerous authors to provide valuable insights on the environmental debate, its hypothesis about the links between institutional preferences, rationalities and myths of nature has not been tested. Nevertheless, despite these reservations, the theoretical elegance and explanatory insights of the theory make it a natural candidate for further analysis of the SD debate. The following chapters apply the theory in this way, and also attempt to provide a falsification of the theory.

Having established the irreducible plurality of perspectives, cultural theory argues that resilient policies and institutions cannot be developed unless all four perspectives are included in their design. Cultural theory does not provide an operational means of attaining such plurality, but the scenario-based approaches that have been developed within management science appear to provide a means of doing this, which is explored in chapters 13 and 14. The following chapters apply the theoretical insights and hypotheses of complexity and cultural theory to analyse the SD debate, and attempt to shed some light on SD definitions and policies.

Chapter 8: Sustainable Development - An Analysis

8.1. Introduction

Chapters 5 to 7 introduced complexity theory and cultural theory, which provide two alternative foundations for an analysis of sustainable development. Both theories predict that there will be a plurality of alternative ways of understanding SD, including SD definitions and preferred policy recommendations. However, whereas cultural theory predicts that there will be just four basic perspectives, complexity predicts that there will be an essentially unlimited diversity of perspectives, although it does not preclude the possibility that they may be clumped into four loose groupings, in the way that the Earth's biodiversity is grouped into different phyla of organisms. Cultural theory makes an additional prediction that the four perspectives will be correlated with four preferred institutional forms. Chapter 8 tests the cultural hypotheses by taking a broad cross-section of policy perspectives from the SD debate, and classifying and analysing them in terms of cultural theory. In this way, it examines the relationships between myths of nature and preferred policies and institutional arrangements.

8.2. Definitions of SD

Cultural theory identifies four myths of nature and explains how alternative environmental policy positions may be mapped onto the four rationalities, as outlined in chapter 7. The following analysis concentrates on the three 'active myths' of the individualist, hierarchist and egalitarian, omitting the fatalist perspective, since fatalists do not see the purpose of engaging in the policy debate and so have no policy positions (Thompson et al. 1990). The first step is to establish representative benchmarks of the policies and institutional preferences of these three cultural perspectives, which is done in the next section.

8.2.1. Establishing Three Benchmark Policy Perspectives

In order to establish benchmark SD policy perspectives, it is necessary to find examples that can be reliably associated with individualist, hierarchist or egalitarian institutions, and which contain detailed expositions of SD problem definitions and preferred policies. This may be done by using three broad-ranging policy documents, one for each rationality, each of which satisfies the following criteria:

- *Clear Institutional Origins*: the institutional commitments behind the selected policy document should be unmistakable, allowing a meaningful classification in cultural theory terms. A consensus position resulting from debate among representatives of a given political culture typically provides such clarity.

- *Wide-Ranging, Clear Policies*: the document should be as wide-ranging and complete as possible in covering SD issues, both in terms of describing perceived problems and proposed solutions. The preferred policies and institutional solutions should be described clearly, to allow a cultural analysis of the underlying 'myths of nature' and decision rationalities.

- *Mainstream*: the institution should represent a mainstream position which is well known and cited in the SD debate;

The following three exemplars were chosen on the basis of these criteria:

- *Individualism*: Companies are generally the best representatives of the individualist, free market perspective, even though many may be hierarchically organised internally, or favour interventionist and protectionist policies. The most comprehensive business perspective on SD is provided in the book *Changing Course* (Schmidheiny et al. 1992), which represents the consensus views of the 48 chief executives of some of the world's leading companies who comprised the Business Council for Sustainable Development.

- *Hierarchy*: Governments are the upholders of hierarchy, and the policies generated by intergovernmental groupings are typically the closest to an idealised hierarchical position, since individual national special interests are less prominent. A benchmark intergovernmental policy perspective on SD is provided by the European Union's Fifth Environmental Action Programme *Towards Sustainability* (CEC 1992).

- *Egalitarianism*: The egalitarian perspective is held by most environmental NGOs (Non-Governmental Organisations), although many of them tend to temper their positions in order to gain admission to the policy debate. One of the most complete SD policy statements, including a detailed quantitative analysis of the implications of the transition to sustainable lifestyles, is provided by FoE (Friends of the Earth) in *Action Plan: Sustainable Netherlands* (FoE 1993).

Other policy documents which could have been chosen on the basis of these criteria include the hierarchist UNCED (United Nations Conference on Environment and Development) document *Agenda 21* (UN 1992), and the more egalitarian *Caring for the Earth* (IUCN/UNEP/WWF 1991), which was produced by a collaboration of IUCN (International Union for the Conservation of Nature, now renamed World Conservation Union), UNEP (United Nations Environment Programme) and WWF (Worldwide Fund for Nature). Additional perspectives, especially those of an academic origin, may provide 'purer' examples of the respective policy myths, but because their institutional origins are less clear, or because they are less wide ranging in their scope, they are examined in section 8.2.2 instead.

Using the benchmark positions, a set of definitions of sustainability, problem definitions, proposed solutions and policy measures for SD has been compiled (Appendix A), some of the key results of which are summarised in table 8.1. The benchmarks appear to support the cultural hypothesis, since the selected institutions fit the institutional types well (rows 1 to 28 in Appendix A), and their myths of nature, preferred policies and institutional solutions are seen to be broadly consistent with the predictions of cultural theory.

For example, the individualist (Schmidheiny et al. 1992) sees environmental threats as uncertain and not overly serious (Appendix A: 8, 9, 24), consistent with the myth of 'nature benign'. Since there are no limits to growth (Appendix A: 6, 7, 8), and economic

Policy Issue	Individualist	Hierarchist	Egalitarian
Overall Policy	Innovation and growth in competitive free markets	Government intervention to steer economy to SD	Restructuring and lifestyle change to radically reduce impacts
SD Policy Priority	Improve eco-efficiency through new technologies and better management	Incentives and regulation to change behaviour and economic structure	Stop unsustainable consumption, change to low-consumption lifestyles and low-impact technology
SD Implications	New markets and business opportunities	Continuation of balanced and stable development	Better lifestyles by staying within limits of environmental space
Cultural change?	Not needed	Influence through incentives	Change in culture and values is vital
Economy			
Growth?	SD needs rapid growth	SD needs growth that also improves quality of life	No physical growth, some reductions needed (e.g. meat, transport)
Growth and Environment	Growth is essential to protect environment	Growth must take account of environment	Environmental limits dictate whether growth is possible or not
Environmental cost internalisation?	Distorting subsidies should be removed	More economic and fiscal instruments needed	High levels of environmental taxes and liability for damage desirable
Transport	Restriction not viable as transport too important	Need better infrastructure and improved efficiency	Need large reductions in transport use; more bicycles, public transport
Role of Industry	Innovate, improve eco-efficiency, create wealth	Clean up through better control and management	Radical clean-up; shut down polluting sectors entirely
Role of Government	Stimulate innovation and entrepreneurship	Manage change to SD with regulation and incentives	Ensure environmental space is stayed within and shared fairly
Environment			
Limits to Growth?	No	Perhaps threats in future	Yes, serious and close at hand
Environmental threats	Seriousness is unclear, but improve efficiency anyway	Some threats, which need intervention to manage	Degradation and risks are very serious, need large changes to halt
Climate change	Effects uncertain, more research needed	Warming may have risks, which need managing	Warming would cause serious damage and must be prevented
CO_2 target	No target	Stabilise by 2000	60% reduction by 2010
Energy Policy			
Carbon tax?	No, remove subsidies first	Yes, introduce gradually	Yes, large taxes needed quickly
Nuclear energy?	Yes	Yes, if safely manageable	No
Renewable energy?	If economically viable	Yes, incentives to promote	Yes, large-scale transition to solar

Table 8.1. Illustrative SD Policies of the Cultural Perspectives

growth is the source of improved quality of life, liberal growth-promoting economic policies are seen to be desirable (Appendix A: 4, 12, 13, 19). Continuing improvements in environmental efficiency can promote profitability, so they are seen as acceptable (Appendix A: 3, 18), and best achieved through the managerial and technological innovation that arises in open and competitive markets (Appendix A: 19). Climate change is not seen as a serious problem (Appendix A: 24, 25), and while removing subsidies to create more liberal energy markets would be desirable, economic intervention in the form of carbon taxes would create distortions that would dampen growth and increase unemployment, and would therefore be undesirable (Appendix A: 15, 26). To the extent that consumption patterns produce environmental burdens, they should be tackled through innovative new cleaner technologies and products (Appendix A: 20, 21) rather than draconian regulation or attempting to change cultural norms and values (Appendix A: 10).

This partial summary demonstrates how the individualist's view of environmental threats, his preferred policy responses and his preference for a given institutional form, in this case the market, are all self-reinforcing. Reference to Appendix A confirms that the same self-reinforcing relationship holds in the case of the hierarchist and the egalitarian exemplars. The relationship is not perfect, however, as the institutional proposals of the egalitarians are generally a more rigorous version of the hierarchist's preferred government intervention combined with lifestyle change at the individual level, rather than the small-scale, community-focused model that is suggested by cultural theory, and which is found in 'purer' egalitarian proposals such as those of Daly and Cobb (1990). A possible explanation for this is that Daly and Cobb's recommendations are so far outside the scope of the mainstream policy debate that they would not have, and indeed have not had, any influence on this policy debate. Instead, their model of a communal society is perhaps best seen as belonging to the utopian tradition (Manuel 1967, Manuel and Manuel 1979). FoE's perspective is, however, consistent with the way that cultural theorists classify policy perspectives as egalitarian in other environmental policy debates, as discussed in chapter 7.

The robustness and internal consistency of the benchmark policy perspectives having thus been confirmed, they can be used as a tool for classifying the perspectives represented by other policy statements, and thereby to test cultural theory. For example, if an 'egalitarian' perspective is held by a hierarchist institution, this would constitute a falsification of cultural theory's claim to be able reliably to predict the myth of nature that will be held given known institutional commitments. The classification of policy perspectives in this way is discussed in the following section.

8.2.2. A Cultural Analysis of Perspectives on Sustainability

A total of 102 policy perspectives have been classified using the benchmarks developed in section 8.2.1 and Appendix A. The results of this classification, together with interpretative comments, appear in Appendix B. These perspectives have been chosen to provide a broad coverage of alternative perspectives for a 'horizontal' analysis, as well as providing depth in the case of some authors to permit a 'vertical' analysis as well. They are not intended to be statistically representative in any way; indeed, it is not clear what such a concept might mean in this context, nor how an objective measure of representativeness might be developed. On the basis of the results in Appendix B, it is evident that cultural theory is a useful heuristic for classifying SD definitions and policy perspectives. Of the 102 cases analysed, 86% can be classified broadly in terms of the myths of nature and cultural rationalities. Of these, further support for cultural theory is provided by cases that exhibit an internal plurality which can be exactly mapped onto the three rationalities (e.g. Daly 1992c, Dovers and Handmer 1993), or by those that recognise the inherent and irreducible plurality in the SD debate and its social and cultural origins (e.g. Heuting 1986, Jasanoff 1993).

The cultural analysis also makes it clear that the selected benchmark perspectives do not completely map out the spectrum of the possible diversity of cultural perspectives. For example, individualist views from a high-technology entrepreneurial perspective (Kelly 1994, Angell 1995) highlight the fact that the BCSD's perspective is that of a group of large multinationals with hierarchist tendencies, and a purer individualist perspective would come from a smaller-scale, more entrepreneurial organisation, or from liberal economic theorists (e.g. Beckerman 1974, 1994, Bernstam 1991, Bhagwati 1991). Indeed, since individualists tend towards the view that environmental problems are unimportant compared to issues of technological innovation or competition in the information economy, their perspectives are under-represented in the SD debate compared to discussions on economic policy, competitiveness or management theory. The relative scarcity of individualist perspectives in the SD policy debate, as opposed to the debate on economic theory of SD, indicates a potential lack of resilience in the SD policies and strategies under development, as discussed further below.

Similarly, the benchmark egalitarian perspective is more hierarchist than others found in the literature. FoE's desire to be policy relevant has led it away from the more community based, anti-growth egalitarianism of Daly and Cobb (1990) or Goodland et al. (1991), and the deep ecology perspectives (Naess 1973, 1978, Jacob 1994) are more egalitarian still. The hierarchist tendencies of BCSD and FoE are perhaps not surprising, as their involvement in a public policy debate necessitates a modification of the natural approach of these rationalities, neither of which would normally be policy-driven. Individualists would normally be interested in attaining progress through innovation and competition in the market, while egalitarians would favour community programmes, local initiatives and campaigns of 'direct action'. Nevertheless, the choice of the benchmarks is vindicated given their overall breadth of policy discussion, as the alternative 'purer' myths that can be found in some examples of Appendix B do not provide a broad enough basis for classifying and analysing other myths.

Cultural theory can also be used to shed light on the development of the environmental debate between the 1970s and 1980s, which is described by Ekins (1993a) and Bramwell (1994). Appendix B confirms that the protagonists in the 1970s 'Limits to Growth' debate were egalitarians and individualists, while those in 1980s 'sustainable development' debate were egalitarians and hierarchists, joined by individualists from the corporate world in the early 1990s. The relative absence of the individualists from the SD debate, which has already been noted, can also be understood by looking at the futures debate more generally. As Marien (1994a) notes, there are two streams of futures thought which have remained largely separate, and which are based respectively around the 'sustainable society' and the 'information society', with individualists largely absent from the former and egalitarians from the latter. Nor is this bifurcation recent, as it is nearly two decades since Marien (1977) argued that "there is no evidence that any writer holding either of the two visions of post-industrial society has any appreciable understanding of the opposing vision". Cultural theory suggests that significant benefits could be derived from integrating these streams to build a more complete and robust understanding of the world, although this has not yet begun.

Business contributions to the SD debate have brought individualism, but not perspectives on the economic and social challenges posed by the transition to a post-industrial, information-based economy. If such a transition is indeed underway, as several analysts suggest (Reich 1991, Drucker 1993, Wriston 1993), its scope will change the dimensions of the sustainability debate to a great extent. Despite the generational time-frames considered in current SD policy discussions, the SD debate's oversight of the issues arising from the information economy represents an important blind spot, since SD is closely related to social, technological and economic developments, all of which are likely to be affected dramatically by information technology in the early 21st century. It would appear that the mainstream SD debate will inevitably be defined too narrowly without a consideration of the information economy, hence an analysis of SD based on cultural theory that included these individualist perspectives could add important insights to the debate (Trisoglio 1994a). The call for greater attention to be paid to individualism might seem unexpected in the light of the evident difficulties that environmental policy has encountered in the face of resistance from business and economic interests (Trisoglio 1993). This apparent contradiction is discussed further below.

Despite the heuristic utility of cultural theory, however, the cases in Appendix B present important problematic empirical data, or what Lakatos (1976) calls "monsters", that challenge cultural theory in a number of ways:

- *Bipolar myths*: 24% of the cases can only be classified using two cultural categories, and examples of all three pair-wise combinations of myths are present. In some cases, the plurality results from a broader problem definition or set of solutions than fits any single rationality (e.g. Corson 1994, ERM 1994a, Harman 1985), but in others it represents an internally inconsistent perspective where the 'problem definition', or myth of nature, does not correspond to the proposed institutional solution (e.g. Goodland et al. 1993, Marien 1994a). The first type of duality provides a classificatory challenge for cultural theory; the second provides a falsification of cultural theory.
- *Gaia*: As has already been noted in chapter 7, the Gaian perspective appears to

be unclassifiable within cultural theory, not least because although it holds that nature is resilient, it is nevertheless used as an icon by egalitarians. With Gaia, a single myth of nature is used to justify radically opposed policies, in direct contradiction of cultural theory. Yet another derivation of policy conclusions from Gaian theory is provided by Wallace and Norton (1992), whose results correspond to the complex/ adaptive policy model introduced in chapter 4, and not to any of the simple responses of the political cultures.

- *Changing Myths*: The 'vertical' analysis of different policy positions from the same author at different times uncovers two types of behaviour. In one type, typified by Meadows (1972, 1973, 1992), the same position is maintained over long time intervals, demonstrating the tenacity of myths of nature. In the other type, authors take different positions in different articles. In the case of Ekins, both the problem definition and the proposed responses alter, from strongly egalitarian (Ekins 1991) to moderately hierarchist (Ekins 1993b). Daly, however, maintains a consistently egalitarian problem definition (Daly 1977, 1985, 1992b, 1992c, Daly and Cobb 1990, Goodland, Daly and El Serafy 1993), but his policy prescriptions range from being strongly egalitarian (Daly and Cobb 1990) to strongly hierarchical (Goodland, Daly and El Serafy 1993). These results appear to be inconsistent with cultural theory.

- *Politics of Interest*: Cultural theory asserts that myths of nature are linked to preferred institutional forms, whereas a more traditional political science analysis would suggests that problem definitions are selected for reasons of political and economic self-interest. In the case of nation states, the political science analysis appears superior to the cultural analysis in several examples. For example, the US and the UK had very similar individualist, market-oriented political cultures and institutional preferences in the late 1980s, yet the UK became a supporter of action to curb climate change, whereas the US resisted such action (Boehmer-Christiansen 1994). In effect, the same preferred institutional form was correlated with different myths of nature. Other divergences in environmental policy responses among nations are recorded by Andersson et al. (1992), while substantial cultural differences within capital market structures, all of which cultural theory would classify as belonging to the individualist mode of institutional arrangements, are identified by Albert (1993).

Another example is provided by the different corporate members of the BCSD. For example, both Shell and ABB are leading international companies with an individualist market orientation, yet ABB supports a European carbon tax, while Shell opposes one. Both positions are consistent with their commercial interests, since ABB's business is in high-efficiency electricity generation and transmission equipment, which would prosper with economic incentives for higher energy efficiency, while Shell's is in producing fossil fuels, which would suffer under a carbon tax. Here again the divergence of preferred policies from institutional commitments is explicable using traditional political analysis, but not with cultural theory.

A more general challenge for a cultural analysis of corporate organisations is that it is impossible to reduce the tremendous diversity and complexity of corporate organisational forms along a simple grid/group scheme. For example, Harrison (1988) identifies four different organisational forms which have some overlaps with the cultural model, but are incompatible in other ways: the power culture, which is associated with a web structure; role culture/pyramid structure; task culture/net structure, which is also known as organic or matrix; and the person culture / galaxy structure. Handy (1985), Morgan (1986) and Trompenaars (1993) provide further perspectives on organisational theory which cannot be reduced to the cultural types. These issues are discussed further in chapter 12.

- *Complexity*: Several definitions from Appendix B are unclassifiable within cultural theory because their problem definitions and proposed solutions derive from a complex systems perspective (e.g. Allen 1990, Brooks 1992, Slocombe 1993, Wallace and Norton 1992). A complex adaptive myth of nature is dynamic, and does not fit any of the static categories of nature resilient, perverse/tolerant or ephemeral. Indeed, a complex system typically demonstrates all of these behaviours at different times and places. Similarly, a complex/adaptive policy model calls for a pluralistic institutional and policy response which cannot be categorised within any single rationality. Even more problematic are approaches based on the bottom-up genetic and evolutionary models of change discussed in chapter 5, which are not compatible with cultural theory's top-down idea of a rationality or mental model at all.

These results yield a mixed conclusion. Cultural theory's four myths of nature are indeed a useful heuristic, since they form the basis of most policy positions except for those based on Gaianism or complexity. They also provide a rapid means of assessing the plurality of SD policies or indicators. For example, both Corson (1994) and Henderson (1994) provide extensive sets of policies and indicators, yet in both cases these sets are exclusively hierarchist and egalitarian. The omission of the individualist perspective, which emphasises entrepreneurship and technical innovation, is also visible in many of the most well known egalitarian perspectives, most famously *The Limits to Growth* (Meadows et al. 1972). Its inclusion would not only provide for much more resilient policies and sets of indicators, but also help to resolve many of the debates between environmentalists and economists (Ekins 1993a). To this extent, a cultural heuristic would seem to be very useful.

At the level of an explanatory theory, however, cultural theory appears to be rather weaker. There are many examples of mismatches between myths of nature, preferred policies and institutional commitments, which falsify the primary cultural hypothesis. Moreover, there are cases where cultural differences are not the primary cause of policy or institutional choices, as illustrated in the climate change examples. In the light of these cases, we may conclude that cultural theory is only one of several analytical approaches in social and political explanation, rather than the sole source of insight, and that its claim to predict the correlation between myths of nature, policies and institutions in every case is unjustified.

The policy models based on a complex systems understanding are less common, but perhaps more significant. They cannot be encompassed within the four-fold myths of nature, but instead demand a more plural approach to interpreting meaning and action. The Gaian myth is also intrinsically dynamic, and its self-organising and resilient behaviour is more easily understood in terms of complexity and adaptation than the static cultural myths of nature. Instead of the rigidly hierarchical four-fold, top-down structure of cultural theory, a more appropriate analytical basis for these complex cases is provided by intrinsically diverse frameworks such as postmodernism. Orr (1992a) similarly applies post-modern analysis to point to the limitations of ecological metaphors such as cultural theory's myths of nature in the face of the complexity of the natural and social worlds.

8.2.3. A Note on Individualism and Sustainability

The suggestion that greater attention needs to be paid to the individualist perspective may appear incongruous, since it is such seemingly individualist perspectives from business organisations and economists that are typically the primary obstacles to implementing environmental policies (Robins and Trisoglio 1992). At one level, this problem can be explained in terms of the political and economic self-interest of those organisations, as with Shell's position on carbon taxes. But at another level, the free market rhetoric of the business community is often accompanied by protectionist tendencies, which require hierarchist intervention to prevent free market competition, for example with the US car industry's ongoing effort to maintain market dominance in the US not through building better cars, but through securing government regulation to prevent Japanese imports to the US market (Womack et al. 1990). The BCSD (Schmidheiny et al. 1992:69-70) itself comments that "this is a difficult truth for business because the great majority of barriers to trade - tariff and otherwise - are the result of businesses lobbying governments".

An individualist business would seek to compete in an open market, rather than favour the intervention of hierarchy, although a company lobbying for government protection usually does so in order to secure individual gain. Rather than seeking to prevent change, however, an individualist would argue that environmental improvements can save money and improve competitiveness, agreeing with Porter (1991) that "the nations with the most rigorous [environmental standards] requirements often lead in export of affected products . . . The strongest proof that environmental protection does not hamper competitiveness is the economic performance of nations with the strictest laws".

The innovation and entrepreneurship at the heart of individualism fosters technological optimism and the belief in possibilities, but equally it coheres with a recognition that the economy is a dynamic, evolving process of continual change, and that competitiveness requires innovation and adaptation. Individualism seeks and welcomes change, rather than attempts to stop it. An individualist would therefore see solar power as both a threat to established energy businesses based on fossil fuels, and an opportunity to create a huge and potentially profitable new market. The cultural stereotype of individualists being anti-environment is therefore misleading, since the real anti-environmentalists are hierarchists who are becoming concerned that their industrial sectors may be unsustainable, and therefore seek to influence environmental policy either for protection against less environmentally damaging alternatives or to slow the pace of change in the regulatory conditions that govern their profitable markets.

The business response to the issue of ozone depletion provides an example of these hierarchist tendencies in action, and the way that industry frequently overestimates the costs of change in an attempt to delay it. During the debate on the phase-out of ozone depleting chemicals, manufacturers which produced chlorofluorocarbons (CFCs) "mobilised research and public relations efforts to stress the scientific uncertainties, the necessity of CFCs for modern lifestyles, the unfeasibility of substitutes, and the alleged high costs and economic dislocations associated with controls on these chemicals' (Benedick 1991b). Even when companies admitted that alternatives were possible, they held back. For example, Du Pont announced in 1986 that it could develop CFC substitutes within about five years but that "neither the marketplace nor regulatory policy . . . has provided the needed incentives to justify the required investment" (Du Pont 1986). As soon as the Montreal Protocol was signed in 1987, companies began to move in directions that two years earlier had been considered impossible, making it clear that industry's claims regarding the costs and difficulties of adapting to new regulations had been "greatly overstated" (Benedick 1991). More recent estimates put the cost of CFC/halon production phase-out as half that estimated by industry in 1987 (Lovins and Lovins 1990).

In summary, from an economic self-interest point of view, many 'individualists' blocking environmental policy are in fact acting 'hierarchically'. This is another example where cultural theory fails to provide an adequate classification and explanation for the relationship between world-view and institutional arrangements. The way that many companies show protectionist, anti-change behaviour simply reinforces the importance of including true individualists who are pro-change and understand the significance of technological developments, especially in informatics.

Anticipating the likely social and economic conditions in which environmental policy instruments will be implemented is hard enough for policy makers without them ignoring the individualist perspective and its insights about technological changes and their possible implications. In addition, individualists are able to give alternative perspectives on technological possibilities that are not marked by the hierarchist tendencies to over-estimate the costs of change and underestimate its benefits. It is in these senses that the importance of greater individualist involvement in the SD debate is to be understood.

8.3. Conclusions

The cultural analysis of SD policy perspectives has demonstrated that cultural theory is a useful heuristic. Cultural theory's argument that there are three myths of nature, or problem definitions, and three sets of preferred policies is largely vindicated by the policies analysed in this chapter. Cultural theory therefore provides a powerful tool to analyse the plurality of a policy, strategy or institution, and assess whether any perspectives are excluded, thereby helping to improve resilience. Performing a cultural analysis of the SD debate as a whole, it becomes clear that the hierarchist and egalitarian perspectives are dominant to the extent that sustainability might almost be considered a bipolar myth of nature. The policy conclusion is that the inclusion of an individualist perspective emphasising entrepreneurship, technological innovation and the challenges of managing in an information economy would be likely to foster the development of more resilient policies and institutional structures for SD.

From a theoretical perspective, however, cultural theory's assertion that myths of nature are always associated with the same policy preferences and institutional forms is found not to hold in practice, and falsified by the evidence assembled in this chapter. In addition, cultural theory is seen to be one of several analytical approaches in social science that can shed insight into political and institutional debates, rather than the only one. Mainstream explanations in terms of politics of interest and economic self-interest are still relevant, and will be the most important in many cases.

The other finding is that there is a small but significant proportion of policy perspectives that cannot be classified or interpreted using cultural theory. These are all based around complex/adaptive myths of nature, including the Gaian myth, and complex/adaptive policy recommendations. This suggests two conclusions. First, that most of the SD debate is still conducted without an awareness of complexity theory and its implications for understanding natural and social systems, and the types of policy and institutional structure that would be appropriate. These issues are discussed further in chapter 12. Secondly, that cultural theory is unable in its current form to provide explanations of a complex world or complex myths of nature, even though it provides a good summary of the pre-complex myths of nature that dominate today's policy debate. The relationship between complexity and cultural theory is explored further in the next chapter.

Chapter 9: Cultural Theory and Complexity

9.1. Introduction

Chapter 8 used cultural theory to analyse numerous policy perspectives within the SD debate, and found that while cultural theory is a useful heuristic for explaining the three most common myths of nature and policy positions, it has a number of shortcomings. Many of the perspectives analysed were found to be a combination of two or more myths of nature, which raises the question of the classification of plural positions. Furthermore, perspectives arising from a complex systems understanding, including Gaian myths of nature, were seen to be problematic for cultural classification. These experimental findings suggest that there may be some inadequacies with the underlying theoretical framework of cultural theory, which appear to have some relationship to complexity.

This chapter explores the theoretical status of cultural theory and its relationship with complexity, starting with an examination of the problems of classification and change within cultural theory, and then exploring the derivation of the myths of nature. This analysis confirms that there are significant differences between cultural theory and complexity at a theoretical level, and identifies key issues that need to be resolved.

9.2. Classification and Cultural Theory

Chapter 5 demonstrated that analysis of a complex system necessarily involves classification, which is inevitably arbitrary to a degree. The classification of SD policies in chapter 8 found that 24% of the sample could not be classified within a single rationality, but were to some degree plural. Moreover, the classification was performed qualitatively, by comparing problem definitions and policies, rather than in any quantitative manner. These observations may be built on to raise a series of questions.

9.2.1. Cultural Theory: Continuous or Discrete?

In considering the four-fold framework and the two grid-group axes, we must first ask whether the axes are meant to be continuous, or whether we are simply dealing with four discrete categories. A brief consideration of, for example, the existence of literature on different governmental forms and administrative cultures in Europe, which are all variants of hierarchy, or different approaches to organising and regulating capital markets in the US, Japan and Europe, all variants of market individualism, confirms that there are many different sorts of hierarchy and many different sorts of individualism. By extension, we may reasonably expect that there are many sorts of egalitarianism and fatalism as well; the debate on 'shallow' and 'deep' ecology confirms that this is indeed the case (Jacob 1994).

Most real organisations are not therefore 'ideal types' as might be found in the corner points of cultural theory's quadrants, but are instead somewhere in the middle of a quadrant. Using the notation of co-ordinate geometry, we may indicate 'pure' hierarchy as (1,1), the top right hand corner, 'pure' individualism as (-1,-1), and so on. In other words, a typical real institution would be somewhere in the middle of a quadrant, e.g. (0.6, 0.4). As it is formulated, cultural theory only distinguishes between the four basic cultures. In other words, (1,1), (0.5,0.2) and (0.1, 0.9) are all classified as "hierarchy", and cultural theory does not provide distinctions within political cultures. This lack of distinction produces a curious result. The institutions (0.01, 0.01) and (0.01, -0.01) are entirely different political cultures: one is hierarchist, the other egalitarian, and yet they are almost indistinguishable when plotted graphically. Meanwhile, (0.01, 0.01) and (1,1) are both hierarchist, yet they are at opposite corners of the hierarchist quadrant.

One may conclude either of two following results from this observation. Either we can maintain the grid/group system, in which case speaking simply of the four basic types is an excessive over-generalisation, since there can be much greater variety within a quadrant than between quadrants. Alternatively, we accept that the co-ordinate system derived from the grid/group axes is meaningless, since the distance in the grid/group plane does not correspond to an equivalent degree of difference or distance in the real world. In this case, the cultural types can only be seen as ideal types, corresponding to the outer corners of the quadrants, and any attempt to make distinctions inside the quadrants is made meaningless through the lack of a co-ordinate system.

Cultural theorists implicitly reject the second option, since they propose that cultural theory can be applied quantitatively, as in the study of household consumption styles by Dake and Thompson (1993). Yet this quantification appears to weaken the cultural case, as it demonstrates that the correlations proposed by cultural theory between beliefs and institutional types are rather weak. Adams (1995:64) points out that the strongest correlation in a cultural study of risk by Dake (1991) is 0.46, indicating that cultural bias only accounts for some 20% of the variance in concern about nuclear war among the egalitarians in the sample. Adams (1995:201) also notes that in attempting to explain the unsatisfactory results of their quantitative study, Dake and Thompson (1993) maintain that people or groups may display two behaviours when they are "in transition" between world-views, and also that "cultural classification is made more difficult by mixed cultural orientations, complex alliances, and evolving world views". Furthermore, cultural theorists speak only of differences between the cultures, not within cultures (e.g. Thompson et al. 1990). Taken together, these observations strengthen the case that cultural theory cannot provide a detailed description of the difference between policies and institutions if distinctions are only made in terms of the four basic cultures. To clarify this criticism, the point is that cultural theory speaks of hierarchy as a clearly distinct category from egalitarianism, despite the fact that two "hierarchical" institutions may be much more different, in terms of their co-ordinates within the grid/group system, than a hierarchical and an egalitarian institution.

In terms of applying cultural theory to political and technological analysis, for example, these criticisms appear to hold significant barriers. For example, Wynne (1992) offers a detailed analysis of scientific and political controversy surrounding radioactive fallout from Chernobyl and its effects on Welsh sheep farming. The controversy arose from scientific differences among the hierarchists as a result of indeterminacy, and not as a political dispute between different organisational types. As a result, cultural theory is unable to shed much light on this particular issue. Similarly, the classification of policies in chapter 8 was unable to make fine distinctions between different conjunctions of, for example, the various perspectives including both egalitarianism and hierarchy. We may conclude that while cultural theory may provide a useful broad classification, we require additional theoretical distinctions for fine-grained analysis.

9.2.2. Rhetoric Stealing, Alliances and Plural Myths

The problem of plural myths noted above is just one of several theoretical constructions in cultural theory which detract from the framework's basic elegance. These include:

- *Rhetoric Stealing*: this is where a hierarchist, say, pretends to be an egalitarian for the purpose of achieving his or her ends. Such mimicry is extremely common in biological and ecological systems (Colinvaux 1986, Dawkins 1989), and should therefore be expected in social systems too. The problem with rhetoric stealing is that 'objective' classification of an individual or institution becomes impossible, since one cannot know if they are telling the truth. Thus although it allows cultural theory to explain why an individual or institutional world view may not map with its assigned organisational form, it creates a bigger problem for falsifiability of the theory as a whole. If an institution's world view does not match its organisational form, are we to attribute this to rhetoric stealing, or to a instance of the failure of cultural theory? And if we accept the widespread occurrence of rhetoric stealing, what then is left as an explanatory framework within cultural theory if there are so many exceptions to the rule? In the cases of mismatch between institutions and their world-views discussed in chapter 8, common sense explanations based on political self-interest are eminently more satisfactory than attempts to explain the divergences as a result of rhetoric stealing.

- *Alliances*: occur where two or more institutions with different cultural preferences form a super-institution through some kind of merger or alliance. This is common, for example, in political parties. The question then arises of how to describe an alliance of, say, a hierarchist and an egalitarian. Is it egalitarian or hierarchist or both? Applying this reductionist logic in a recursive fashion, we may similarly argues that since all individuals are different, how can we classify any institution which contains individuals from more than one political culture? It is easy to verify that real-world institutions such as companies contains individuals from many cultures. Indeed, much of modern management theory on teamwork explicitly discusses how one can assemble a team of diverse individuals in this way.

- *Plural Myths*: what if an individual holds plural myths, say he believes both in cycling to work, which is an egalitarian transport mode, and driving a sports car at weekends, which is individualist? How should he be classified? In particular, how are we to classify *clumsy institutions* , which manage to hold all myths in their heads at the same time, and which are called for by cultural theory?

Since individuals and institutions are rarely, in the real world, free from these kinds of contradictions, we need a way to classify them despite their plurality. An alternative formulation of cultural theory might suggest that most institutions are mixtures of two myths, namely that almost every institution is at least partially hierarchical, while some also have individualism and others egalitarianism. For example:

- *Industry*: is typically organised both hierarchically and individualistically. Its blind spots, as evidenced by Shell's Brent Spar fiasco in 1995 (Corzine 1995, Corzine et al. 1995, Elkington 1995) and the lavatory rim blocks story told in Schwarz and Thompson (1990), are therefore egalitarian, which means it tends to be unable to understand the moral stance of environmentalists and their aversion to the sort of technological optimism shown by big business.

- *Environmental Groups*: are typically both hierarchical and egalitarian, as those that try to maintain pure egalitarianism seem rapidly to descend into ineffective utopianism and internal policy schisms. Their blind spots are individualist, which means they cannot understand the importance of innovation and technological progress, and they are often antagonistic to industry. The shortcomings of the *Limits to Growth* study of 1972 can be understood in this way.

We may further ask whether such hybrids should be classified according to their 'dominant' culture, assuming we can discover what this is, or whether we should admit that they are a mix of cultures, with a corresponding mix of patterns of cognition and behaviour. The way such questions are not resolved in cultural theory points to an overall absence of a methodological framework for quantification along the grid/group axes. More generally, the predictive capability of the theory is diminished, since an institution with a plural mental model would presumably have access to a plural portfolio of behaviours, and it would be reasonable to expect a hybrid hierarchist/egalitarian to behave according to each of the myths for some of the time.

There appears, in addition, to be no objective standard which would allow different researchers to decide, for example, where the boundary between "egalitarian" and "hierarchist" should be drawn. This difficulty is illustrated in practice by the way in which different cultural theory researchers make different classifications. For example, Schwarz and Thompson (1990) classify the concept of "carrying capacity" as belonging to the hierarchist world view, while Rayner (1994) classifies it as "egalitarian". If cultural theorists cannot agree among themselves, other researchers attempting to apply cultural theory may legitimately argue that the theory is too imprecise to be applied in a scientifically falsifiable and meaningful way. In the light of these observations, we may conclude that the theory should more properly be seen as a useful heuristic rather than a rigorous scientific theory. Further support for this conclusion is given below.

9.2.3. A Cultural Explanation of Change and Surprise

Cultural theory's description of change is explained in terms of surprise. Any individual or institution holding a given world view, corresponding to a given political culture, has blind spots due to the necessarily partial description afforded by any world view. As a result, the institution will sometimes encounter events that are "surprises", inexplicable in terms of its prevailing world view. The institution can either ignore the surprise, or must alter its world view, a mechanism which might be likened to Kuhn's description of paradigm change in science. Since in cultural theory there are only four basic world views, an individual can only be surprised out of one and into one of the other three, and there are therefore a total of twelve different types of surprise, which are enumerated in detail in Thompson et al. (1990:71-78). The problem with cultural theory's mechanism of change is two-fold.

Firstly, the change to a new world view must presumably also imply a change to a new preferred organisational form, since cultural theory holds that the two are interdependent. This means, if we follow the theory narrowly, that an institution cannot maintain its preferred form if it is surprised, which appears to hold out little hope for those who believe in organisational learning. A broader, and more sensible, interpretation is that an institution becomes "clumsier", or more pluralistic, as it learns, although this would seem to imply that all institutions must drift into a 'grey area' in the middle of the grid/group diagram as they become older and wiser. This would presumably also mean that cultural theory becomes less able to distinguish between institutions as they become more clumsy. The problem with this theory of learning and change is that many institutions live to be centuries old, yet maintain a strong organisational identity and culture. Some of the world's oldest companies, such as Stora and Du Pont, have gone through different phases such mining, finance, and manufacturing, all the while maintaining the same corporate identity, and a relatively constant orientation in terms of political culture (de Geus 1995).

The second problem is that the mechanism of change only allows for twelve transitions, those between the four cultures. Yet as noted above, there can be much bigger transitions within a culture than between cultures. Moreover, it does not seem unreasonable to suggest that the majority of learning and change within an organisation will occur in such a way that the overall paradigmatic world view is unchanged. If this is true, we must accept that cultural theory's change mechanism, that of surprise, only explains a small proportion of the change and learning in institutions in the real world. In particular, cultural theory would appear to be of little utility for students of corporate evolution and change, and of organisational learning in business. Thus although it offers a theory of organisation, cultural theory may be of limited use in designing institutional forms that are able to learn and exhibit adaptive change in a complex world.

9.2.4. Origins and Evolution in Cultural Theory

The unsatisfactory nature of cultural theory's explanation of change extends more deeply when the origin of the four myths is examined. Cultural theory asserts that they are timeless, unchanging ways of seeing the world; they are eternal objects, ideal types of an almost Platonic purity. This explanation denies that technological change, societal progress or any other aspect of human social development can change the myths and political cultures themselves. All they can do is alter the balance between one culture and another (Thompson et al. 1990).

Since cultural theory holds that cultures are continually engaged in a dynamic process of re-balancing and change, and that all cultures are present in all societies to a greater or lesser degree, it is therefore unable to include any time dimension or any historical explanation, except in terms of ongoing dynamic transitions between myths and cultures. Cultural theory cannot pick up any long-term trend such as industrialisation, modernisation or technological change. Developments such as the impact of computer technology on organisational forms appear to be beyond the scope of cultural theory. In particular, the whole intellectual movement associated with postmodernism is at odds with the rigid formal structure of cultural theory.

Cultural theory provides a snapshot of a system at a point in time, rather than an explanation of the mechanisms of evolutionary change. In particular, the complex systems perspective presented in chapter 5 suggests a co-evolutionary and emergent process of change in social systems, which is both bottom-up and top-down at the same time. Through the bottom-up interaction of individuals, institutions and cultures form. These in turn affect the actions of individuals in a top-down manner, and hence a co-evolutionary process ensues. Each individual's actions are affected by the 'environment', which is made up of the other actors in the system together with exogenous systems such as the natural environment, yet also play a role in changing this surrounding environment.

A complex systems view also provides a perspective of growing diversity in structures, technologies and organisational types which appears to contradict cultural theory's assertion that there have only ever been, and will only ever be, four basic types of organisation or structure. As Adams (1995:198) notes, this strict interpretation of cultural theory risks what Whitehead (1932) calls the "fallacy of misplaced concreteness", of confusing the theory's abstractions with reality. Cultural theory's assertion that there are only four ways of organising would be more convincing were it supported by, for example, an evolutionary model of social systems which started from atomised individuals and explored what types of interaction are possible, and what organisational forms emerge as a result. Work to date on artificial life simulations at the Santa Fe Institute appears to draw conclusions that contradict cultural theory's assertion, and instead find a multiplicity of forms that arise in a complex and changing taxonomy over time, as in ecological systems, rather than an eternal four-fold structure (Waldrop 1992).

9.3. Cultural Theory and Complexity

The cultural synthesis is undoubtedly attractive, as Thompson's myths appear to fit the institutional categories of cultural theory very well. Upon closer inspection, however, the case is not so clear-cut. Section 9.2 has identified a number of problematic issues of classification and explanations of change in cultural theory, which are essentially incompatible with a complex adaptive systems view of social systems. Another divergence between cultural theory and complexity arises at the level of myths of nature.

Thompson et al. argue (Thompson et al. 1990:26, Schwarz and Thompson 1990:4) that cultural theory's myths of nature are derived from Holling (1986) and Timmerman (1986), yet there are important discrepancies between these myths. Instead of finding that cultural theory predicts the myths of nature discovered by ecologists, we find that not only do Holling and Timmerman not agree on what the myths are, but that Thompson et al. do not agree with either of these sources from which they claim to have derived their myths.

For example, Thompson et al. argue that "since fatalists seldom find themselves in charge of major national and international agencies, one of the five myths - Nature Capricious - was not fully described by ecologists" (Thompson et al. 1990:37). This statement appears to be contradicted by Timmerman, who explicitly discusses the fatalist's myth, arguing that "the high grid-low group world is the realm of the alienated citizen (or the failed entrepreneur), to whom all anomalies and surprises are indicators that 'no one is really in control', i.e., the myth of Instability" (Timmerman 1986:447). Furthermore, Timmerman also discusses 'Nature Capricious', although he calls it 'Wandering Nature', and assigns it to the hierarchist, since under this myth nature is "sometimes stable, sometimes unstable . . . [and] appears to need controlling". It is evident that Thompson and Timmerman disagree on what the fatalist's myth should be, and on which political culture should be associated with the myth of 'Nature Capricious'.

Although these anomalies between the myths are manifest in the literature, they have not been commented on previously, and cultural theory has been applied using Thompson's myths. We argue below that there are advantages to be gained by focusing on these anomalies since, as Kuhn argues, "anomalous experiences . . . by evoking crisis, prepare the way for a new theory" (Kuhn 1970:146). The ecologists' work presents important findings that can be used to strengthen cultural theory, and expand its robustness in the analysis of myths of nature in complex systems.

The next sections develop this argument. The myths of nature, and the extent of the anomalies, are analysed. It is then shown how it is possible to think about myths of nature using cultural theory, although not using the myths of the ecologists. Finally, we examine why the myths differ, how ecology and cultural theory can be reconciled, and how cultural theory can be extended to think about complexity and sustainable development.

9.3.1. The Ecologists' Myths of Nature: Holling and Timmerman

Holling's framework of myths has three distinct viewpoints (Holling 1986:294):

i. *Equilibrium-centred view: nature constant*: this is a world of global equilibrium, which cannot be damaged by a trial-and-error approach to policy, i.e. 'Nature Benign'.

ii. *Multiple equilibria: nature engineered and nature resilient*: This is a dynamic viewpoint with more than one stable state. The world is complex: the ball is seen as journeying among hills and valleys that are non-linear, discontinuous and spatially grainy. This world supports two policy options depending on an additional assumption about whether the landscape is changing or not:

- If the landscape is fixed, or if there is sufficient knowledge to keep it fixed, nature can be engineered to keep the ball away from danger. This myth is equivalent to 'Nature Perverse/Tolerant'.

- If the landscape is changeable, and only maintained in its current configuration by the journeys of the ball, then we have nature resilient. The appropriate policy is to retain variability (diversity), and allow the ball to exceed flexible limits so long as natural and designed recovery mechanisms are encouraged. Thompson has no equivalent myth.

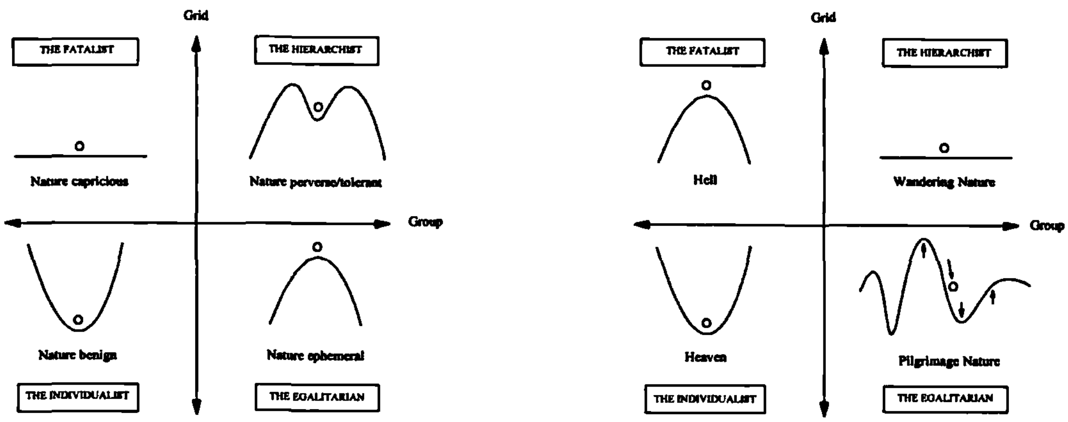
iii. *Organisational change: nature evolving*: the world is evolutionary, a complex adaptive system in which a variety of genetic, competitive and behavioural processes maintain dynamic stability and order (e.g. homeostasis) over certain spatial and temporal domains. As the system evolves, stability domains shift, and new regimes of behaviour emerge. Holling notes (Holling 1990:296) that this myth of a complex adaptive system, and the necessary theoretical frameworks to describe it, are not as well developed as the others. Thompson has no equivalent myth.

Holling's myths describe types of evolutionary behaviour in complex adaptive systems, in which the landscape will change and the ball will move even without external intervention. Thompson's myths, by contrast, are of static landscapes that do not exhibit endogenous change. Timmerman's myths are drawn from classical economic theory (Timmerman 1986:437-444) and the theological myths catalogued by Northrop Frye in *An Anatomy of Criticism* (Timmerman 1986:446). Timmerman's five myths, and his assessment of their counterparts in economic theory and theology, are contrasted with the myths of Holling and cultural theory in table 9.1.

	Timmerman			**Holling**	**Thompson**
	Myths	**Economics**	**Theology**	**Myths**	**Myths**
i	Stability	Adam Smith's 'invisible hand', neo-classical.	Heaven - perfect, stable, self-contained, internally defined, infinitely timeless.	Nature constant	Nature benign
ii	Resilience	(no equivalent)	Pilgrimage nature - *Natura naturans* - nature as a learning experience altered by the perception of the pilgrim and the course of the journey.	Nature resilient	(no equivalent)
iii	Cyclical renewal	(no equivalent)	Cyclical nature -the possibility of renewal in nature.	(no equivalent)	(no equivalent)
iv	Multiple stability	Keynesian and post-Keynesian.	Wandering nature - *Natura naturata* - at times stable and unstable, nature is unpredictable and appears to need controlling.	(no equivalent)	Nature capricious
v	Instability	Malthus and Marx	Hell - imperfect, catastrophic, eternally static.	(no equivalent)	Nature ephemeral
	(no equivalent)			Nature engineered	Nature perverse / tolerant
	(no equivalent)			Nature evolving	(no equivalent)

Table 9.1. Contrasting Myths of Nature: Timmerman, Holling and Thompson

In table 9.1, myths (iv) and (v) are classified with their equivalents in cultural theory on the basis of their stability properties. 'Wandering nature' is equated with 'nature capricious', since both are unpredictable. 'Hell' is equated with 'Nature Ephemeral', since both are unstable. 'Wandering Nature' might appear to be similar to 'Nature Perverse/ Tolerant', since both have regions of stability and instability, but the difference is that 'Wandering Nature' is unpredictable, and hence not amenable to a hierarchical management style. Table 9.1 demonstrates that Holling's, Timmerman's and Thompson's myths of nature form three non-equivalent sets. The difference between the latter two sets of myths is further highlighted when Timmerman incorporates his myths into the grid-group system of cultural theory (figure 9.1). The difference between the ecologists and cultural theory is that Holling and, to a lesser extent, Timmerman both seek myths to describe the dynamic and adaptive behaviour of complex adaptive systems, while Thompson presents myths that characterise a static snapshot of system at a point in time. Thompson's approach is captured by choice of imagery of a ball in a bowl, which is a paradigmatic Newtonian system, in stark contrast to the complexity of ecosystems.



Myths according to Thompson et al. (1990) **Myths according to Timmerman (1986)**

Figure 9.1. The Political Cultures and Myths of Nature according to Thompson and Timmerman

9.3.2. Myths of Nature in Cultural Theory: A Resolution

This proliferation of incompatible sets of myths is damaging to cultural theory's hypothesis of a link between institutions and myths of nature. Contrary to the assertion of Schwarz and Thompson, cultural theory's myths are not derived from those of Holling and Timmerman. There are two ways of resolving this problem. The first, which is explored below, is to reject the ecologists' anomalous myths and find a theory that can generate Thompson's set. The second, which is beyond the scope of this chapter, is to alter cultural theory needs to accommodate the ecologists' myths.

We can generate a set of 'static' myths from first principles by considering what elements we would need to describe a snapshot of a complex adaptive system. These would be the three types of attractor described by dynamical systems theory and discussed in chapter 5: point attractors corresponding to stable equilibrium, cyclic and chaotic attractors (Allen 1990:560). We thus recover Thompson's set of myths (figure 9.2), where in mathematical terms, figure 9.2 depicts the fatalist's myth in parameter space, and the other myths as one-dimensional potential functions.

This list of myths is exhaustive, as there are only three basic types of attractor. The cyclic attractor is not used by cultural theory, but Timmerman associates the equivalent myth of 'Cyclical Renewal' with the hermit's way of life (Timmerman 1986:447).

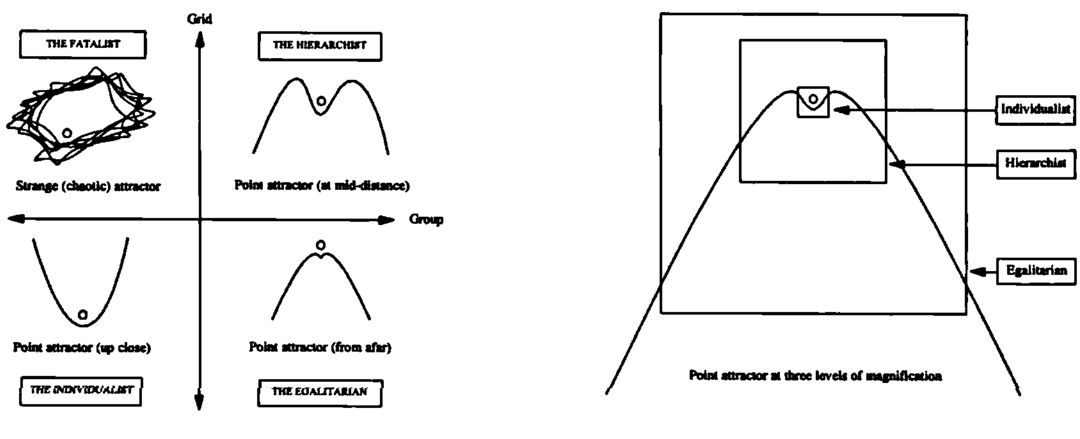


Figure 9.2. Cultural Theory's Myths of Nature derived from Systems Theory

We may interpret the point attractor of figure 9.2 as describing the biosphere, the human body, or any other complex living system. Such complex systems can only survive, maintaining their structure, function and identity, within certain physical, spatial and temporal bounds. For example, if the Earth were 100°C hotter or colder, it would not sustain life. There is therefore a domain of stability or life, corresponding to the attractor, bounded on both sides by instability or non-life. In biological terms, such an attractor could represent the 37°C temperature at which a mammal typically maintains its body, although this is stretching the analogy somewhat, since no complex living system can be adequately described in terms of a single attractor in a single dimension. If, however, we were to project the multi-dimensional dynamics of human life onto the single dimension of "temperature", then the notion of an attractor at around 37°C is a very reasonable description of the human system. This might be compared to keeping a diary in which the only entry made each day is of bodily temperature.

The three active ways of life all see this attractor, but at different scales (represented by the size of the squares in figure 9.2):

- *Individualists*: see only the central domain of stability, the region of life and creativity. Their narrow, non-systemic perspective corresponds to a short-term and personally-oriented focus. In the economic realm, these people would operate with high discount rates, and they assume complete substitutability between natural and man-made capital (Victor 1991).

- *Hierarchists*: see the domain of stability, but are also aware of its limits. Their wider focus corresponds to thinking on an broader level, encompassing wider social and institutional concerns, and considering the sort medium-term time-frame typical of institutional decision-making.

- *Egalitarians*: see the small domain of stability as an island of order in the vast oceans of chaos. Their concern is truly systemic, taking in the whole biosphere as well as the interests of future generations. They operate with low or negative discount rates, and assume that natural and man-made capital are complementary, not substitutable.

This approach puts cultural theory's myths of nature on a sound theoretical footing, while retaining the management styles and institutional arrangements described above. To recap, we have been able to do this with only one assumption: namely that cultural theory's myths provide a static, Newtonian description of a world that is in fact complex, dynamic and adaptive. As the above discussion has shown, if we reduce the dynamic complexity to a static snapshot, we can recreate the imagery of cultural theory's myths of nature. But in so doing, we are discarding the very aspects of the system that make it complex, namely its dynamic and adaptive behaviour over time, and we therefore move from a complex to a Newtonian description of the world. As chapters 4 and 5 showed, moving away from a complex view of the world has important consequences, not least in terms of following a complex/adaptive approach to policy and institutional design.

9.3.3. Cultural Theory and Complexity

That cultural theory's myths of nature are an artefact of Newtonian thinking is not entirely surprising. One of the legacies of the Newtonian revolution in science is that it still forms the dominant paradigm in economics, which in turn has an important influence on policy science, management and decision making. Cultural theory is telling us, in effect, that most people and most institutions still see the world in a pre-complex way: they use pre-complex myths of nature, and do not appreciate the dynamic evolutionary nature of a complex adaptive system. As chapter 5 demonstrated, we must simplify the world in order to comprehend it. The Newtonian myths are the most straightforward simplification, so it is not surprising that they are the most widely held, despite their basic limitations in a complex world.

An alternative way of thinking about the reductionism of cultural theory is to consider it as a projection of a multi-dimensional organisation reality onto the two-dimensional plane defined by the axes grid and group. As such it is certainly an improvement over the one-dimensional projection onto the axis of "hierarchy - market", but it is nevertheless a reduction that dispenses with a significant level of detail about the other dimensions in the original complex social and organisational system. It may be that in certain cases the two dimensions of grid and group contain nearly all the relevant information about the system, and that people may indeed make decisions on the basis of simpler rationalities, but it seems likely that in many, if not most, cases, other dimensions will be required to provide a more complete description of the system.

Cultural theory is certainly useful as a tool to open people's minds, especially in the light of the mainstream political theory that still thinks in terms of the one-dimensional distinction between hierarchies and markets, and in the light of the mainstream SD debate which emphasises the hierarchist and egalitarian perspectives at the expense of the individualist. It also provides a check to ensure requisite variety in strategy and policy making, notably to ensure that the egalitarian perspective is included. Cultural theory is also, however, highly structured. It is in fact, to analyse it using its own methods, a distinctly hierarchical theory, with a framework imposed from above, and a proper place and order for all myths, rationalities and cultures. Mary Douglas herself, the originator of the theory, confesses to being a hierarchist (Douglas 1992:266), although some of her later co-workers such as Wildavsky are avowed individualists. She also appears to be conscious of the theory's limitations, and appears to be suggesting that we should see it as a heuristic, a "gimmick", rather than a scientific theory (Douglas 1992:265):

> "For the present global problem we would do well to develop gimmicks for appreciating other forms of life, and for contemplating them without rivalry. Such a gimmick, I suggest, is this form of cultural analysis."

In order to appreciate the plurality of the complex organisational, institutional and cognitive processes that surround us, cultural theory is a powerful tool to help people take the first step towards understanding. However, as our understanding of paradigms, mental models and metanarratives increases, it becomes clear that human cognition and the institutions and technologies that co-evolve with it are best understood in terms of complexity. There may be meta-stable periods of order, but equally there is increasing diversity, complexity and non-linear change. Such processes have already been described by theorists of postmodernism, and the challenge remains to develop a complex systems perspective on social evolution, which may well be informed by cultural theory.

As noted above, another theoretical challenge is to develop a new set of myths for cultural theory that are based on the more complex world hinted at in Holling's and Timmerman's myths, and to consider what institutional forms would make sense in the light of such myths. This challenge is already being tackled in the field of management theory, where organisational theorists are considering the challenges of managing in a world of unpredictability, change and complexity, as discussed in chapter 12.

9.4. Conclusions

In section 7.2, the claims made by cultural theorists regarding the cultural approach were set out. They argue that the grid/group framework provides:

- *Classification*: A robust and systematic typology with "an exhaustive and mutually exclusive set of categories".
- *Theory of Change*: The ability to demonstrate endogenous and non-deterministic change.
- *Prediction*: The ability to make predictions on the basis of the correspondence between myths of nature, rationalities and preferred institutional forms.

The application of cultural theory in chapter 8 and its analysis in this chapter has demonstrated that each of these claims is problematic.

- *Classification*: The classification of SD policy definitions in chapter 8 demonstrated that the cultural categories are not exhaustive, since they do not encompass Gaian and complex systems definitions. Chapter 9 demonstrated that there are additional theoretical problems with classification, which are related to cultural theory's inability to discriminate within a given rationality, and to the unclear status of 'rhetoric stealing', alliances and plural myths.
- *Theory of Change*: The cultural theory of change through twelve surprises is

seen to be highly simplistic and inadequate when compared to learning and the adaptive, evolutionary behaviour seen in actual social and natural complex systems. In addition, the lack of a theoretical explanation for the origins of the four myths of nature and institutional forms is also problematic.

- *Prediction*: Chapter 9 has shown that cultural theory cannot make clear predictions for clumsy institutions or plural rationalities, and since these hybrids appear to be very common, if not dominant, in real-world institutions, then the theory's predictive power is severely curtailed. Furthermore, chapter 8 demonstrated that the correspondence between myths of nature, rationalities and preferred institutional forms does not always hold in any case, so cultural theory is not predictive even for single myths. As a result, the overall predictive power of the theory is limited.

These problems are all seen to be related to complexity. The rigid four-fold classification obscures the diversity and plurality of real complex systems, the explanation of change is inadequate for a complex adaptive reality, and the predictive limitations stem from the complexity of social systems. Similarly, the myths of nature are seen to be snapshots of reality, which omit the dynamic processes of change that are the hallmarks of complex adaptive systems. In addition, the theoretical problem of cognitive change in a given institutional framework presents cultural theory with great difficulties in advising on suitable structures for organisational learning and adaptive change, even though it remains plausible that organisational resilience is improved through a pluralistic approach to generating mental models, strategies and policies.

In summary, cultural theory is a useful heuristic for classifying plural definitions and for gauging resilience and plurality, but it has numerous theoretical shortcomings which are associated with its formulation in a way that does not take account of the insights of complexity theory. The theoretical divergence of cultural theory and complexity centres around questions of adaptiveness, resilience and learning, which are also central concepts for SD. The relationship between these ideas is explored in chapter 10.

Chapter 10: Resilience, Learning and Sustainability

10.1. Introduction

Chapter 9 demonstrated that cultural theory has a number of theoretical shortcomings which are related to an inadequate description of complexity in issues of classification, the theory of change and surprise, and prediction. In these areas cultural theory proposes a rigid schema of classification and surprise, and makes claims about the predictive power of the cultural framework that do not hold in practice. Despite these differences, however, cultural theory and complexity theory have complementary perspectives on adaptiveness, resilience and learning, and both theories are consistent with the complex/adaptive model of policy for SD discussed in chapter 4. Given their importance for sustainability, it is important to attempt to develop a integrated understanding of concepts such as resilience and learning which encompasses the insights of both complexity and cultural theory, and resolves any issues of incompatibility between the theories.

Chapter 10 examines the areas of agreement and disagreement between complexity and cultural theory with a view to developing such an integrated understanding in areas such as plurality, resilience and learning. This synthesis can then be used to develop some general propositions about the nature of sustainability and policies required to attain it, which is the subject of chapter 11.

10.2. Cultural Theory and Complexity: Areas of Agreement

Drawing on the findings of chapters 5, 7, 8 and 9, the areas of agreement and disagreement between cultural theory and complexity are enumerated in table 10.1. Although chapter 9 highlighted the divergence between the two theories, table 10.1 demonstrates that the theories have more in common than they have separating them, especially when contrasted with comprehensive/rational policy approaches and economic theories that dominate current SD policy debates. These wider contrasts may be summarised as follows:

Issue for Theoretical Explanation	Cultural Theory	Complexity	Status
Uncertainty: Social systems key to SD are characterised by great uncertainty	Yes - uncertainty is structural	Yes	Agree
Classification: Decision making involves a subjective classification and introduces a set of assumptions about reality	Yes - classification is a function of social and institutional links	Yes - classification is necessary to reduce complexity of reality	Agree
Plurality: The existence of plural typologies and hence plural rationalities is inevitable	Yes	Yes	Agree
Behaviour, Myths and Rules: behaviour is derived from underlying myths or rules	Yes - mental models, myths, rationalities	Yes - rules, classifier systems, genomes, etc.	Agree
Intelligent Agents: the agents are intelligent, strategising, cognising.	Yes	Yes	Agree
Resilience: Multiple perspectives and strategies provide greater resilience	Yes - to avoid surprises from missing other myths	Yes - to have plural models and strategies	Agree
Learning: Learning is a central component of resilience.	Yes - social reality is always changing	Yes - all social and natural systems evolve	Agree
Policy Model: A comprehensive/rational approach to policy will be ineffective	Yes - there is no one correct rationality	Yes - complexity requires adaptiveness	Agree
Non-Optimised: Optimisation is both impossible and undesirable	Yes - different myths optimise differently	Yes - redundancy is key to resilience	Agree
Patterning: how is uncertainty patterned in social and institutional systems?	Four-fold pattern as per grid/group (chapter 7)	No theory	Complementary
Myths and Institutions: is there a link between myths of nature and institutions?	Yes - institutions and myths are correlated	No theory	Complementary
Origins of Uncertainty: what are the origins of uncertainty?	No theory	Non-linearity, emergence and evolution (Ch. 5)	Complementary
Origins of Myths: what are the origins of the myths of nature?	No theory - they are timeless, without origins	Stable attractors in dynamical system (Ch. 8)	Complementary
Origins of Institutional Forms: what are the origins of the various institutional types?	No theory	Hypothesis (untested): arise through emergence	Complementary
Learning: how do institutions learn and develop more sophisticated models?	No theory - only theory of surprise	Through evolutionary adaptation (Ch. 5)	Complementary
Requisite Variety: what are the necessary behaviours of a balanced system?	Action according to the four rationalities	Innovation/exploration and efficiency (Ch. 5)	Complementary
Plural Rationalities: how many significant dimensions of plurality are there?	Two - which generate four rationalities	Many - there is no limit on possible rationalities	Disagree
Institutional Forms: how many different types of institutional design are there?	Four - market, hierarchy, commune and isolation	Many - diversity is unbounded and growing	Disagree
Process of Change: what is the explanation for social and institutional change?	Change arises through one of 12 surprises	Complex adaptation, innovation and evolution	Disagree

Table 10.1. Areas of Agreement, Complementarity and Disagreement Between Cultural Theory and Complexity

- *Uncertainty, Plurality, Optimisation*: Both complexity and cultural theory accept the existence of uncertainty, and recognise that this allows the possibility of plural subjective classifications, problem definitions, mental models and rationalities. Given this uncertainty and plurality, optimisation is doubly impossible, firstly for reasons of sheer unpredictability and uncontrollability, but secondly because plural rationalities preclude the development of a single metric which can be used as the measure of optimality. By contrast, the mainstream comprehensive/rational model sees uncertainty as limited and reducible through improved science and modelling, and optimisation as not only possible but an essential part of integrating 'sound science' and cost-effectiveness to develop the 'right' policies.

- *Myths, Rules, Resilience, Learning*: Both complexity and cultural theory see decisions as arising from underlying mental models or rule sets, which are plural and diverse. As a result, more resilient policies and strategies can be developed by developing more plural, adaptive and resilient rule sets and mental models, which requires a process of individual, institutional and social learning. By contrast, the comprehensive/rational model sees decisions as arising from the self-interested behaviour of economically rational agents constrained by a framework of regulations and incentives, so intervention in the system is a question of altering the regulations and incentives that guide these behaviours.

- *Intelligence, Co-Evolution, Emergence*: Complexity and cultural theory see intelligence as distributed through the complex adaptive system of agents and institutions, and hence they see learning and resilience as complex, emergent phenomena that necessarily involve all the parts of the system, and institutional change as a co-evolutionary process with both top-down and bottom-up elements. By contrast, the comprehensive/rational model sees agents as automata that respond optimally to economic signals, so learning applies primarily at the policy level where these signals are set, and institutional change is therefore understood to operate in a top-down manner, albeit with participatory or consultative processes to advise the top-down decision making system.

Since cultural theory and complexity both suggest that the complex/adaptive policy model is superior to current approaches to SD policy, their convergent findings are perhaps the most important to note in terms of their policy implications. The different perceptions of resilience and learning and their relationship to sustainability are explored in section 10.4, following a discussion of complementarity and divergence among cultural theory and complexity.

10.3. Cultural Theory and Complexity: Areas of Difference

In addition to their areas of agreement, cultural theory and complexity are complementary in several respects, that is they provide mutually supportive insights in alternative domains of explanation. In essence, complexity theory provides explanations of learning, change, and evolution which are common to complex adaptive systems, including social systems, whereas cultural theory adds the specific patterns of behaviour that are emergent social phenomena, and which are not predictable *a priori* using complexity theory. In particular, cultural theory's findings that there are four myths of nature which commonly recur, and that these myths tend to be linked to certain preferred institutional forms, cannot be predicted from complexity.

Nevertheless, complexity theory may be able to shed light on cultural theory's myths and institutional types. Using the types of artificial life approach outlined in chapter 5, it may be possible to develop models of social interaction and institutional development using a bottom-up, agent-based approach. Such models would in principle be able to shed light on cultural theory's observation that there are certain patternings of social behaviour, and also on the disagreement between its insistence that there are only four institutional types and complexity's expectation that a rich diversity of institutional forms should evolve, in the same way that biological evolution has led to a rich diversity of forms of life. Such types of modelling of social and institutional development are being carried out at the Santa Fe Institute, although there are no conclusive results as yet. As was noted in chapter 5, the purpose of such modelling is not prediction, since the behaviour of complex systems is intrinsically unpredictable. Rather, it is to improve our understanding of how complex systems function, adapt and evolve, in order to shed insights on how we might improve the resilience and adaptiveness of our institutions and strategies in business and government.

A complex systems interpretation of the origins of the four myths of nature was developed in chapter 9. In summary, the myths correspond to two of the stable attractors of dynamical systems. Because the structures in a complex system derive from such attractors, it is to be expected that the attractors underlying the structures will influence the perceptions of the system's behaviour, that is to say the myths of nature. Equally, because a generalised complex system has numerous different attractors at different scales and times, plural myths will emerge from alternative partial views of the system. The significance of this result is primarily to reinforce cultural theory's claim that each myth is partial, and also to point out there is a deeper level of explanation in terms of complex adaptive systems that has eluded cultural theory. It is also noteworthy that the non-systemic nature of the myths is illustrative of a more general problem of non-systemic human thinking observed in psychology (Simon 1978, Lindblom 1979, Tversky and Kahneman 1982, Bowonder 1987, Senge 1990, Bardwell 1991), which may explain the persistence of pre-complex myths and policy models despite accumulating evidence to the contrary from complexity theory and from practical experience of natural and social systems.

The Gaian myth of nature is of particular interest, since it is unclassifiable within cultural theory, having been associated with all four myths of fatalism (we cannot control Gaia, so there is no point trying), individualism (Gaia is resilient, so we need not fear global collapse), egalitarianism (Gaia is a holistic, living entity that needs to be respected and left alone) and hierarchy (the self-regulating processes of Gaia only function within certain limits, so if we stress the biosphere beyond those limits, the system will break down). The self-organisation theory at the heart of Gaia is the same as the theory of self-organisation in complex adaptive systems, and with the exception of its mystical and anthropomorphising elements, Gaian theory is eminently compatible with and explicable in terms of complexity. Complexity is therefore seen to provide a more complete set of myths than cultural theory, since it can not only be used to derive cultural theory's four myths of nature, but it can also accommodate the myth of self-organisation behind Gaia.

The differences between cultural theory and complexity arise where cultural theory attempts to over-simplify reality or impose overly rigid conceptual frameworks for its interpretation. These two difficulties are aspects of the same problem, namely that the cultural framework provides only two dimensions to describe rationalities and institutional types, and insists that these are the only relevant dimensions. As noted in chapter 9, this tendency towards rigidity points to the hierarchical origins of cultural theory itself. On the basis of findings from previous chapters, there would appear to be little prospect of retaining the 'strong' interpretation of cultural theory which argues for only two dimensions, as the theory can easily be falsified in this strong version, as demonstrated in chapters 8 and 9.

A more relaxed interpretation, which would necessarily imply reduced predictive or explanatory claims, would be that cultural theory describes just two of many relevant dimensions for describing institutions and rationalities, and that these two appear to be responsible for some interesting regularities of institutional life. This interpretation implies revising the status of cultural theory from a falsifiable theory to a heuristic, but it is consistent with complexity, and it is adopted henceforth in this thesis. To summarise, this understanding does not argue that myths, institutions and rationalities will always be precisely aligned according to the cultural hypothesis. It does, however, accept that the egalitarian, hierarchist and individualist myths provide three different views of reality and policy, all of which contain important insights. To the extent that a particular policy or institution does not take account of all these perspectives, its resilience could be improved through a consideration of any perspectives currently omitted. Similarly, the application of cultural theory to the SD debate in chapter 8 demonstrated that it can provide useful insights about the shortcomings of the debate as a whole, and the need for further integration of individualist perspectives alongside the hierarchist and egalitarian myths that currently dominate the SD debate.

10.4. Learning and Resilience

In addition to their theoretical justifications for plurality, cultural theory and complexity theory both support the complex/adaptive policy model, which stresses the need for resilience and adaptability in the face of an uncertain and unmanageable future. This perspective is summarised by Clark et al. (1995): "the long-term survival (or extinction) of any particular group of humans is perhaps more related to its ability to cope with uncertainty and change, and to generate appropriate responses, than to the optimality of its precise behaviour at a given time". Since these notions have been closely associated with sustainability, as was noted in chapter 3, it is worth examining their meaning in greater depth.

Optimisation is possible in a Newtonian world, but not in an ever-changing and complex world. In such a world the primary objective is survival, which requires resilience: the ability to withstand shocks and crises that arise over the short term. This does not mean that a system must be fail-safe, but rather that the system should be able to recover quickly and easily from failure, error, accident or shock. Complex systems have evolved a number of ways to improve resilience, such as redundancy, continuous error-checking and monitoring, self-repair, parallel or back-up systems, and distributed functionality and processing (Emery 1969, Herbst 1974, Levy 1992, Kelly 1994). Despite the importance of increasing resilience in organisational and policy design, the economics-driven focus on optimisation has resulted in decreased redundancy, which may lead to increased fragility (Holling 1994).

Resilience can mean at least two different things in organisational terms. The first is resilience at the level of strategy, so that a company's strategy and planning are able to cope with turbulence in the business environment. Much of the early work on scenario planning was designed to improve resilience, and this remains an important role for strategists today. The way that scenarios can help companies achieve resilience in turbulent environments is described by Wack (1988a, 1988b), and explored further in chapter 13. The second type of resilience is at the level of structure, so that if one structural element of an organisation fails, there is a back up system.

Resilience is essentially a static concept of design, in which a system is designed to cope with whatever short-term crises and shocks it encounters. There is a second aspect to survival in a complex world, which is adaptability. This is a dynamic concept, which refers to the system's ability to reconfigure itself as circumstances change. Whereas resilience is a matter of restoring a system to its normal operating state after it has been disturbed, adaptability is a matter of changing the normal operating state as environmental conditions change over time. This adaptive, co-evolutionary process is likely to involve more far-reaching changes in structure and strategy (Boulding 1981, Trist 1982). Natural complex systems are adaptable in two ways: evolution and intelligence. Evolution allows genetic adaptation from generation to generation. Complex systems research into artificial life and genetic algorithms has found that evolution is a very effective mechanism of adaptation, and can produce change very rapidly, as noted in chapter 5. Intelligence provides an even more rapid mechanism of adaptation, giving humanity its unique adaptability (Diamond 1991). The possibility of adaptation is closely linked to diversity and requisite variety (Ashby 1952, 1960): where there is a greater pool of ideas or designs to experiment with and draw from, the system can more rapidly explore a number of alternative options to test their success. This idea is discussed further in section 10.5.

Adaptability is also a matter of strategy and structure, and the capability to learn is an important indicator of adaptability (Michael 1973, Williams 1982, Senge 1990). Learning can be promoted through diversity both at the level of mental models and of approaches to problem solving. Diverse thinking can be fostered by ensuring a mixture of cultures, backgrounds and perspectives in building management teams (Senge et al. 1994). Moreover, it can be encouraged within each individual, by fostering open-mindedness, experimentation and tolerance (Vickers 1965, 1972). Diversity in action can be encouraged by decentralised structures that allow different units to adopt alternative approaches in solving problems. In this way an organisation can evolve better ways of doing things by comparing the effectiveness of different approaches, and learning from and encouraging the dissemination of those that work best.

This approach involves decentralising management and responsibility, and precludes a centralised approach that aims to find the 'one best way'. As chapter 5 notes, experience from complex systems shows that learning from repeated experiments run in parallel is a far more effective way of finding effective solutions than attempting a single optimal design. The other benefit of a pool of competing and co-evolving strategies and approaches is that it confers much greater resilience. If the system encounters a shock or problem which means that some approaches are no longer successful, there will still be others that work, and which can be rapidly disseminated to cope with the new conditions. By contrast, if a centrally defined strategy has been applied throughout the organisation and then it encounters problems, going through another iteration of centralised redesign is likely to be highly time-consuming and damaging, and the organisation will still be vulnerable to similar shocks in the future. These observations are equally relevant to policy design for sustainability as they are for designing effective corporate strategies.

In designing institutional structures for sustainability, it is also possible to derive insights from natural systems such as plants and animals. These structures are far more efficient than any human artefact, and they show a number of approaches to resilience and adaptability which hold valuable lessons for business, including (Kelly 1994):

- *Chunking*: Complex natural systems are assembled bottom-up from small, simple working systems rather than attempting to build the whole structure in one go, or designing structures that are conceived as a whole. A similar approach is now taken to large software projects, where the error rate can be greatly reduced by building small working modules of code.

- *Local control*: Living creatures demonstrate local control. Most of the 'intelligence' that is required to move a leg or ensure that the heart beats is built in locally at the point of action. If this were not the case, the demands on the central intelligence system would overwhelm it, as has been demonstrated by attempts to build walking robots (Levy 1992). Local control also allows chunking to work: if sub-units could not control themselves, it would be impossible to know whether a sub-system worked until the whole system was active. The organisational analogy is decentralised control, small functional units, self-managing teams and similar approaches.

- *Parallelism*: Complex systems have parallel structures and functions, which either serve to check each other's functioning, provide back-up in the event of failure, or increase processing speed. Perhaps the most important example of parallelism is the structure and function of the brain, although back-up functions can also be seen in many bodily systems. One of the challenges to develop effective parallel structures in organisations is to ensure that different parts of the organisation benefit from their co-dependency, and work together effectively. The approach taken by Microsoft in developing Windows NT provides an interesting example. David Cutler, manager responsible for NT, developed a system he called "eating your own dog food". After the first year of programming, Cutler declared that henceforth programming teams would have to write their NT code on computers running the crude and unfinished version of NT itself. Programmers quickly became aware of the bugs introduced by other teams, or parts of the software that did not work. The system stimulated productivity, as programmers' jobs became easier to do as they introduced additional functionality, and it also create a fierce opposition to bugs without any need for management monitoring and control (Zachary 1994). Such systems for self-organisation would also appear to hold potential for designing institutions for sustainability.

Systems that are efficient at change are not merely open to change, they actively seek change. There are two lessons from complex systems research, one of which is obvious, the other quite unexpected.

- *Active Fringes*: Diversity is a source of adaptability, and allows varied experimentation and change. However, most organisations and entities have a core, where most of their activity is focused, so diversity must be expressed largely at the fringes. The fringes are the source of most truly innovatory ideas in cultures, economies and organisations. By promoting an active fringe, which may appear uneconomic or positively anti-systemic, an organisation can ensure that it is continually testing for new ideas and possibilities (Schwartz 1992, Kelly 1994). The management challenge is that much fringe activity will create no value, whereas the occasional idea could prove revolutionary. As a result, assessing cost-effectiveness for fringe activity in general can prove difficult.

- *Parasites*: Recent study of evolution, both in the natural world and in computer based complex systems, has developed the surprising result that the presence of parasites in a system accelerates evolution dramatically, through the Red Queen effect, which is named after the character in *Alice in Wonderland* who runs as fast as she can just to stay in the same place (Allen 1990, Levy 1992, Ridley 1993). A parasite will find a way to take advantage of a host; the host will find a way to retaliate; the parasite, in turn, will find a new line of attack. In such 'evolutionary arms races', the ability to change more rapidly than the other organism is truly the only sustainable competitive advantage. Creating institutional parasites may appear to be a counter-intuitive way to promote sustainability, but it may be the most effective stimulus to organisational change. The market is already a source of ever-changing competitive challenges, but successful companies lead, rather than react to, market changes. Companies already employ hackers to test their computer security, and there would appear to be similar scope for them to create beneficial parasitic structures elsewhere.

10.5. Resilience and Diversity

Cultural theory proposes that resilience refers to the type of behaviour demonstrated by a 'balanced' institution which includes individualism, hierarchy and egalitarianism: "the particular blend of anticipation and serendipity . . . [and] taboo or sacrosanctification that enables a culturally plural *regime* to ride with, and make the most of, all the changes that it both experiences and contributes to" (Schwarz and Thompson 1990:106, emphasis in original). An alternative formulation (ibid.) clarifies the nature of this plural behaviour:

> "How, we ask, can the pluralised whole arrange itself in such a way as to ensure that some of its parts effectively anticipate the anticipable [sic.] whilst others of its parts successfully interrogate the unknown, and still others of its parts tell us which stones are best left unturned?"

This argument proposes that resilience is a question of the diversity and plurality of possible behaviours, which in this case means including at least some types of behaviours to represent each rationality. Definitions of resilience in complex systems similarly emphasise the importance of diverse behaviours: "the degree of resilience is linked to the ability of the system's components to explore and develop mutually beneficial strategies and behaviours which will permit them to change and adapt in response to disturbance" (Clark et al. 1995). Brooks (1986) develops a parallel argument based on technologies rather than policies, and he recognises that technologies embed implicit strategies, for example in the assumptions about the environments that they will be used in. He concludes that "there may be an inherent value in the maintenance of technological diversity that is analogous to the value of the maintenance of genetic diversity in natural and man-made ecosystems" (Brooks 1986:339). This result supports the findings of Allen and Holland outlined in chapter 5, which were based on understanding the behaviour of complex adaptive systems in terms of behaviours encoded in plural and redundant rules sets. A complete description of such rule sets is both impossible, given its complexity, and inappropriate, given its specificity to the particular circumstances and 'environment' of each system. We can say, however, that the mechanism generating the rule sets should exhibit the general functional components of an evolutionary/adaptive process outlined in chapter 5. By way of illustration, the biological mechanism is evolutionary change through genetic crossover and mutation, and the rule set is encoded in DNA; in a company, the mechanism might be the corporate board, and the rule set the corporate strategies and operating procedures.

In particular, this mechanism requires components or aspects covering both efficiency/optimisation and learning/experimentation, as discussed in section 5.5.1, which correspond to 'rational' behaviour in the light of current knowledge, and exploration to discover new information and knowledge (Allen 1990). In other words, agents cannot simply optimise within their current rule sets, but they need continually to generate and test new rules in order to make sense of their changing environment. These behaviours can be compared with the information handling styles noted by Schwarz and Thompson and, and also with a hypothetical analogy from genetic /evolutionary models of change such as those of Allen and Holland, thus providing a cultural basis for a generalised rule set (table 10.2).

Rationality	**Information handling**	**Behaviour**	**Evolutionary perspective**
Individualist	Explore the unknown	Innovation	Find /colonise new niches
Hierarchist	Anticipate the what can be anticipated	Optimisation	Exploit current niche
Egalitarian	Know which stones to leave unturned	Precaution	Avoid danger

Table 10.2. Three Types of Behaviour Needed for Resilience

The cultural and complex perspectives on resilience are thus seen to be complementary in arguing for a combination of anticipation/optimisation and innovation/interrogation. The primary difficulty from a policy perspective is ascertaining the 'appropriate' balance between these activities, particularly since there are different views of what is appropriate. Allen (1990:567) notes that in economic terms exploration is seen as less attractive than exploitation, so that "in the short term it is always true that the more 'rational' actor must outperform the less", and maximising present profits must therefore be better than not doing so. Yet over the longer term, "the best performance will not come from the most rational but instead from behaviour which is some complex compromise" (Allen 1990). Similarly, Brooks (1986) notes that "an overall system that is less efficient or more costly . . . may nevertheless have greater viability or survival potential . . . yet there are few apparent rewards to organisations, or even nations, in directing efforts toward such diversity". Although a suitable balance between experimentation and optimisation cannot be derived analytically, computer simulations can help to establish the viability and success of different portfolios of behavioural strategies in different environments (Holland 1992a, Clark et al. 1995). An example of such an application of complex systems modelling is the work of Allen and McGlade (1987a, 1987b) in devising balanced fishing strategies for the Canadian fishing industry that are both ecologically and economically viable.

The fact that a less 'optimal' strategy in the short term might nevertheless provide the best results in the long term is an example of the limitations of the traditional comprehensive/rational policy model in a complex world. Simon (1978:8) criticises simplistic notions of rational choice in the face of complexity, noting that the number of considerations that are potentially relevant to the effectiveness of any strategy or organisational design "is so large that only a few of the more salient of these lie within the circle of awareness at any given time". He argues that in a complex, changing environment, "'learning' in the form of reaction to perceived consequences is the dominant way in which rationality exhibits itself", so that the means by which decision makers cope with uncertainty and cognitive complexity should be central to a theory of rational behaviour. Simon proposes that economic theory should focus not only on *substantive* rationality, the traditional economic analysis of the extent to which appropriate courses of action are chosen, but also on *procedural* rationality which seeks to understand what constitutes an effective decision making strategy in the light of complexity and the limitations of human cognitive powers.

Lindblom (1979:518) develops a closely parallel argument to Simon, arguing that for complex problems "too many interacting values are at stake, too many possible alternatives, too many consequences to be traced through an uncertain future - the best we can do is achieve partial analysis or . . . 'bounded rationality'". Instead of a perfect synoptic policy process, Lindblom sees that real decision processes involve "muddling through", a term reminiscent of the call for "clumsy institutions" by Thompson et al. (1990). Since all analysis is inevitably incomplete, the problem arises that policy makers may settle on a "local optimum", a policy better than its near and only incrementally different neighbours, but possibly "much inferior to a more distant alternative policy never examined" (op. cit.:519). Both Simon and Lindblom conclude that the problem of how to search throughout the "solution space" for such global optima is central. Simon proposes that efficient search techniques may be derived from approaches in cognitive science and artificial intelligence, of which Holland's work on genetic algorithms discussed in chapter 5 is one of the most promising examples. Lindblom points to the benefits of a "competition of ideas", noting that complex social problems can often be attacked in an emergent way, "by 'resultants' of interaction rather than 'decisions' arising out of anyone's understanding of the problem at hand" (op. cit.:524).

These ideas are consistent with both cultural theory and complexity, and both Simon and Lindblom support the interaction of plural rationalities, strategies and sets of ideas. If a rationality is associated with a particular search strategy, or a particular region of the solution space, then combining plural rationalities provides alternative search strategies and allows investigation of different regions of the solution space, thus helping to break out of locally optimal solutions. The genetic and evolutionary approaches of complexity theory, which were discussed in chapter 5, provide a powerful set of tools for developing resilient policies and strategies bottom-up, as well as allowing efficient search for effective strategies while fostering emergent policy solutions. In principle it should be possible to encode SD problem definitions, policies and strategies in such a way that they could be manipulated and processed using genetic algorithm (GA) techniques, in order to derive more resilient policies and strategies. This should be possible because GA models allow the co-existence in parallel of contending values and perspectives, unlike traditional modelling which can only represent one perspective at any one time. At the moment, however, these approaches are only employed in technical optimisation problems such as engineering design (Holland 1992b), and their use in social decision making is still undeveloped.

An alternative approach is to work directly with the three rationalities of cultural theory which, by virtue of their widely differing approaches to defining and solving problems, provide a compact yet wide-ranging basis for searching for effective policy solutions and processes. In terms of Lindblom's emergent model, the political cultures also provide three very different mechanisms for interaction-driven decision making. A cultural approach may not offer the sophisticated and highly effective mechanism of crossover and mutation that allows experimentation and optimisation in genetic evolution, nor is there any reason to expect that just three approaches will cover the entire solution space (which is in any case likely to be multidimensional), but it would allow a wider search of the 'solution space' than an approach based on just one rationality. This method of improving plurality can be implemented through scenario-based approaches, as discussed in chapter 14.

10.6. Conclusions

This chapter has demonstrated that although there is a divergence between complexity and cultural theory, the theories share significant common ground. If cultural theory's rigid classificatory system is relaxed, and the four myths of nature are seen as common regularities in a complex world rather than the only archetypes for mental models or institutional behaviour, then the two theories become mutually supportive. In particular, their approaches to uncertainty, plurality, learning and resilience are compatible with each other, yet at the same time critical of the comprehensive/rational model dominant in SD decision making.

In proposing methods of increasing resilience, both theories stress the importance of plurality in the behaviours open to the system. In addition, they both support the need for institutional behaviour that is simultaneously optimising within the known and exploring the unknown, and complex systems simulation modelling can help to identify the appropriate balance between these types of behaviour, and thereby help to foster greater resilience. Cultural theory and complexity are also both consistent with the theories of Simon and Lindblom on organisational and political decision making processes, which stress the importance of strategies that can search widely among possible policy and institutional solutions, and also point to the possibility of emergent solutions arising from the pluralistic competition of ideas. Their ideas of bounded rationality and muddling through are seen to be early expressions of the complex/adaptive approach to policy.

The genetic and evolutionary models being developed by complexity researchers would appear to offer an interesting possibility of implementing such an approach to policy making in the longer term, but the cultural framework offers a more immediate tool to improve the plurality of decision processes and hence the resilience of decisions. The implications of all these ideas for sustainability are summarised in the next chapter, and subsequent chapters consider how they might be operationalised into practical tools to aid SD decision making.

Chapter 11: Sustainable Development in a Complex World

11.1. Introduction

The previous chapters have examined numerous aspects of sustainability, including definitional frameworks, policy prescriptions, and underlying theoretical explanations derived from cultural theory and complexity. Chapter 5 has argued that the natural and social systems that are the concern of SD decision making are complex and unpredictable, and chapter 6 has demonstrated that this complexity is present at all levels of the policy debate, from local to global. Chapters 3 and 8 have outlined how many different policies and frameworks for understanding SD have arisen, and shown that complexity, uncertainty and indeterminacy have enabled them to persist. As a result, these chapters have demonstrated that a unified understanding of sustainability is unattainable, while chapter 10 has explored how it is not desirable in any case, since the resilience that is essential for survival in a complex world is dependent upon plurality. The cultural theory of plurality introduced in chapter 7 has been found to be a useful heuristic in analysing alternative SD policies and in suggesting how to achieve greater resilience.

Yet plurality alone is not sufficient to attain sustainability unless it is harnessed to promote adaptiveness and learning, in line with the findings of complexity theory discussed in chapter 5, and in this light the current SD debate is seen to be deficient. Chapter 8 has found that most current SD definitions and policy proposals are pre-complex, while chapter 4 has argued that today's dominant SD policy model as a whole is still based on a pre-complex comprehensive/rational paradigm which is ill-suited to the decision making realities of a complex world. Chapter 9 has demonstrated that the theories of classification and surprise proposed by cultural theory are inconsistent with a complex adaptive systems perspective, although chapter 10 has confirmed that complexity and cultural theory nevertheless have much in common in their critique of the comprehensive/ rational policy model and in their confirmation of the validity of the complex/adaptive model introduced in chapter 4.

This chapter summarises the status of the SD debate in the light of these observations, based on the diverse set of policy perspectives and academic articles introduced in chapter 8 and Appendix B. Following the approach introduced by Adams (1995:209), the conclusions of these books and articles are analysed and classified. In the light of this analysis, two principal types can be distinguished:

(i) *'Traditional' approaches*: problem definitions and proposed solutions based primarily on traditional comprehensive/rational approaches to policy making. These may be further divided into three broad approaches, although these categories are non-exclusive since there is a degree of overlap between them:

- *Problem statements*: problem identifications or calls for action, but without any proposed solutions.

- *Small-scale, Bottom-up*: proposals based on local actions and examples of success stories, but without any systematic analyses or comprehensive approaches that could be developed into policy at the national or international level.

- *Comprehensive, Top-down*: policies involving government intervention through regulations and economic incentives to change patterns of production and consumption.

(ii) *Learning and Flexibility*: solutions emphasising the shortcomings of comprehensive/rational approaches to policy making and calling for new solutions based on learning and flexibility.

The following sections discuss these types briefly, and conclude with some observations about the status of the sustainability debate and possible directions for resolving some of the key issues.

11.2. Problem Statements

The elaboration of problem statements describing environmental threats and development priorities continues to comprise an important component of environmental literature. Such problem statements typically conform to the egalitarian type discussed in chapter 8, and are usually based on criticisms of current institutions, policies, values and ways of life, which is in accord with cultural theory's critical rationality. They are either accompanied by calls for urgent action or else contain no proposed solutions at all. A second type of problem statement without solutions is also found, which involves theoretical discussion of the meaning of sustainability without any explanation of the practical implications, if any, of such results.

A typical example of problems without solutions is presented by Marien (1994a), who sets out three scenarios of environmental decline but without any discussion of possible responses or interventions, and instead invites the reader to demonstrate to him why his pessimism is unjustified. Meadows et al. (1972, 1992) also present scenarios of environmental catastrophe and, in the light of the criticism of their work, conclude that there appear to be fundamentally divergent and irreconcilable perceptions of the mechanisms underlying economic development and its environmental impacts, given which they cannot suggest any avenues forward (Meadows et al. 1973). Wallace and Norton (1992) develop Gaian theory, but conclude that it "does not provide a clear value system for determining what should be the goals and objectives of environmental policy". Heinen and Low (1992) argue that mankind's psychological nature is suited to solving local, "human scale" environmental problems, and that global sustainability will be much harder to attain. They support their case by arguing that international environmental agreements are not very effective (Carroll 1988), but do not, however, suggest any resolution to this problem. Adams (1995) is inconclusive in his analysis of risk and its implications for global warming, based on his contention that the possibility of controlling events "appears more remote the higher one rises on the insight axis", which he uses to justify a position of tolerance and philosophical detachment rather than intervention.

These questioning or detached positions appear to have little positive advice for policy. In contrast, highly engaged environmentalists take the dangers of environmental degradation and the need to intervene as self-evident, and their problem statements are accompanied by proposals for urgent action, although without much in the way of considered analysis, exploration of alternatives, or elucidation of policy proposals. Daily et al. (1991) illustrate this approach in their discussion of climate change, where they conclude that "it's up to the voters and policy makers to do it", although the policies and institutional changes by which their desired ends are to be reached are not discussed. Ekins (1993) calls for the world trading system to be reformed to ensure that "basic norms of social justice and environmental sustainability are both promoted and enforced", but does not explain what these norms are, let alone how they might be attained through policy interventions. Similarly, Gowdy (1992) calls for economic growth to be phased out, Daly (1985) calls for the scale of the economy to be limited, Milbrath (1994) calls for ecosystemic thinking to be put at the centre of policy, Orr (1992b) calls for precaution in the face of climate change, and Viederman (1993) calls for humility, restraint, replacing efficiency by sufficiency, and establishing "right scale" and community as the "foundation of all durable politics and economics". These proposals are the familiar cornerstones of the egalitarian perspective and, equally typically, they are based on emotive calls to arms rather than details of workable policies to attain the espoused social and environmental goals.

A seeming exception is FoE (1993), which provides a detailed description of the changes that will be required to attain sustainability in the Netherlands, with recommendations ranging from a quantification of the required reduction in meat eating and a virtual cessation of international travel to outlines of a wide-ranging restructuring of industry, energy production, agriculture, transport and other major sectors. Although clear targets are given by FoE, however, there are few recommendations on how these targets might be attained, nor how the implementation process might begin.

The lack of policy advice is perhaps most evident in the calls for a change in values, consciousness and lifestyles. For example, Ekins (1991) sees a radical transformation of human consciousness as vital for sustainability, ERM (1994a) calls for a fundamental change in values and the acceptance of the need for sacrifices, and Fosberg (1991) proposes that sustainability requires "promoting, as a replacement for the present growth and materialistic motivation of humanity, the ideal of attainment of . . . higher quality of the human environment". These authors offer little advice on how these value shifts are to be brought about or whether they are even feasible, although Harman (1985) interprets the rise of the Green movement as evidence of a burgeoning underlying concern which might presage a more fundamental shift in values. In contrast, the members of Schmidheiny et al. (1992) distance themselves from such approaches by stating that they do not base their policy proposals "on radical changes in human nature or on the creation of a utopia", preferring an approach with clearly defined recommendations. To the extent that many current SD issues, including the debates on sustainable consumption or the need for more sustainable habits of living and working, call for shifts in human values without explaining how these might be attained, they are closer to the utopian tradition in social and political writing than to realpolitik attempts to influence policy making (Moorcroft 1992).

As bluntly as the environmentalists state the evident need for action, there is another extreme of authors who refute environmental problem statements and conclude that there is practically no need for policy intervention related to environmental issues at all. For example, Nierenberg (1993) emphasises that technological development and societal learning have falsified many of the high-profile predictions of environmental catastrophe of the last 20 years, while Smil (1987) argues that the growing evidence of the great resilience of biogeochemical systems lends support to the Gaia hypothesis and further weakens the case for intervention.

In addition to those authors with strong convictions but few solutions, the definitional debate on sustainability continues unabated, as noted in chapter 3, and a number of authors are still operating at a purely theoretical level without linking definitions to policy proposals. For example, Jacob (1994) questions how an appropriate balance might be drawn between deep and shallow ecology, and Shearman (1990) proposes that additional work is still needed even to answer why sustainability is a desirable goal. Redclift (1988) argues that current perspectives on sustainability are "ethnocentric and ahistorical", and that "environment" is a historically and culturally constructed category, although he does not elucidate the policy implications of these insights. Previous chapters have demonstrated that attempts to resolve definitional questions unambiguously are unrewarding quests, and that a plural and complex definition is the appropriate resolution.

An additional problem with the definitional debate is the ongoing search in many quarters for the meaning of sustainability at the level of nations, corporations or individuals

(Schmidheiny et al. 1992, Pearce et al. 1993, ERM 1994a). The search for such reductionist definitions is perhaps natural in the light of growing interest in market-based approaches to SD that stress individual performance. There are, however, important differences between reductionist approaches and the systemic thinking needed for sustainability, an issue which is a central concern of Daly's discussions on allocation, efficiency and scale (Daly 1992c). Indeed, there can be no such thing as a 'sustainable' company. It is perhaps easiest to see this in the context of an industry directly based on a renewable natural resource, such as the fishing industry. A captain of a fishing vessel might fish for his entire life without depleting fish stocks in an area, but if he were joined by a sufficiently large fleet of identical vessels, the fishery could be destroyed. The behaviour of the captain has not changed, but in the first case it is sustainable and in the second it is unsustainable (Trisoglio 1993). The problem, as was noted in chapter 5, is that many decision makers are not used to thinking in systemic terms (Senge 1990), and still have difficulties in understanding the systemic and interdependent nature of the concept of SD.

In summary, a significant part of the sustainability debate is still at the stage of defining problems, and has not progressed discussing the implications for policy, decision-making or action at any other level. As chapter 3 has demonstrated, the breadth of the SD problem definition is already very great, and it would appear that research and policy debate could be more fruitfully directed towards an examination of potential solutions.

11.3. Small-Scale, Bottom-Up Approaches

The second type of policy conclusion contains problem statements, but also suggestions for action which are centred on local, small-scale interventions. Such authors typically illustrate their proposals through a series of case studies, which are offered as a guide to action in the absence an underlying theoretical framework. For example, Clark (1994) has recommendations that focus on "meeting our most basic human needs for genuinely shared meaning", and her examples include co-operative communities such as Japanese village fishermen and villages in rural India. Similarly, Heinen (1994) argues that "the only meaningful measure of sustainability relevant to human perception is the relatively small, local scale" , which leads him to favour local interventions and actions for sustainability, and to question the possibility of achieving progress on SD at the national or global level. Elkington et al. (1994) provide numerous other examples of bottom-up initiatives, which are typically associated with environmental organisations active at a local level.

The rich diversity of examples of pragmatic local actions provides a valuable resource for learning and sharing best practice, as well as developing community awareness and involvement in programmes for sustainability. The problem is that in the absence of a systematic analysis of problems of sustainability at the national and international levels, it is impossible to build a co-ordinated and comprehensive policy for sustainability, and there is no guarantee that the local projects will make an effective contribution at a broader level. In addition, local initiatives may be held back by inappropriate economic or regulatory incentive structures, and some form of top-down intervention could make an important difference to the success of bottom-up approaches. The shortcomings of the small-scale, bottom-up approach are summarised by Marien (1994a), who comments that the "environmental movement is vast, non-hierarchical and fragmented . . . good at tackling specific grassroots issues . . [but] not good at conceiving and implementing a broad, overall strategy".

Although bottom-up and small scale actions and projects can play an important role, they cannot form the basis of a comprehensive strategy for sustainability unless they are part of a wider analysis that includes a systematic analysis and top-down approaches to policy. Other authors, such as Schmidheiny et al. (1992), Carley and Christie (1992), IUCN and IIED (1994), also provide case studies and examples of localised actions, or in the case of business, actions that were initiated voluntarily by companies, but within the context of a wider policy analysis. These more comprehensive strategies are discussed in the following section.

11.4. Comprehensive, Top-Down Approaches

The comprehensive, top-down policy prescriptions form the basis of the mainstream SD policy positions such as WCED (1987), Schmidheiny et al. (1992), CEC (1992) and UN (1992). Their principal recommendations include new integrated, comprehensive and cost-effective regulations together with the simplification and rationalisation of old regulations; new economic incentives and instruments such as tradable permits, charges and ecological tax reform (Weizsäcker and Jesinghaus 1992, de Andraca and McCready 1994); education and training; investment programmes and subsidies to promote research, development and implementation of new, more environmentally sound technologies; and new indicators of progress, environmental reporting (VNO 1991, Owen 1992, CEFIC 1993, WICE 1994a), and assessment and accounting tools to enable more rational decision making (Gray 1990, DTTI et al. 1993). Speth (1989) sums up a common perception when he argues that it would be counterproductive to reduce economic growth and there is little prospect of reducing population, so "the only factor that can move in the 'right' direction is technological change, broadly conceived to include both changes within economic sectors and shifts among them". The thrust of policy making is therefore directed towards promoting and guiding such technological change and its application to key sectors such as industry, agriculture, transport and tourism. Ekins (1993) points out, however, that the type of changes required to reconcile economic growth and the environment through technological innovation could nevertheless generate unacceptable social problems which would make the overall policy mix unsustainable. The concern for social issues, including both distributional effects and issues such as unemployment, is emerging as an important new dimension of the SD debate, which may pose considerable difficulties for solutions based purely on technocratic and technological policies (Trisoglio 1993, CEC 1994, NPCA 1995).

The economic component of the mainstream recommendations is especially prominent (Cairncross 1992). Young (1992) presents the SD objective in terms of the '3E's of equity, economic efficiency and environmental integrity, and proposes that these might be attained by using economic instruments to operationalise the polluter pays principle, the user pays principle and the precautionary principle. Goodland et al. (1993) call for sound economics, and greater use of environmental assessment and accounting, although they conclude that "work is urgently needed on pragmatic means to get there", while Daly (1992) argues that tradable permits can also contribute to his policy objective of reducing the scale of the economy. The use of ecological tax reform and other economic instruments to internalise environmental costs has become a near-ubiquitous policy prescription within the mainstream debate, and the environmental economics literature has burgeoned in response to this perceived policy need (Pearce et al. 1989, 1993, Costanza 1991). Environmental information and indicators are also seen as important economic instruments (CEC 1992), since tools such as eco-labels and corporate environmental reports can influence economic decisions, and the need for broader measures of quality of life and standard of living is also seen as having an important signalling function (Goodland et al. 1991, Henderson 1994).

Other policy analysts advocate even more comprehensive uses of economic instruments. For example, Pezzey (1992) argues that there are "psychological externalities" created by the ease with which people can compare their wealth and lifestyle with one another, which encourages them in turn to consume more. He proposes that these externalities should be internalised, for example through taxes on advertising to discourage the formation of materialist values, and taxes on telecommunications to discourage excessive transience and dispersion.

It is perhaps not surprising that Pezzey's proposals are politically unimplementable, but ERM (1994a) argues that problems of implementation are more widespread, since even for mainstream proposals related to central issues of sustainability such as climate change or transport policy, "official strategies are perceived as too costly or irrelevant". The problems of implementing SD policies may be related to more general questions about the changing roles of government and business in the 21st century. Angell (1995) concludes that the policy-making power of governments everywhere is in steady decline with the advance of the information age and the accompanying liberation of international commerce and financial markets, a theme that is supported by Reich (1991), Wriston (1992) and Drucker (1993). Ekins (1993) similarly questions the relevance of economists' assumptions of free trade and perfect competition in a global economy that is dominated by the activities of a few hundred trans-national corporations, and he argues that the contours of the trade and environment debate would look different if more realistic models of the economy were used. If these authors are correct in their assessment of the impacts of deregulation, privatisation and globalisation, then private companies will increasingly become responsible for the economic transactions in society, and hence for the process of redistributing wealth, which means that the role of business will become central in determining the extent of progress towards sustainability.

In the light of its potential importance, this issue is worth discussing further. According to WCED (1987) and UN (1992), sustainable development requires a distributional modification between groups in society, generations and peoples and regions of the planet. The traditional approach to redistribution has been through the system of taxation and benefits managed by governments, a role that in a liberalised information economy will increasingly fall to private firms. Business leaders have traditionally seen their mandate in terms of maximising the financial performance of their enterprise, and the increasingly demanding investment community is unlikely to forgive managers who do not deliver the best possible return on investment (Drucker 1989). However, this tends to mean that in situations when companies must trade off individual benefits against societal benefits, they are under great pressure to side with their company and against society (Demb and Neubauer 1992). Sustainable development is likely to produce great tensions between industry and society, as many of the key issues for sustainability, such as environmental quality and societal equity are of little interest to the investment community, but of central interest to society (UBS Phillips & Drew 1989, Rada and Trisoglio 1992). The key challenge of sustainable development for the firm may not be managerial or technical, but rather how the necessary process of redistribution is governed (Trisoglio 1993).

This issue of governance has important implications for managers, especially senior managers, who could be pulled into doing things about which they know very little. The management mindset has traditionally been built around a uni-dimensional measure of success, the 'bottom line'. Venturing into non-commercial areas requires an overhaul of the management paradigm, and a reassessment of what counts as information in the decision-making process. As executives become sucked in to this process, they will become involved in social phenomena for which nobody elected them. In the West, nations have tried to rid themselves of the corporatism that was previously exercised by the clergy and the army, but once business leaders become social managers, we could see the emergence of large tensions in democratic societies (Aykaç 1992).

This change would also exacerbate questions of international equity and accountability. If most of the skills and financial power to implement change are in a few hands, the developing countries could face a bleak outlook. We could see the rise of a form of neo-imperialism, where the logic of the powerful could be imposed on those without means or technical know-how. If even part of this scenario comes to pass, then it would seem that the real challenge of sustainable development is not technical, but socio-political. Judging by the absence of these issues from mainstream policy discussions, it would appear that SD policy analysts have not begun to think about this central challenge (Trisoglio 1993). Further exploration of this point is unfortunately beyond the scope of this thesis, but the preceding discussion confirms that discussions of SD policy cannot be restricted to environmental issues, but must be set in the context of wider social, economic and business trends.

The shortcomings of the comprehensive/rational approach to policy have already been discussed in chapter 4, and subsequent chapters have illustrated how complexity and plurality necessitate alternative approaches. In addition, the unsuccessful history of the EU's proposed carbon/energy tax, and the slow progress in implementing the EU's Fifth Environmental Action Programme (CEC 1996) and the UN's Agenda 21, all show that there are significant political obstacles facing SD policies, many of which arise from business concerns over economic costs and competitiveness and, more recently, social concerns about growing unemployment (Erdman et al. 1992). The mainstream policy community's technocratic focus on cost internalisation and technological responses risks overlooking the wider questions of decision making in the emerging information economy, which are likely to redefine some basic elements of the policy process. Some alternative perspectives are outlined below.

11.5. Learning and Flexibility

In the light of the difficulties outlined above, and the economic and political challenges presented by the changing roles of industry and government, it has become apparent that narrow scientific and economic calculus will not indicate which policies are socially and politically implementable, nor which policies will contribute to adaptiveness, resilience and learning in a complex and uncertain world. There is a growing realisation that policy making will increasingly have to incorporate insights from social science and management theory to design effective, implementable and adaptive policies. These types of conclusion form the fourth category of conclusions on SD policy, as discussed below.

- *Political Will and Vision*: The slow progress of SD policy following the great expectations generated prior to the UNCED conference at Rio in 1992 may be attributed to a large degree to an absence of political will (Weizsäcker and Jesinghaus 1992, ERM 1994a). An eloquent statement of the problem is provided by Enzensberger (1990), who compares the challenge of sustainability with that of the political restructuring of Eastern Europe that accompanied the end of communism:

> "...The Western democracies are also facing an unprecedented dissolution ... the most difficult retreat of all will be in the war against the biosphere which we have been waging since the industrial revolution ... An energy or transport policy worthy of the name will only come about through a strategic retreat. Certain large industries - ultimately no less threatening than one-party rule - will have to be broken up ... But instead our political leadership senses victory, indulging in ridiculous posturing and self-satisfied lies. It gloats and it stonewalls, thinking it can master the future by sitting it out. It hasn't the slightest idea about the moral imperative of sacrifice. It knows nothing of the politics of retreat. It has a lot to learn"

Although few analysts suggest how to put in place the preconditions to generate political will, Viederman (1993) argues that we require "a vision of a sustainable society ... a common dream, a grounded vision, of where we need to go". He notes that although the scientific and economic analysis of current trends is important, "the challenge is to develop a sense of where we want to be". The challenge is to develop new tools to generate and communicate visions, as well as helping decision makers take account of them in developing strategies and policies, and scenario approaches are cited as playing a valuable role in this respect (Brooks 1986, Mannermaa 1986).

- *Policy Process and Empowerment*: In addition to the need for political will, there is also a need for an inclusive and empowering policy process (Carley and Christie 1992, Robins and Trisoglio 1992). As IUCN and IIED (1994) point out, the economic and environmental trade offs and questions of redistribution are essentially political and people-centred, so they cannot be decided using the rational calculus of science and economics, but must instead be negotiated politically. Redclift (1994) argues that much of the SD debate hinges on contested resources and definitions, which have roots in the "different epistemological systems" held by different groups in society. In particular, he argues that a fair policy process can only emerge once disempowered social groups are empowered, although he does not propose mechanisms for this.

  Empowerment and legitimacy also arise at the level of science for public policy, which currently plays a dominant role in the SD debate. Jasanoff and Wynne (1995) argue that "uncertainty, like knowledge, is revealed as a deeply cultural production", which reflects such social imperatives as "the need to maintain particular models of agency, to safeguard valued social identities and relationships, and to assert moral sensibilities about the appropriate limits of controlling both human beings and nature". They voice concerns about the dominance of modelling and 'scientific' approaches to policy, notably in the area of climate change, where "the scientific study of climate change threatens to generate expectations that cannot be met and promises that begin to strike many as illusory". They argue that the legitimacy of the international science process as an input to policy is likely to come under question, and may provoke a political backlash against risk-based environmental policy, a concern that is shared by Boehmer-Christiansen (1994).

- *Plurality and Partnership*: An important component of improving the policy process is increasing the plurality of problem definitions and solutions that are considered. As Rayner (1994) points out, since different parties typically have different priorities and objectives, their understandings of 'winning' are different. Including a wider range of dimensions in SD policy development thus provides more opportunities to discover 'win-win' solutions. Rayner argues that we should therefore move away from a technocratic policy of seeking the best objective solution towards a political one that concentrates on fairness. In particular, he argues that policy makers require better tools to do this, and he proposes cultural theory as a valuable way to include a requisite minimum of plurality. The call for more co-operative partnerships is also made by Markley (1994), as well as the mainstream business and government perspectives of Schmidheiny et al. (1992), CEC (1992) and WICE (1994b), who suggest that increased co-operation during the policy process and partnership in implementing solutions can generate more effective and lasting results.

The results-orientation is shared by Richardson (1985), who argues that an ideal policy process "recognises different points of view as contributions and makes it clear that no one point of view is right", and that the participants in the process should become "more committed to producing results than to being right". In this respect at least, the acceptance of irreducible plurality in the SD debate should enable business, government and environmentalists to move beyond an argument about whose perspective is correct, and towards a partnership-oriented focus on producing results. Boehmer-Christiansen (1994) analyses the climate debate to demonstrate that since the central implementation issues are managerial and socio-economic, governments need to seek policy input from a "wider knowledge base" than just scientists and modellers, and they require new tools and approaches to assist in this process. Mannermaa (1986) argues that the tools of futures research can provide important benefits in improving the quality of decision making and public discussion, particularly the use of scenarios in an "emancipatory" mode, that is one which increases alternatives, "making 'impossible' into possible".

Despite the overall optimism about the potential of partnerships and plurality, MacKellar (1995) adds a cautionary note. Comparing the population debate with the climate change debate, he argues that while the UN Population Conference in Cairo achieved some kind of closure and consensus, "problems such as global warming . . . reflect . . . global scale and distributional issues on which there is no substantial common ground between the three positions [identified by cultural theory]; not to mention the fact that they reflect fundamentally opposed views of nature, welfare criteria and interpretations of sustainability". In conclusion, greater partnership and plurality is seen to be desirable but no means sufficient.

- *Flexibility and Resilience*: Dovers and Handmer (1993) argue that the ability to live with paradox and contradiction is an important strength, "enabling us to make quite rapid shifts and changes in priorities as global ecological constraints are realised and redefined", thus building the flexibility and resilience that is vital for sustainability (Clark 1986, Clark et al. 1995). Developing this idea, Bossel (1987) suggests potential indicators of resilience and viability, while Jasanoff (1993) argues that neither individual nor state action is ideal as a means to flexibility. Instead, it may be obtained through "loosely networked substate institutions", since "competing patterns of resource use that have not been cast into technological or organisational straightjackets can be more easily accommodated through flexible management systems and economic and other incentives". Jasanoff's illustrations of this principle in forest management and hydroelectric power in India demonstrate the concept of technological and institutional flexibility, which is also emphasised by Schwarz and Thompson (1990) and Collingridge (1980). The ideas of flexibility and resilience cannot easily be encompassed in the optimising approach of the comprehensive/rational framework, but examples of SD policies based upon them are still scarce (Holling 1994).

- *Learning*: Just as resilience is one desirable institutional characteristic for survival in a complex world, another is learning. The rapid growth of knowledge and its impacts on social and technological change are highlighted by Macrae (1994), who concludes that "the age of constant innovation and regeneration has just begun". Brooks (1992) emphasises the importance of creating and diffusing knowledge in the process of social learning, as a precondition to promoting changes in production and consumption patterns. He calls for expenditure on consumption to be diverted to research, development and human resource development to stimulate social learning, and also recognises that the cognitive complexity of SD and its multidisciplinarity presents new challenges to decision makers, who therefore need new tools to assist them. Slocombe (1993) calls for a SD process focusing on learning, which should be participatory, adaptive, based on multiple theories and future oriented, although he does not translate these objectives into operational design principles.

Awareness of the importance of learning is especially prominent among business. The BCSD (Schmidheiny et al. 1992) argues that "companies must become learning organisations" if they are to prosper in the transition towards sustainability, and presents case studies of companies using new approaches both to accelerate learning both internally, as in the environmental auditing process at Norsk Hydro, and between companies, as in the chemical industry's Responsible Care initiative. Ehrenfeld (1994) proposes a model of organisational learning and culture change in which changes in institutional demands such government policies, trade association codes of practice, consumer behaviour and employee concerns stimulate new practices to grow out of the current culture, although here as with other authors in the environmental debate, the design of institutions so as improve their learning ability remains largely unresolved.

- *Decision Making Tools*: In addition to the need for new institutional designs and policy processes, SD requires new decision making tools that can cope with complexity, interdisciplinarity, plurality and indeterminacy. Schmidheiny et al. (1992) and Gladwin et al. (1995) report on progress in developing such tools in the business community, including life-cycle assessment (Ryding 1992), design for the environment (WICE 1994c), full cost accounting and new forms of auditing and management systems (Steen and Ryding 1992, Beaumont et al. 1993). Yet these tools tend to be based on single metrics, and business discussions of sustainability generally fail to appreciate its plural nature, which is lost in uni-dimensional approaches such as full cost accounting. In contrast, Clark et al. (1995) explore the potential contribution to sustainability of new tools from complex systems research, especially new forms of modelling based on spatial dynamics, evolutionary processes and genetic algorithms, which are able to include plural perspectives and evolutionary change.

Despite the promise of complex systems approaches, however, other authors have reservations. Shackley and Wynne (1995) argue that complexity tools need to be built in such a way that does not reinforce the current model of prediction and control, which could be achieved by "building in to the intellectual content and design of the . . . tools themselves the intimation of their own human construction and indeterminacy". Adams (1995) questions whether management tools are even possible in a complex world, since they can only ever provide partial descriptions of a co-evolutionary and unpredictable world. This objection goes to the heart of the comprehensive/rational approach, and highlights the need for new ways of making decisions. As chapter 5 demonstrated, however, the evolutionary processes in nature do not depend upon science and economics or supposedly rational or optimal decisions, but on partial models that are locally valid and continually evolving. The lessons for decision making are that tools to generate supposedly optimal policies in the comprehensive/rational mode are certainly deficient, and that while complex systems approaches can never produce the 'right' answer, they can at least shed new light on how to improve flexibility and resilience, and thus aid the design of policies and institutions for sustainability.

11.6. Conclusions

In summary, there are several streams of thought regarding policy making for SD. A small, but vocal, minority is still concerned with expounding problem statements of greater or lesser severity and urgency, although their concern stops short of suggesting changes to policies and institutions. Another group is actively involved in small-scale activities and practical interventions to improve environmental and economic conditions at a local level, although here too there are no policy recommendations. Within the policy debate proper, the mainstream position is that sustainability requires new regulations, incentives and technologies, together with market-friendly institutions to manage the transition. There are many differences on the appropriate policies, but the comprehensive/rational policy model is largely accepted, and there is little questioning of the role of science and economics in developing optimal policies and institutional structures. There are, however, two underlying contradictions which have not been addressed by the mainstream and which serve to undermine its policy consensus:

- *Plurality*: The mainstream position accepts that different individuals and groups in society have different perspectives on sustainability, and it therefore accepts the need for participatory processes, partnerships, and other plural approaches. Despite this awareness, however, most tools used to support SD decision making are still based on single-metric approaches such as cost-benefit analysis that require all the richness and diversity of insight and understanding in plural perspectives to be reduced to a single dimension, thus discarding much valuable information that could be used to develop better decisions.

- *Complexity*: The mainstream position accepts the need for flexibility and resilience, as it is now accepted that the SD debate involves risk and unpredictability, and that traditional command and control regulations can be inflexible and costly, as can ill-considered institutional and technological designs. Yet despite the awareness of the complexity of the debate, and growing experience of indeterminacy and surprise, there remains a strong conviction that the application of science and economics will eventually establish clarity and define optimal policies. As a result, there is inadequate exploration of the types of resilient and flexible policies that are required for a complex world.

It is only the fourth group, which is still a tiny minority, that sees either or both of these contradictions, and which is becoming aware that a new approach to policy is necessary. This distinction between the comprehensive/rational approach of the mainstream and the complex/adaptive approach of the insightful minority has already been pointed out in chapter 4, but we are now able to understand its implications more clearly in the light of subsequent discussions of complexity, cultural theory and resilience. These theoretical frameworks and the insights derived from their application to the SD debate have demonstrated that in the light of their contradictions, the dominant perspectives on plurality and complexity do not stand up to critical analysis. The growing political unacceptability of tools such as cost-benefit analysis, and the growing concern that science cannot provide unambiguous policy guidance, provides further evidence that the contradictions have not been resolved.

The perspectives on vision-building, empowerment, plurality, resilience and learning outlined above provide a basis for a new policy approach, although there are few recommendations on how these might be translated into policies or institutions. An exception is the use of scenario techniques, which are seen to be beneficial in exploring alternative visions of the future, in legitimating multiple perspectives, and in developing more resilient strategies. Their use is explored further in chapters 13 and 14. More generally, however, the leading edge of the SD debate has arrived at a recognition of the importance of plurality, adaptiveness and learning, but it has not yet developed theoretical models or practical advice on how institutions might be managed so as to achieve these characteristics. For such insights it is necessary to turn instead to insights on organisational learning within management theory, which is the subject of chapter 12.

Chapter 12: Managing in a Complex World

12.1. Introduction

Previous chapters have identified the importance of resilient and flexible strategies and institutions as a basis for sustainability, but they have also found a shortfall of theoretical and practical guidance within the SD literature on attaining resilience. This chapter therefore explores the potential role of management theory in providing new approaches to organisational resilience and learning, and also examines the extent to which more traditional approaches to management are able to respond to the strategic and organisational challenges of a complex world.

Chapter 5 demonstrated that science has given us two world views: the Newtonian world that is machine like, controllable and at equilibrium; and the complex world that is creative, evolving, ever-changing and unpredictable. In chapters 4 and 9, the same division was identified between the comprehensive/rational and complex/adaptive policy models for sustainability.

Management science has not drawn heavily on complexity research, yet this same split between two world views is reflected in today's two leading approaches to management theory and practice (table 12.1).

Science	**World-View**	**Objectives**	**Management Theory**	**Focus**
Newtonian	Machine like, Controllable, Equilibrium	Optimisation, Efficiency, Control	Re-engineering	Optimisation
Complexity	Creative, Evolving, Unpredictable	Learning, Resilience & Survival, Adaptiveness	Organisational Learning	Creativity, Resilience

Table 12.1. Two Approaches to Management Theory

The following sections examine re-engineering and organisational learning and their relationship to complexity, and find a strong relationship between these management theories and their corresponding world views. The findings of complexity theory are then used to review management theory's analyses and recommendations for organisational learning, to suggest improvements and also implications for management and policy making for sustainability.

12.2. Managing For Optimisation: Re-Engineering

As noted in chapter 5, the 18th Century was the age of the machine. The laws of Newtonian science saw the world as a giant celestial machine, a giant "clockwork" mechanism created by God and running according to immutable laws. The application of the classical science had given rise to the technologies and machines that were the hallmark of the Industrial Revolution, and the birth of management theory created models of organisation based on the machine. The thinking of the machine age has continued to play a leading role in business to this day.

Factory owners in the 18th Century and their engineers realised that the efficient operation of their new machines ultimately required major changes in the design and control of work. They devised new ways to fit their workforce to the rhythms of the machine, and pioneered the division of labour which was praised by Adam Smith in *The Wealth of Nations* (Smith 1776). Meanwhile, Frederick the Great of Prussia was creating another prototype of the mechanistic organisation in his quest to shape his army into a reliable and efficient instrument. He introduced ranks, uniforms, standardised operating procedures and equipment, the creation of a command language and systematic training. To ensure that his military machine operated on command, Frederick fostered the principle that men must be taught to fear their officers more than the enemy. And, for wise command, he developed the distinction between advisory and command functions, freeing advisers (staff) from the line of command to plan activities

Many of these practices were adapted by entrepreneurs in the 19th century, as they struggled to find organisational forms suited to machine technology, and the ideas formed the basis for classical management theory and "scientific management". Classical management theorists, such as Fayol, Mooney and Urwick, believed that management is a process of planning, organisation, command, co-ordination and control. Drawing on military and engineering principles, they set the basis for modern management techniques such as management by objectives (MBO); planning, programming and budgeting systems (PPBS); and other methods stressing rational planning (Mooney and Reilly 1931, Gulick and Urwick 1937, Fayol 1949). The machine metaphor was also at the centre of Frederick Taylor's principles of scientific management, which provided the cornerstone of work design until after the Second World War, and which are still present in many companies right up to the present day. Taylor (1911) advocated five simple principles, aimed to optimise the performance of work, which are summarised in table 12.2.

	Principle	**Managers should:**
1	Control & Responsibility	Take all responsibility for design, planning and organisation of work. The role of the workers should be limited to implementation.
2	Optimisation	Use scientific methods to determine the most efficient way of doing work, design tasks and roles accordingly, and specify in precise detail how work should be done.
3	Selection	Select the best person to perform the job thus designed.
4	Training	Train the worker to do the job efficiently.
5	Monitoring	Monitor performance to ensure procedures are followed and appropriate results achieved.

Table 12.2. Taylor's Principles of Scientific Management

There is an evident connection between Taylor's principles and the image of the organisation as a machine, with the manager as its operator and mechanic. Although Taylor's work is most often associated with the assembly lines of Henry Ford, mechanistic approaches to organisation have remained very popular, partly because of their efficiency in carrying out certain tasks, but also because of their ability to reinforce and sustain particular patterns of power and control. The influence of "classical" and "scientific" theories of management can still be felt today, not least in the currently fashionable business process of re-engineering (Hammer and Champy 1995). The word "re-engineering" itself suggests a machine-based vision, and one can clearly sense Taylor's principles of top-down control, design and optimisation resonating behind the new approach as outlined by Hammer, a co-founder of the re-engineering movement (Hammer and Stanton 1994):

> "Re-engineering entails sweeping change to an organisation. When a company's operating procedures are rethought from the ground up, virtually every other aspect of the company is called into question: the content of people's jobs, the structure of the organisation, the mechanisms for reward and compensation . . . these must all be consistent with the ways in which the organisation's work is being performed . . . Only senior executives have the authority to institute such changes: to reassign personnel, to recalibrate measurement and reward systems, to institute new organisational structures, and to compel the participation of those who might prefer to give the whole thing a miss".

Hammer's words show that re-engineering is the latest incarnation of the management tradition based on the machine. Taylor's five principles are all present: top-down control and authority; the redesign and optimisation of all aspects of work; choosing and assigning personnel; training; and systems for monitoring and enforcement.

The principle underlying this tradition is that *efficiency* is the basis of success in a competitive market, as any inefficiencies in terms of costs, delays or quality will lead dissatisfied customers to take their custom elsewhere. The problem is that machine management will only flourish in a machine-like world that is linear, predictable and at equilibrium. An optimised organisation may function very efficiently in today's circumstances, but tomorrow's circumstances will be different, and there is no reason to suppose that what is optimal today will also be optimal tomorrow. Since increasing complexity and evolution ensures that what is an efficient or high-quality process today will soon be overtaken by new technological or managerial innovations, businesses need to improve efficiency on a continuous basis.

Companies have responded to this challenge through continuous improvement programmes and total quality management to improve performance against internal criteria (Womack et al. 1990), and also through benchmarking, in which a company seeks to assess its own performance against the best-of-class among industry leaders (Liebfried and McNair 1994). All this is consistent with re-engineering, but it suffers from the same criticism that is directed at re-engineering, namely that "its focus is on corporate mechanics, not on vision or strategy" (Lloyd 1994). There is a striking correspondence between the focus on efficiency in management and in the comprehensive/rational approach to policy making, while the reality of continuous improvement has a similar correspondence to evolutionary processes discussed in chapter 5.

Mechanistic forms of organisation may work well where precision, safety and clear accountability are at a premium, for example in surgical wards and aircraft maintenance departments. But they have great difficulty adapting to changing circumstances because they are designed to achieve predetermined goals; they are not designed for innovation (Burns and Stalker 1961). In a changing world, flexibility and capacities for creative action become more important than narrow efficiency. As Kanter (1983) has shown, mechanistic organisations lead to the kind of 'segmentalism' that plagues so many companies, where divisions between levels, functions, roles and people create barriers and stumbling blocks that prevent innovation and change. Mechanistic organisations are not only unable to innovate rapidly, but they also foster a bureaucratic 'instrumental rationality', where people see themselves in a fixed relationship to their job, rather than a flexible and entrepreneurial 'substantive rationality' that encourages employees to determine what is appropriate and act accordingly. This in turn reduces employee creativity and motivation, further reducing organisational performance.

Kippenberger (1994) argues that re-engineering and much of the "buzz" in modern management is at risk of failure "if the prevalent mind-sets inherited from the 19th century are not put up for questioning", a criticism of Newtonian thinking that is also voiced by Lorenz (1994), and which corresponds to the criticism of the comprehensive/rational policy model outlined in chapter 4. Management scientists have been aware of these problems for many decades and, the recent interest in re-engineering notwithstanding, much of the work in organisation theory since the 1960s has been studying alternative approaches to management and organisation, laying the foundations what is today known as organisational learning (Bateson 1972, Argyris and Schön 1974, 1978, Argyris 1982).

12.3. Managing For Creativity: Organisational Learning

The previous section has demonstrated that there are strong intellectual links between Newtonian science and the mechanical models of organisation and management theory, and this section finds a similar connection between more recent developments in science and other approaches to management theory. At the beginning of the chapter, a contrast was drawn between management models that focus on efficiency and optimisation, and those that focus on creativity and learning. This second approach is the hallmark of organisational learning, which was popularised by Senge (1990) in the book *The Fifth Discipline.* Senge's starting point is certainly sympathetic with a complex systems based view of the world. He argues that as the world becomes more interconnected and business becomes more complex and dynamic, "It's just not possible any longer to 'figure it out' from the top", so instead we need to create *learning organisations* that "discover how to tap people's commitment and capacity to learn at all levels" (Senge 1990:4). The organisational learning approach can be characterised by three assumptions about reality and how organisations should deal with it:

- *Adapting to Change:* The business world is complex and changing. Successful organisations must be able to adapt to this changing environment.

- *Organisational Learning:* In order to change effectively, organisations need to be able to learn, both to understand the changing world, and effect an appropriate reorganisation of their goals, structure and behaviour as a result.

- *Cultural Change:* Organisational learning implies cultural change, such as creating shared vision and values, and re-evaluating managerial mental models, to ensure they are both appropriate to changing external realities and supportive of a creative and effective atmosphere within the company.

Morgan (1986) demonstrates that these three aspects of organisational learning stem from different metaphors of organisation, and they draw on different intellectual roots (table 12.3).

Management theory	Focus	Metaphor	Intellectual roots
Re-engineering	Efficiency & optimisation	Machine	Newtonian Science
Organisational Learning	Adapting to change	Organism	Biology, Ecology, Open Systems Theory
	Organisational learning	Brain	Cybernetics, Cognitive Science, Psychology
	Cultural change	Culture	Social science, Anthropology

Table 12.3. Management theories, Metaphors and Intellectual Roots

The link between Newtonian science and the machine metaphor explored above is straightforward. Since complexity theory and organisational learning are both multidimensional, the links between them are less immediately obvious, but table 12.3. demonstrates that each of the key assumptions of organisational learning draws on a metaphor and an intellectual tradition that is now being developed by complexity theory. As chapter 5 discussed, natural systems, social systems and intelligence are the three principal subjects of study in complex systems theory. This confirms the connection between complexity and organisational learning that was proposed earlier. The realities of a complex business world and the managerial failings inherent in human nature and cognition constitute organisational learning's 'problem statement', which is outlined in table 12.4.

These characteristics of people and the business world are drawn purely from writers in management, finance and economics, none of whom is a complex systems researcher. Yet their findings strongly support those of complex systems theorists in demonstrating both that the business world is a complex place, and that managers are fallible and non-rational when they make decisions in the face of complexity. Among the theorists cited in table 12.4 the Nobel prize-winning economist Herbert Simon, is especially direct: "Complexity is deep in the nature of things . . . A theory of rationality that does not give an account of problem solving in the face of complexity is sadly incomplete. It is worse than incomplete; it can be seriously misleading by providing 'solutions' to economic questions that are without operational significance" (Simon 1978:12). To meet these challenges, organisational learning theorists provide practical tools to overcome existing

	Property	Description	Reference
System	Endogenous change / Structure influences behaviour	Systems are continually changing, evolving and causing crises even without external forces or individual actions. Different people in same system produce similar results.	Senge (1990:19, 40-47).
	Structure is in relationships	Structure is in "the basic interrelationships that control behaviour", not imposed through external constraints	Senge (1990:40).
	Non-linearity / Leverage	Small, well-focused actions can produce significant change. Intuitively obvious solutions don't always work.	Senge (1990:62-65).
	Turbulence	Rapid change gives rise to turbulence.	de Geus (1988:70).
	Distant Effects	Cause and effect are separated in time and space.	de Geus (1988:74).
	Reflexivity	Action, based on cognition of change, causes further systemic change, hence re-cognition and further action.	Soros (1994:27-45).
	Disequilibrium	Economies are neither at, nor approaching, equilibrium.	Soros (1994:45).
	Unpredictability	Systems are too complex to be predictable. Forecasting is often highly inaccurate, especially at important times.	Wack (1985a:75).
	Holism / Integrity	"Dividing an elephant in half does not produce two small elephants".	Senge (1990:66).
	Innate Complexity	Real-world systems and decisions are vastly too complex for resolution by computational or "rational" means.	Simon (1978:12).
Individual	Fixation on Events	People react to events rather than underlying causes and systemic changes, especially slow changing ones.	Senge (1990:21, 52, 73).
	Linear Thinking	People see linear cause-effect changes, not relationships	Senge (1990:73).
	False Dilemmas	Dilemmas result from overly narrow problem description. Re-framing may allow "both/and", e.g. 'Quality is Free'.	Senge (1990:65).
	Learning Horizon	Learning from experience is impossible when the consequences of our actions are distant in time, space or the system .	Senge (1990:23, 63).
	Lack self-awareness	We often fail to see how we contribute to our own problems. Truly objective self-understanding is impossible in any case.	Senge (1990:20), Soros (1994:11).
	'Non-rational'	We respond to the risk of winning and losing in ways that are not in our best interests mathematically.	Tversky and Kahneman (1982)
	Skilled incompetence	Failure to learn, admit error or uncertainty; skilled communicators may be good at covering up problems.	Argyris (1986)
	Bounded rationality	Decision-making is based on partial models & information, we cannot cope when cognitive complexity is high.	Simon (1978:8-10).

Table 12.4. Problems facing Decision Making and Organisational Learning

limitations and 'learning disabilities', such as Senge's five 'disciplines' for thinking, problem-solving and learning in a complex world, although without a coherent theory (table 12.5).

Challenge	Discipline	Objective
Thinking successfully in a complex world	Systems thinking	Fosters shift of mind, to seeing ourselves as connected to world, understanding relationships between parts and whole, and between cause and effect in space and time, to allow meaningful decision-making and action.
	Mental models	Understanding our assumptions and pictures of the world, focusing on openness needed to unearth shortcomings in our present ways of seeing, balancing inquiry and advocacy, and creating new mental models through planning as learning.
	Shared vision	Creating shared visions of future and principles to foster genuine commitment to the longer term, making people want to excel and learn.
Learning and problem solving	Team learning	Thinking and learning together, to foster co-ordinated action, look for the large picture that lies beyond individual perspectives, get the best out of all team members, and create a whole greater than the sum of the parts.
	Personal mastery	Fosters personal motivation and commitment continually to learn how our actions affect the world, deepening vision and focusing energy.

Table 12.5. Senge's Five Disciplines for Organisational Learning

The 'problem statement' about doing business in a complex world, and the 'solutions' proposed by organisational learning are broadly consistent with those of complexity theory. The world is complex and unpredictable, and optimisation and narrow concepts of efficiency must give way to learning, adaptability and change, just as in SD policy. At this level of generality, complex systems theory has little to add. Probing deeper reveals more scope for constructive intervention, not least when it comes to the systems theory that Senge places at the heart of organisational learning. Senge argues that while all the learning disciplines should be applied together, systems thinking is the most important, "the fifth discipline" that integrates the others and fuses them "into a coherent body of theory and practice". As is pointed out in section 12.5, the systems dynamics ideas that Senge chooses as the basis for his tools and approaches are seen to be distinctly limited in the light of complexity research. This is one of several areas which could form a research agenda for updating organisational learning in the light of complexity research (table 12.6).

Organisational Learning Approach	Evaluation in the Light of Complexity Research
The world is complex, changing and unpredictable. The appropriate managerial responses are adaptiveness to change, organisational learning and cultural change.	Yes - complex systems theory provides insights into successful structures, behaviours and solutions for managers to combine organisational learning with the actions needed for short-term survival in increasingly competitive markets.
Organisational learning can be achieved through five disciplines: systems thinking, shared vision, mental models, team learning and personal mastery. (Senge 1990:5-13).	Fine as far as it goes, although it is very general. In addition, the disciplines are all process-related, there is no guidance on structures for organisational learning. Complex systems theory can make a valuable contribution here.
The fifth, and most important, discipline is systems thinking. Systems dynamics provides an appropriate tools for systems thinking in the business world. (Senge 1990:12-13; Senge et. al. 1994:89).	Yes - for the systems thinking. No - for the systems dynamics, which is a methodology closely related to the non-linear theories and models of the 1970s (see section 12.5). Complex systems theory provides the appropriate theory for the 1990s, and could help to update organisational learning, by feeding in fresh insights and approaches.
Changing mental models is at the heart of improvements in learning and managerial decision making. Scenario tools can be helpful in this respect. (Senge 1990, chapter 10).	Yes - cognitive science and cultural theory supports this approach. In addition, a synthesis of complexity theory and cultural theory can provide valuable insights into the content of mental models and scenarios, which can provide valuable benefits for organisational learning.

Table 12.6. Organisational Learning and Complexity: An Evaluation

12.4. New Tools and Approaches

Organisational learning theorists offer a wide variety of qualitative tools to improve the quality of decision making (Senge et al. 1994). Many of these tools are process-oriented, for example tools to improve teamwork or foster creativity. Others are content-oriented, for example tools to develop shared visions of the future, or to develop managerial mind-sets and mental models that are more flexible. In the light of Senge's contribution to popularising the importance of organisational learning, systems thinking and other new tools to assist managers, it is useful to examine his work in the light of complexity theory. These comments are not intended to reject Senge's approach, but rather to suggest how his initial work can be carried in a direction more consistent with the findings of complexity theory, and how tools for organisational learning can be improved.

According to Senge (1990:73), the process of change leading to organisational learning will only take hold once managers start systems thinking, which involves "a shift of mind - seeing interrelationships rather than linear cause-effect chains, and seeing processes of change rather than snapshots". This much is strongly supported by systems theory, which grew out of the pioneering work of the theoretical biologist Ludwig von Bertalanffy in the 1950s (von Bertalanffy 1950, 1968, Hardin 1985). Senge builds his work on *systems dynamics*, a form of systems theory which was developed for modelling purposes by Forrester at MIT in the 1960s (Forrester 1961), and which achieved fame when it was used as the basis of the 1972 study *The Limits to Growth*. Systems dynamics seeks to reduce the complexity of systems in the real world by classifying the structures in our personal and organisational lives into a number of 'systems archetypes', such as 'tragedy of the commons', 'escalation' or 'shifting the burden' (Senge 1990). This approach of structural classification provides valuable insights into some of the types of behaviour of non-linear systems, but suffers from three important drawbacks:

- *Mechanical Paradigm*: Since they are based on the mechanical paradigm, systems dynamics approaches cannot model complex systems. They suffer from the same problems as all dynamical systems models, as outlined in chapter 5: such models can only function; they cannot evolve, innovate or be creative. Their behaviour and predictions thus rapidly diverge from the behaviour of a complex reality, just as the Limits to Growth models of the 1970s wrongly predicted massive resource depletion by the 1990s. Meadows and Forrester strongly believed that linear and equilibrium-based approaches to modelling, especially in economic policy, were inapplicable to the real world. However, rather than accept the possibility that the world might be too complex to allow predictive modelling, Meadows et al. (1973:136) insisted that "instead of waiting for perfect models, we must work to construct and implement the best models possible today". As explained in chapter 5, it is now clear that predictive modelling in a complex or highly non-linear system is impossible. Modelling of the technological, social and economic change in the modern world cannot be achieved with such simplifications. Senge's apparent hope that systems dynamics can be used to reduce complex reality to manageable order appears to be the 1990s continuation of the systems dynamicists' utopian dream of the 1970s.

- *Over-Simplification*: Systems dynamics speaks of 'archetypes', which are useful shorthand for certain situations. They can help managers appreciate the importance of systems behaviour, but cannot describe the rich diversity of behaviours of a complex system. Managers who apply archetypes to their business situations will inevitably have to throw away important, possibly crucial, aspects of the situation and thus create blind spots for themselves.

- *Dangerous Assumptions*: Senge accepts that "simulations with thousands of variables and complex arrays of details can actually distract us from seeing patterns and major relationships", and recommends that we cut through the complexity by learning to recognise the archetypes, as this "simplifies life" (Senge 1990:72). The problem with archetypes is not just that they are simplistic, but that they encourage managers to think they can *classify* systems and types of behaviour, and thereby understand them. Instead, such classification usually involves falling back on existing assumptions rather than really learning about the complexity of the system and building a richer understanding of the complexity of the real world: "an archetype is nothing more than a mental model made visible" (Goodman and Kemeny 1994). Using archetypes is limiting, since there are many more conceivable mental models than there are archetypes. In order to understand reality more fully, managers need to abandon preconceptions about classification, or as a postmodernist might say, they must "reject all metanarratives" (Lyotard 1984). Furthermore, the concept of 'mental models' risks reification, by assuming that such models are fixed objects, whereas they should instead be seen as complex evolving processes, as discussed in chapter 5.

The results of work on chaos and complexity have demonstrated that it is futile to attempt predictive modelling of complex systems. But there is a difference between prediction and learning. Learning depends on recognising and acting upon slowly-changing regularities in patterns of structure and behaviour in the world. It does not depend upon predicting when or how they will arise, but it assumes certain regularities in behaviour. A chaotic system is so totally unpredictable in its behaviour, and generates so little in the way of regularity and structure, that learning would be completely impossible in a chaotic world. This aspect of chaotic systems appears not to be appreciated by many authors writing on chaos theory, management and economics, who suggest that chaos theory implies that learning is the only response to a chaotic world (Parker and Stacey 1994).

However, the world is not chaotic, but complex. Although prediction may also be difficult in such a world, a complex world does exhibit patterns of structure and behaviour, and learning is therefore possible. Just as the limitations of strategic planning are becoming evident (Mintzberg 1994), so are those of systems based on a top-down, command-and-control, mechanistic model of organisation. Today's priority, which is amply confirmed by the tremendous growth of the personal computer market, is for tools that managers and professionals can use to increase their productivity and effectiveness in their 'knowledge work'. Competitive advantage is steadily shifting to those corporations and nations best able to take advantage of their 'knowledge workers' and 'symbolic analysts', and it is likely that economic success will increasingly come to depend on providing knowledge workers with tools that allow them to be as productive as possible (Reich 1991, Handy 1991, Kennedy 1993, Handy 1994 and Peters 1994).

Senge (1990) reports that once managers accept that reality is complex, and that linear thinking must be replaced by systems thinking, they soon arrive at the questions of how best to manage their mental models and build a shared vision in a complex world, which form the second and third of his five disciplines. Senge (1994:238) argues that "the frontier of this discipline lies with creating innovations in infrastructure where work with mental models can take place. One of the most influential such innovations [is] scenario planning". The potential of scenario techniques is explored in chapter 13.

12.5. Conclusions

This chapter has argued that there are two strands within management theory which map onto the Newtonian and complex views of the world, and which are close parallels of the two policy models discussed in chapter 4. The work on organisational learning provides theoretical insights and practical tools that are applicable to a complex/adaptive policy process, and stresses the importance of managing mental models and building shared visions, both of which have been identified in earlier chapters as priorities for developing more resilient policies for sustainability. Scenario based approaches, which are highlighted as a tool to promote organisational learning and resilience, are discussed further in the following chapter.

Chapter 13: Scenario-Based Tools for Decision Making

13.1. Introduction

Chapters 10 and 11 have argued that a central challenge in sustainable development is developing resilient, adaptive and plurally responsive strategies and decision making tools that can cope with the uncertainty and complexity inherent in SD. Chapters 5 to 7 have shown how such uncertainties arise from environmental, social, technological and economic factors, and how they are central to SD decision making. There is extensive research directed at reducing uncertainty, for example through global modelling of climate systems and integrated assessment modelling, but this work is unlikely to produce conclusive results until at least 2005, if ever (Bella et al. 1994, Boehmer-Christiansen 1994). In the mean time, we require tools to support decision-making, investment planning and environmental policy making under the prevalent conditions of uncertainty and complexity (Meadows et al. 1973, Brewer 1986, Brooks 1986, Clark 1986, Holling 1986, Ravetz 1986, de Young and Kaplan 1988, Allen 1990, Dovers and Handmer 1992, Thompson & Trisoglio 1993, Trisoglio 1994b, Clark et al. 1995).

Scenario planning is such a tool. It has an established track record in strategic decision making in government and industry under conditions of complexity (Wack 1985a, Wack 1985b, Becker 1988, de Geus 1988, Senge 1990), and also has been applied successfully in enabling constructive dialogue and building consensus in multistakeholder groups involved in environmental planning (Brewer 1986, Clark 1986, Mannermaa 1986). Scenario-based planning has demonstrated improved flexibility, adaptability and resilience of strategies, which are key requirements for SD decision making (Becker & van Doorn 1987, Robinson 1990, Schwartz 1991), as has been noted in chapters 10 and 11.

Previous chapters have noted that both policy analysts and management theorists see scenarios as a potentially valuable technique for improving the quality of policies and strategies for sustainability. The wider use of scenarios in SD decision making has, however, been constrained by the absence of a sound theoretical underpinning and methodology (Becker & van Doorn 1987, Becker 1988 , Godet 1990, Senge 1990). This chapter examines the potential of scenarios as a decision making tool, and explores the extent of theoretical and methodological development in scenario planning. In particular, it explores the constraints preventing wider use of scenarios, and what would be required for them to be overcome.

13.2. The Emergence of Scenarios as a Tool for Decision Making

Scenarios were developed following World War II as a method for military planning, when the U.S. Air Force tried to imagine what its opponents might do, and to prepare strategies to meet these possibilities. In the 1960s, Herman Kahn, who had been part of the Air Force work, refined scenarios as a tool for business decision making (Paxson 1963, Jones 1980, Schwartz 1991, NCPB 1992). The next stage of development was carried out by Pierre Wack in the Shell Corporation in the 1970s, when the company was becoming dissatisfied with traditional forecasting (Becker and van Doorn 1987). In describing the business view then emerging on forecasting, Wack (1985a) notes that "In few fields has the concentration of the best techniques and the best brains been as high as that in short-term macroeconomic forecasting for the United States". Yet, for example, in summer 1981 the median one-year forecast of five prominent forecasters predicted 2.1% growth in US GNP for 1982, but instead the economy plunged into deep recession, with a GNP decline of 1.8% (McNees and Ries 1983). Wack (1985a) comments that "This is like forecasting partly cloudy and getting a ten-inch snowstorm instead". Similarly, nobody had predicted the 1973 oil crisis, and when the crisis was at its worst, forecasters predicted a long term shortage of crude oil that did not materialise (Wack 1985a, 1985b, de Geus 1988). Shell realised that many of the conditions affecting its business are largely unpredictable, so the company decided no longer to rely on predictions, except for issues such as population growth and demographic developments for 5-10 years into the future. Instead of forecasting and prediction, Shell now uses scenarios to prepare its corporate strategy (Shell 1991, Shell 1992).

Shell (1992) defines scenarios as follows: "[they] are a set of plausible and challenging stories about what might happen . . . They are not forecasts; that is, they do not predict what will happen by extrapolating from the past, but instead offer . . . very different stories of how the future might look". In its scenarios, Shell aims to reflect a variety of viewpoints, from both within and outside the company, so as to cover a broad range of future possibilities (Schoemaker and van der Heijden 1992). The stories are exercises in applied futurology designed in order to provide a valuable tool for decision makers. Shell reports that scenarios serve three functions in the company: they help preparations for discontinuities and sudden change, for example in economic or market conditions; they create a common culture or shared vision; and they challenge the mental maps held by managers. Senge (1990) and Schwartz (1991) argue that through the insights provided by scenarios, and their application to improving the quality of managerial decision making, Shell moved in the 1970s from being "one of the weaker of the 'Seven Sisters', the seven largest oil companies . . . [to] one of the two largest [after Exxon] and, arguably, the most profitable" (Schwartz 1991). If such results could be attained in the environmental field, scenarios could represent a valuable means to improve decision making for sustainability.

Other companies became aware of Shell's experience, and Linneman and Klein (1983) report that by 1982 over half of the *Fortune* 500 leading industrial companies were using scenarios. Yet Shell's success only came after a decade's work, and has not always been easy to replicate in other companies. Mintzberg (1994) comments that "All things considered, the probabilities of getting all things right do not seem to be high, perhaps explaining . . . [Wack's observation that] scenario planning has been scarcely developed". This chapter considers the role of scenarios, the reasons for their limited development, and whether there are any approaches that might permit their wider use.

13.3. Scenarios: Definitions and History

The term scenario has many meanings, ranging from theatre scripts and loose projections to statistical combinations of uncertainties, and in its broadest sense, scenario thinking is as old as prospective story telling (Schoemaker 1993). As a formal tool for decision making, however, its roots may be traced to the Manhattan project. In 1942, atomic physicists such as Teller and Oppenheimer were unsure whether an atomic bomb might literally ignite the skies (Davis 1968:129), and since the equations were too complex to solve, a series of scenarios based on computer simulations were used to estimate probabilities of the atmosphere catching fire. The subsequent development of scenarios arose from the merging of three trends: the development of computer technology and its application in simulations; the development of game theory (von Neumann and Morgenstern 1947, Poundstone 1993), which provided a rich structure for studying social interaction (Dresher 1961, Shubik 1964); and the post-war military decision-making needs of the US, which emphasised the use of war games and simulated decision making environments in which humans and machines could interact (Brewer and Shubik 1979).

Given this evolution, scenarios have plural meanings. To military 'gamers', it refers to the contextual definition or operating environment within which a man/machine simulation is played out (Brown 1968). Scenario analysts such as Schoemaker (1993) define scenarios as "focused descriptions of fundamentally different futures presented in a coherent script-like or narrative fashion", while in corporate planning they are often used to characterise a 'likely' range within which the future might evolve (Huss 1988). Hadridge et al. (1995) describe scenarios as "a number of internally consistent, plausible, yet significantly different and novel stories of the future". DeWeerd (1967:2) proposes that "The scenario tells what happened and describes the environment in which it happened", and Bell (1964:865) clarifies further by stating that scenarios are the representations of "alternative futures" by which analysts "sketch a paradigm (an explicitly structured set of assumptions, definitions, typologies, conjectures, analyses and questions) and then construct a number of explicitly alternative futures which might come into being under the stated conditions". In summary, scenarios are a set of alternative visions of the future, most often three or four in number, each of which is based on a set of assumptions about the evolution of current trends and the emergence of new phenomena in the economic, social, political, technological and environmental conditions that constitute the organisation's decision-making 'environment'.

A similar degree of plurality may be found in discussions of the purpose of scenarios. Some authors still seek to employ them predictively (Georgoff and Murdick 1986), but most analysts agree that scenarios should be seen as aids to learning rather than tools for forecasting. Schoemaker (1993) argues that "scenario analysis is an important new tool to examine fundamental uncertainties and expand people's thinking". Hadridge et al. (1995) see their function as "[providing] a backdrop to strategic thinking by challenging assumptions and sparking imaginative exploration of options", while Elgin (1994) argues that they provide a useful means of discussing trends and their implications, fostering systematic and interdisciplinary thinking, and integrating knowledge from different groups and perspectives. Thamotheram (1994) proposes four uses for scenarios: challenging mind-sets and creating space for new thinking, creating a readiness for change, encouraging commitment and ownership, and putting the short term within a longer term perspective. Schwartz (1991) holds that "scenarios are vehicles for helping people learn . . . [and they] allow a manager to say 'I am prepared for whatever happens'", while de Geus (1988) notes that in Shell the use of scenarios "started off serious work throughout Shell, not on answering the question 'What will happen?', but rather exploring the question 'What will we do if it happens?'". In summary, scenarios are seen as a tool to assist and promote organisational learning, including challenging mind-sets and assumptions, fostering creativity, improving awareness, and thereby increasing the quality of decision making.

The original military applications of scenarios emphasised a technical approach, for example Kahn et al. (1976) propose that a scenario is a "Hypothetical sequence of events constructed for the purpose of focusing attention on causal processes and decision points". In contrast, Mannermaa (1986) points out that they may also be used in an "hermeneutic" way to foster communication within an organisation or society, or in an "emancipatory" way which seeks to envisage and promote 'preferable' futures. Mannermaa describes the Nordic Alternative Futures project, which has a normative egalitarian focus, and which uses scenario based approaches to sketch a consistent vision of the desired future society; to analyse present societal realities and the 'degrees of freedom' for alternative developments; and to construct social processes to initiate the change process. The normative use of scenarios is described further in section 13.5.

Although scenarios have only been formally developed since World War II, their deeper role in model building and cognition suggests that they have been implicitly involved as a fundamental part of all decision making long before their formal development. For example, Brown (1968:300) argues that scenarios are the fundamental building blocks of all modelling and analysis, since they provide the basis for bounding and structuring models, and provide criteria for evaluation of outputs:

> "It is from our anticipations of environments in which our systems are to operate [i.e. our scenarios]. . . that many of the criteria for evaluating the performance of a given system emerge . . . If we accept the proposition that our analyses can be no better than the criteria we employ, then we must accept the corollary proposition that our analyses can be no better than our scenarios".

As chapter 5 observed, all thought or communication requires tackling the complexity of reality and building reduced descriptions of it in the form of mental models, which are "deeply held internal images of how the world works, images that limit us to familiar ways of thinking and acting" (Senge 1990:174). The term 'mental models' from management theory is seen to be closely related to cultural theory's 'myths of nature' that were discussed in chapter 7, and also the concepts of paradigms and metanarratives that were introduced in chapter 5. By providing the underlying assumptions and frameworks that bound cognition and analysis, these models provide the context for decision making. In order to improve decision making, it is therefore necessary for scenarios to effect change at the level of the underlying mental models (Wack 1985b, Brewer 1986, de Geus 1988). Wack (1985a:74) emphasises that the successful use of scenarios is challenging:

> "They must involve top and middle managers in understanding the changing business environment more intimately . . . Scenarios help managers structure uncertainty, when (1) they are based on a sound analysis of reality, and (2) they change the decision makers' assumptions about how the world works and compel them to reorganise their mental models of reality. This process entails much more than simply designing good scenarios. A willingness to face uncertainty and to understand the forces driving it requires an almost revolutionary transformation in a large organisation. This transformation process is as important as the scenarios themselves".

The point is that unless the scenarios can be connected to decision-making realities, and set in the context of supportive institutional structures that promote strategic change and action on the basis of new insights, then organisational learning will be stifled (Senge 1990, Mintzberg 1994). Since the world is continually evolving and changing, this process of changing mental models cannot be a singular event, but must become part of the overall process of individual and institutional learning (Senge 1990). This raises the more general question of devising structures and processes that can promote such learning or, as de Geus (1988:71) argues, "The critical question becomes, 'Can we accelerate institutional learning?'". De Geus answers the question affirmatively, and concludes that the development of learning tools is a corporate priority, since "the only competitive advantage the company of the future will have is its managers' ability to learn faster than their competitors". The conclusions from the corporate world are of direct interest to the sustainability debate, bearing in mind that learning tools are equally important in attaining the resilience and flexibility required for sustainability, as was explored in previous chapters. The next section introduces the procedure for using the scenario method.

13.4. The Scenario Method

There are several detailed prescriptions for scenario building (De Leon 1975, Wack 1985a, Wack 1985b, Schoemaker 1991, Schwartz 1991, Schoemaker 1993), but the essence is perhaps captured most clearly in the simple four-step process of scenario development described by Kleiner (1994):

(1) *Refining the Sense of Purpose*: Scenarios provoke genuine learning only when they answer genuine concern, so the first step in their development is achieving a degree of consensus about the concerns that they are to help address. In the case of SD decision making, the concern could be the overall question of how to attain global sustainability, or it might also be a more geographically, sectorially or institutionally focused equivalent of the same question.

(2) *Understanding Driving Forces*: Scenarios are based on uncertain driving forces, which might include elements such as technological development and social and economic change. These forces need to be mapped out and included within the scenarios, while the selection of key uncertainties can shed light on the most important ramifications of the decisions under consideration. The selection of possible driving forces is discussed in greater detail below.

(3) *Scenario Plots*: Developing scenarios involves considering plots to describe how the current situation might develop, which Kleiner refers to as "classic stories". These plots provide a coherent logic to the scenario, and are different for each scenario in the set. One of the primary methodological shortcomings with scenario planning is that there is no guidance on how to select the plots, as discussed further in section 13.6.

(4) *Strategy, Rehearsal and Conversation*: Following the development of the scenarios, their implications must be assessed. Typical questions include: What strategies would be effective no matter which of the futures came to pass? What would it feel like to live in such worlds? How flexible and resilient are current strategies and institutional structures in the light of these possible futures?

In considering which driving forces, or variables, should be included within the scenarios, there is a reasonable degree of consensus among scenario practitioners. Schwartz (1991:227) recommends the inclusion of social, economic, political, environmental and technological forces. Svidén (1986:682) proposes management, economic structure, science and technology, cultural transfer and change, individual goals and political structure. Although Marien (1989:563) notes that "I know of no theory of driving forces", his list comprises technology, economic structure, politics and international relations, environment, and information. In summary, the interdisciplinary nature of scenario planning would therefore appear to be well suited to exploring the social, environmental and economic issues of sustainability in an integrated manner.

Brewer (1986) argues that a good scenario should have several characteristics: it should be problem oriented, as determined by its success in focusing attention and opening up unknown possibilities; it should lay out biases for collective scrutiny; it should not unduly violate common sense; and it should be explicit and communicable. Schoemaker (1993) further argues that scenarios must also be consistent, in three dimensions: there must be consistency of trends within the chosen time frame; there must be outcome consistency, so that the scenarios postulate outcomes for the key uncertainties that fit together; and there must be stakeholder consistency, which means that the major actors in each scenario are not placed in positions they dislike and can change. Wack (1985b) concludes that the success of scenarios can be evaluated with two questions. Firstly, what do they leave out?

In five to ten years, "managers must not be able to say that the scenarios did not warn them of important events that subsequently happened". And secondly, do they lead to action? If scenarios do not push managers to do something other than indicated by past experience, "they are nothing more than interesting speculation" (Wack 1985b).

In addition to content issues, the process of building and using scenarios is also important. Schwartz (1991) argues that in a business context, the key elements are support and participation from the highest levels of management; representation of a broad range of functions and divisions on the scenario development team; and using imaginative people with open minds who can work together as a team. In the preparation of the Mont Fleur Scenarios for South Africa, team members were selected on the basis that they should be able to understand the present, identify the predictable elements about the future, identify the main uncertainties, identify plausible possible pathways into the future, and take cognisance of divergent views (CTWM and Guardian Weekly 1992).

In a policy context, the focus on assembling a group for scenario development would be on partnership and stakeholder representation, as identified in chapter 4. The methodological issues associated with scenarios are explored in section 13.6, following a review of the benefits of a scenario-based approach in the following section.

13.5. The Benefits of Scenarios

Wack (1985b) concludes that the conceptual re-framing which can be catalysed by scenarios is of more than intellectual interest, since the discovery of new strategic openings to which it can lead is the essence of entrepreneurship:

> "Scenario planning aims to rediscover the original entrepreneurial power of foresight in contexts of change, complexity and uncertainty. It is precisely in these contexts - not in stable times - that the opportunities lie to gain competitive advantage through strategy" (Wack 1985b:150).

The principal application of scenarios to date has been in military and corporate contexts that have had little concern for sustainability, but their power in assisting decision making in conditions of complexity means they can also be used as a tool for achieving greater resilience in a complex world, which is the central policy and management challenge for sustainability identified in chapters 10 and 11. One of the most important ways in which scenarios achieve their benefits is by providing a systematic tool for considering multiple perspectives. The cultural basis for alternative perceptions has been explored in chapter 7, and other sources of plurality that have been identified include 'tunnel vision' and short-termism (Miller 1982, 1985); the difference between personal, analytical and organisational perceptions (Linstone 1981, 1984, Bowonder 1987); the distinction between literary, numerical and ecological thinking (Hardin 1985); and various psychological biases (Hogarth and Makridakis 1981, Barnes 1984, Russo and Schoemaker 1989). As Wack (1985b) notes, an attempt to take account of the complexity, uncertainty and plurality simply through considering alternative possibilities among a few key parameters would lead to "hundreds of outcomes", which would not be a useful framework for judgement. Indeed, Schwartz (1991:233) argues that even four scenarios represents an upper limit, since beyond that number "they begin to blur and lose their meaningful distinctions as decision tools".

Scenario development must therefore attain a compromise between the benefits of considering many perspectives and the limited number of alternatives that can be processed given the cognitive constraints of human decision makers. Wack (1985b:146) argues that although a set of scenarios cannot explore every possible combination of factors, it will succeed if it "illuminates the major forces driving the system, their interrelationships, and the critical uncertainties. The users can then sharpen their focus on key environmental questions, aided by new concepts and a richer language system through which they exchange ideas and data". In other words, scenarios can help create richer mental models that take advantage of the insights of plural perspectives and thereby improve the resilience of strategies (Brewer 1986, Bowonder 1987, Wahlström 1992). In so doing, they can also remove blind spots that obscure understanding and decision making, and help to avoid unpleasant surprises (Hardin 1985, Brewer 1986, Schwarz and Thompson 1990, Schwartz 1991). More generally, by nurturing mental map-building, encouraging more self-aware decision making, improving communications, and setting up creative processes of dialogue, they can also enable more flexible and resilient management styles and contribute to organisational learning (Ansoff et al. 1976, Ackoff 1981, Argyris 1986, Cantley 1986, Einhorn and Hogarth 1987, Senge 1990, Bardwell 1991, Senge at al. 1994). In addition, although plurality may be beneficial during problem formulation and solution identification, coherent implementation of policy and strategy is assisted by shared mental models, which scenarios can also help to achieve (Wack 1985a, Morgan 1986, Rayner 1986, Senge 1990).

In addition to the pragmatic benefits sought in business and policy-making, another application of scenarios is in vision-building. Polak (1973) notes that inspirational images have played a central role in the development of Western Civilisation, and that the heights of classical civilisation, the Renaissance, the Enlightenment and the early industrial era were preceded by daring imaginative leaps to new visions of human possibilities. Polak claims that current societies are cynical and unimaginative by comparison, and that the only hope for cultural revitalisation in the West lies in rekindling the social imagination. Viederman (1993:177) similarly argues that the environmental and economic problems we face are not likely to respond to simple solutions, so we should acknowledge their structural and systemic origins, and above all "We must also allow ourselves to dream - to create a vision - of a sustainable society, to overcome the social inertia of the last decade when . . . we no longer dared to dream".

The importance of visions is also highlighted by Olson (1994:168), who argues that "change is especially critical at the vision level, which involves our highest aspirations for the future and our deepest assumptions about what is needed and possible. Changes at this level guide and motivate all our other efforts". Olson produces a set of scenarios for sustainability, and notes that by assessing their feasibility, decision-makers can gain "important insights about the challenge of moving toward a sustainable future". The importance of visions of sustainability, and the potential role of scenarios, is also highlighted by Jones (1993), and Elgin (1994) argues that we require "alternative visions of sustainability that speak the language of popular culture while retaining their deep integrity". Visioning exercises based on scenarios have been used in diverse decision-making situations, from local community-based planning in the US (Klein 1993) to the development of national visions for the post-apartheid future of South Africa (CTWM and Guardian Weekly 1992). Scenario-based planning exercises would also appear to be well suited to similar visioning exercises for sustainability.

13.6. Unresolved Issues

Scenarios are, as Porter (1985:481) argues, an important "tool . . . [in] the strategist's arsenal". Previous sections have noted their established track record in strategic decision making under conditions of complexity, and their successful application to enabling constructive dialogue and building consensus in groups with diverse opinions and priorities. Experience from business confirms that scenario-based approaches to exploring mental models have demonstrated improved flexibility, adaptability and resilience of resulting strategies, which are key requirements for decision making in a complex world (Becker & van Doorn 1987, Robinson 1990, Schwartz 1991). It would appear, therefore, that scenarios could play a valuable role in decision making for SD, both at the level of developing inspirational visions and as a decision-oriented tool to improve the resilience of strategies and institutions (Robinson 1990, ERM 1994b). There are, however, two important constraints that have limited the wider use of scenarios to support decision making in a complex world:

- *Lack of Theory*: There is no theoretical underpinning or methodology to guide the creation and selection of scenarios (Becker & van Doorn 1987, Becker 1988, Godet 1990, Senge 1990). The problem is, as Wildavsky (1971:104) argues, that the future "is an infinity of branching possibilities". Or, as March (1981:572) puts it: "because there are so many very unlikely future events that can be imagined, and each is so improbable, we ordinarily exclude them from our more careful forecasts, though we know that some very unlikely events will certainly occur. As a result, our plans are based on a future that we know, with certainty, will not be realised". Makridakis (1990) points out that "practical considerations prohibit the consideration of all but a small number of [the "innumerable" possibilities that can arise]", and even those may turn out to have been "precapsuled [sic.] programs to respond in precise ways to stimuli that never quite occurred as expected" (Quinn 1980:122).

  In the face of this basic indeterminacy, there are no guidelines within scenario theory on how the scenarios should be chosen to take account of as many of the dimensions of the uncertainty as possible in order to provide significantly different perspectives that can assist in avoiding surprise and building new perspectives, in just three or four scenarios. There is not even consensus on what the ideal number of scenarios should be (Robinson 1990). Scenario based thinking has therefore remained, as Schwartz (1991:29) comments, "an art, not a science". In the hands of talented and creative scenario builders, it can deliver powerful results, but a systematic theory on the selection of alternative scenarios during the development process is needed before scenarios can be made into a resilient and widely applicable management tool.

- *Difficulties in Application*: Scenario techniques are often seen as unwieldy, time and resource intensive, or disconnected from the real needs of managers. Scenarios have too often been used to support old-fashioned, centralised and inflexible strategic planning that aims to plan the unplannable and predict the unpredictable. In his wide-ranging critique of strategic planning, Mintzberg (1994) singles out scenario planning for particular attack as one of the "fundamental fallacies of strategic planning" for these reasons. Scenarios need to be re-fashioned into a dynamic tool that is not controlled by central planning departments, but that can instead be easily understood and applied by managers, communities and individuals to meet their own decision making needs. This need is even more pronounced if scenarios are to become a viable tool for community-based planning or vision-building on a wide scale.

Apart from these fundamental issues, scenarios can easily be abused in such a way that assumptions are introduced into the development process early on, thus constraining the possible solutions that are examined. For example, Kleiner (1994:276) argues that in devising scenarios, "We can assume that the pace of technological growth will continue, with costs of new devices falling at a fairly predetermined rate". A cultural analysis of this statement demonstrates Kleiner's individualist, technologically optimistic leanings, which would make it unlikely, for example, that any of his scenarios would be able to reflect a more egalitarian, technologically pessimistic perspective. This example reflects the problem that it may be impossible for scenario builders to become aware of their own cognitive commitments unless they are provided with a methodology for scenario construction.

Another related example is the requirement by some scenario builders that scenarios should be plausible (Hadridge et al. 1995). The problem here is that a decision maker's conception of what is plausible is limited by his current world view, and if scenarios are to be used to question assumptions and expand perspectives, then their effectiveness will be severely reduced if those same assumptions and perspectives are used to restrict their design in the first place. One of the primary roles of scenarios is to expand our understanding of what may plausibly occur, so that we can prepare for it. The intrusion of assumptions about plausibility into decision making is well established. Schwartz (1991) notes that in October 1903, two months before the Wright Brothers launched their plane at Kitty Hawk, the *New York Times* argued that heavier-than-air flight was theoretically impossible. Nierenberg (1993) records many similar examples, and observes that as late as 1956 the British Astronomer Royal, Sir Richard van der Riet Wooley, dismissed space travel as "utter bilge". In the environmental debate, a notable example is how the ozone hole went undetected for seven years, which has been discussed in chapter 6. This arose because the computer that analysed the Nimbus-7 satellite data was programmed to reject high ozone depletion figures as anomalous, since the prevailing scientific consensus held that such depletion was implausible.

These examples confirm that our myths of what is plausible are among those aspects of our mental models that could usefully be challenged by scenarios. The practical problem remains that in the absence of a methodology for scenario design, there is no way to decide which futures should be included or excluded, or on what basis.

13.7. Conclusions

This chapter has introduced scenario-based techniques for decision making, and found that they have been successfully applied in both business and policy-related decision making. Scenarios can provide a tool for vision-building for sustainability, for improving organisational and individual learning, and also for improving the resilience of strategies and institutions. Their successful track record in improving decision making and organisational resilience in conditions of complexity suggest that they may be able to play a valuable role in improving decision making for SD.

The chief problem preventing the wider use of scenario planning, however, is the lack of a methodology for choosing the most helpful three or four scenarios from the myriad possible futures. Scenarios are at their most effective when they are able to uncover assumptions, broaden thinking, stimulate creativity and thereby create richer mental models. The challenge for scenario builders is to include the widest possible part of the uncertainty spectrum, so as to ensure that the scenarios will not themselves be trapped in overly narrow assumptions. The difficulty is that there are no guidelines on how to do this.

The next chapter proposes a methodology, based on cultural theory, which may provide a possible way forwards from this impasse.

Chapter 14: Cultural Theory and Scenarios

14.1. Introduction

Chapter 13 demonstrated that scenarios have an established track record in improving decision making under conditions of complexity and uncertainty, by helping decision makers to think more creatively, examine their assumptions and build richer mental models. Scenarios can therefore contribute to improving strategic resilience and fostering institutional learning, both of which are desirable components of policy making for sustainability. Chapter 13 also found, however, that there is no theoretical basis which may be used in determining which of the myriad possible futures should be included when constructing scenarios, nor how to differentiate between plausible and implausible futures.

This chapter proposes that cultural theory can be used to provide a theoretical underpinning for scenario development, and demonstrates the value of this approach with a cultural analysis of other sets of scenarios that have been developed. It also presents a set of three scenarios for SD that were developed using cultural theory.

14.2. Cultural Theory as a Framework for Scenario Development

Chapter 13 has described how scenario analysts emphasise the importance of choosing widely differing futures for inclusion in the set of three or four scenarios. Similarly, Brewer (1986) argues that scenarios should be "positively eclectic" , while Becker and van Doorn (1987) warn of the dangers of "intellectual inbreeding" and an attendant loss of plurality and requisite variety. The advantage of variety is that if a broader range of possible futures can be considered, then decision makers will be able to explore the implications of institutional and strategic resilience across a wider set of potential 'environments'. The problem of including plurality, from a scenario development point of view, is that the combinatorial possibilities rapidly become unmanageable. If there are N dimensions of uncertainty to be considered, such as technological, social, economic and environmental dimensions, then if we wish to consider three different scenarios for each of the dimensions, we require a total of 3^N scenarios. For example, to include all possible permutations of the 17 dimensions in the three benchmark perspectives on SD outlined in table 8.1, we would require over 129 million scenarios.

Cultural theory allows us to reduce this number to three again, since it holds that the myth-holders' perspectives on each of the 17 dimensions can be predicted once their political cultures are known. The three scenarios can then be assembled by choosing the appropriate set of dimensions, which should generally include economic, social, political, environmental and technological driving forces as discussed in section 13.4, and then assigning the appropriate future state to each of these dimensions, where appropriateness is judged by what would be expected by each political culture. There remains a significant methodological question regarding whether a cultural approach will always be able to generate three distinct perspectives, but the cultural analyses in chapters 7 and 8 demonstrate that there is already a significant foundation which can be built upon, and additional applications of cultural theory are expanding this resource continually. For example, Thompson (1992) provides an analysis of the appropriate perspective of the major political cultures along 41 different dimensions, such as learning style, ideal of fairness, energy future, leadership and audit criteria, all of which can help guide scenario construction. Further applications include the cultural analysis of the population debate by MacKellar (1995), the cultural theory based climate and population scenarios by Van Asselt and Rotmans (1995), and the sustainability scenarios developed by Trisoglio (1994) and Trisoglio et al. (1994).

Another methodological issue is whether the future state for each political culture included in each scenario should be a desirable utopian outcome, or an undesirable dystopia. A utopia is here taken to mean the sort of world that, for example, an egalitarian would choose if he were free to do so. A dystopia would then be, for example, the perception that an egalitarian would have of a world run by individualists. Trisoglio et al. (1994) propose that the three utopias should be used for scenarios, since including all six dystopias would generate too many scenarios without shedding any more insight, although there may be situations where using a mix of utopias and dystopias, or all dystopias, is more appropriate.

The central consideration which permits the successful application of cultural theory is that the purpose of scenarios is not predicting the future, but rather improving awareness and accelerating learning. Thus, as long as we consider each of the permutations of each of the variables at least once, thus enabling the assumption testing and mental map building process to occur, it does not matter whether or not we happen to choose the 'right' combination of permutations in any given scenario. Consistency and plausibility are both desirable, since they make the scenarios more accessible, and therefore more effective. Cultural theory ensures that each permutation is indeed considered, and it provides the additional benefit that a consistency check is unnecessary, since the use of the three political cultures automatically builds in consistency as the scenarios are constructed, as the scenario developer identifies which outcome would be consistent with the myth held by each rationality. It is a coincidence, but nevertheless an additional benefit, that there are only three active rationalities in cultural theory, which corresponds to the number of scenarios generally accepted to be optimum (Schwartz 1991).

Having established that it is possible to construct scenarios using cultural theory, we should also consider whether it is theoretically defensible to do so. The objective of scenarios is to consider alternative future possibilities, in order to broaden mental models. As chapter 7 describes, cultural theory asserts that, disregarding the non-active ways of life, there are only three basic world views, each of which is held by one of the three active political cultures. Chapter 8 has considered this hypothesis as it applies to the sustainability debate, and has found that although the cultural hypothesis of a clear correlation between institutional type and world view does not hold up especially well in the light of the evidence, the basic typology of world views appears to be relatively robust, which the exception of Gaian and complex myths of nature. In other words, there are three common and incompatible world views in the SD debate, each of which may therefore be used as the basis for a scenario. As chapters 8 and 9 observed, relatively few actors in the debate are equally conversant with these three perspectives, and their mental models may therefore be assumed to be incomplete to the extent that they exclude any of these cultural perspectives.

It would appear, therefore, that a set of scenarios based on cultural theory would provide a simple tool to help decision makers take account of all the rationalities described by cultural theory, which are also the most important rationalities to be found in the SD debate, and thereby improve their mental models and build more resilient strategies and institutions. It may be noted that this recommendation is equivalent to cultural theory's call for clumsy institutions (Schwarz and Thompson 1990), with the important difference that the scenario technique provides a tool for operationalising the concept of clumsiness, which was left as a theoretical abstraction by cultural theorists. In summary, earlier chapters have demonstrated that the most common mental models are those described by cultural theory, so a set of scenarios based on cultural theory provides a convenient tool for allowing decision makers to expand their own mental models by considering the other common mental models.

At a practical level, scenarios based on cultural theory have the additional benefit that they are not simply hypothetical alternative futures, but that they are the desired futures of different groups in society. Thus they are not only useful in considering uncertainty in the abstract, but also to allow decision makers to consider the viewpoints and strategies that other actors are likely to adopt, and thereby to provide the basis for improved mutual understanding and co-operation.

14.3 A Cultural Analysis of Various Scenarios

The value of a cultural approach may be considered by evaluating other scenarios using the basis for evaluation proposed by Wack (1985b), namely, their inclusiveness. If a set of scenarios omits an important perspective, then it is less useful for decision making purposes. A cultural analysis of various scenarios produces the following results:

- Mannermaa (1986): Has two scenarios, one an egalitarian utopia, the other an egalitarian dystopia of a world controlled by an individualist-hierarchist alliance. The strong egalitarian perspective throughout is notable.

- Svidén (1986): Includes two sets of scenarios. The first is a set of four scenarios for automobile usage in a future information society of the early 21st century, which includes two individualist and two hierarchist scenarios, but no egalitarian. The second 'set' is a single 21st century world gas scenario, which involves a high-technology transition to an all-nuclear future by the year 2100, reflecting a market-driven, individualist scenario.

- Kahane (1991): Describes the two Shell scenarios developed during 1988-90, which refer to the year 2010: 'Sustainable World' and 'Global Mercantilism'. The second scenario is a hierarchist world of managed trade, regional blocs and limited attention paid to environmental concerns. The first is an individualist utopia of sustainability, with free trade, steady growth and rapid technological innovation. There is no egalitarian perspective.

- Schwartz (1991): Has three scenarios for the year 2005: 'New Empires', which is a hierarchist world of economic blocs and "giant bureaucracies, both public and private"; 'Market World', which is entrepreneurial, capitalistic and full of possibilities, and has a clear individualist mentality: "people work to achieve, not to control"; and 'Change Without Progress', a chaotic, unfriendly, unstable world, with growing divisions between rich and poor, and many technological and environmental accidents. It is also an individualist world, the "dark side of 'Market World'" as Schwartz calls it, but unlike the utopian vision of 'Market World', it is the hierarchist dystopia of the excesses of free markets. There is no egalitarian scenario, and the correspondence of these scenarios with those of Shell, Schwartz's former employer, is notable.

- Shell (1991): Presents two scenarios for Britain in 2005: 'Layers and Pockets' has managed competition in a relatively stable political context, albeit with increasing social division. Energy policy is uniform, rational and transparent, while compliance with environmental regulations is deemed to be acceptable. This is a corporate utopia, with elements of competition and elements of hierarchist protection and stability. 'Fraternal State' is an individualist dystopia of closed industrial structures and non-integrated markets, political debate driven by concern over wealth divisions, and an environmental policy process in which "pressure groups [are] supreme and companies have to guess at the future". These scenarios appear to be written as utopian and dystopian visions for Shell itself. As with other Shell scenarios, the egalitarian perspective is absent.

- CTWM and Guardian Weekly (1992): The Mont Fleur Scenarios create four visions of South Africa in the year 2002. The 'Ostrich' scenario is of a non-representative government that looks to the past; the 'Lame Duck' scenario has a protracted transition to representative government which stifles economic growth. The 'Icarus Crashes' scenario is of a populist government indulging in short term spending which leads to longer term economic and social collapse, a story reminiscent of certain Latin American economies. All of these are essentially hierarchist dystopias, which focus on the role of government almost exclusively. The fourth scenario, 'The Flight of the Flamingos' is the hierarchist utopia of good government, broad participation and sustained economic growth. The absence of egalitarian and individualist perspectives is particularly noteworthy.

- NCPB (1992): The Netherlands Central Planning Bureau's study of the world economy up to the year 2015 has three scenarios which are distinguished by alternative economic theories: 'Co-ordination' is Keynesian, a hierarchist perspective; 'Free Market' is neo-Austrian, an individualist perspective; 'Equilibrium' is neo-classical, a mixed hierarchist/individualist perspective. There are no egalitarian perspectives such as, for example, Daly and Cobb's (1990) views on community-based economies.

- Pepper et al. (1992): The revised IPCC emissions scenarios provide six alternative futures for greenhouse gas emissions to the year 2100, all of which are hierarchist. All scenarios but one include nuclear power, and the uptake of solar and biofuels is slow in all six. Since they are all alternative extrapolations of current trends based only on international agreements currently in force, it is not surprising that egalitarian futures are excluded. The absence of an individualist future of rapid innovation and structural change cannot, however, be accounted for in this way, and is perhaps better understood as resulting from the hierarchical institutional structure of the IPCC (Trisoglio et al. 1994).

- Shell (1992): There are two scenarios in the set *Global Scenarios 1992-2020*, based on the primary driving forces of political and economic liberalisation. 'New Frontiers' describes a liberal, competitive, individualist world; 'Barricades' is a protectionist, hierarchist world. There is no egalitarian perspective, although Shell includes a cleaner environment in the 'New Frontiers' scenario and "draconian [environmental] regulations" in 'Barricades'. This is an example of an individualist utopia and an individualist dystopia of a hierarchical world, reflecting the same divisions as previous Shell scenarios (Kahane 1991), and also the first two of Schwartz's (1991) scenarios.

- IAF (1993): Has four scenarios describing the plight of international refugees in the year 2005: 'Restless World' and 'Era of Chaos' are both dystopias of unmanageability, which would be dystopian for both hierarchist and egalitarian rationalities. 'Preventive Diplomacy' is a hierarchical utopia where governments overhaul foreign aid programmes and strengthen the role of the UN, while ''Global Sustainable Development' is a mixed hierarchist/egalitarian utopia which emphasises growth and technological innovation while also focusing on grassroots development, limiting "some aspects of quantitative growth", and using NGOs as an important implementation mechanism. There are no individualist perspectives represented, which is perhaps not surprising given the NGO-based institutional context.

- DRI (1994): Presents three scenarios of how the use of market-based approaches to environmental policy in Europe, including an ecological tax reform, would impact on environmental conditions and economic growth. The three scenarios 'Integrated', 'Reference' and 'Policy in the Pipeline', are all variants on the mainstream hierarchist approach and are almost indistinguishable in their outcomes. There are no individualist or egalitarian perspectives.

- Ecotec (1994): Has three futures for industry and environment in Europe in 2010: 'The Green Backlash', an individualist dystopia of a hierarchist world, 'Efficient Status Quo', a mixed individualist/hierarchist utopia, and 'Rise of Green Values', another hierarchist utopia.

- ERM (1994b): Reports on several exercises that apply scenario-based approaches to decision making for sustainability including the WRI 2050 Project, the MIT Chlorine Policy Study and the EPA Environmental Futures Project. The EPA project contains two scenarios, 'Business as Usual' and 'Desired Future', which are respectively a hierarchist dystopia and a hierarchist utopia.

- Marien (1994a): Has three futures for the "next few" decades: 'False Success', 'More of the Same' and 'Evident Regress', which are all dystopias from a mixed hierarchist/egalitarian perspective. There are no individualist perspectives and, perhaps more intriguingly, no positive visions.

- Olson (1994): Provides three scenarios for the year 2025. 'Continued growth with pollution control' is hierarchist; 'Technology transformation' is individualist; and 'Social transformation' is egalitarian. In the absence of any theoretical derivation, the correlation with cultural theory is surprisingly close, except that he later rejects the hierarchist scenario as "economically impractical", and prefers a combination of the other two. In addition, his approach focuses heavily on technological developments to the exclusion of other variables that would normally be included in scenarios.

Two conclusions that may be drawn from this analysis. Firstly, and perhaps most interestingly, the most professional scenario-builders are by no means the most thorough. Shell (1991, 1992) and the former Shell employees Kahane (1991) and Schwartz (1991) produce very similar sets of scenarios, containing the utopias and dystopias as seen from the individualist / hierarchist perspective one might associate with a large multinational like Shell. There is no egalitarian perspective which, as was noted in section 9.2.2, recently meant Shell was unable to avoid a humiliating confrontation with Greenpeace over the disposal of the Brent Spar oil rig in the North Sea in 1995. Had Shell included an egalitarian perspective among its scenarios, it would have been less likely to have been surprised by the Greenpeace response, and it could have developed a more resilient business strategy since, as chapter 8 noted, business typically has a blind spot with respect to the egalitarian perspective. As an aside, it is perhaps worth making the obvious points that the sustainability of Shell as a company is only a small part of the sustainable development issue writ large, and that what is good for Shell's business may not necessarily be good for SD.

Secondly, despite the deliberate plurality of the scenario method, only one of the 15 sets of scenarios summarised above includes all three perspectives of cultural theory. There would therefore appear to be significant scope for improving the plurality of the scenario method in a systematic way by using cultural theory as a basis for selecting scenarios. The next section introduces a set of scenarios that has been developed by the author based on cultural theory.

14.4. A Set of Sustainability Scenarios Based on Cultural Theory

A set of three SD scenarios has been developed by the author using the approach described in section 14.2 for the Battelle-sponsored *State of the Art Report* (SOAR) on Social Science and Climate Change, and then revised for the European Partners for the Environment (EPE) *Sustainability Laboratory* in September 1994 (Trisoglio et al. 1994, Trisoglio 1994). The EPE scenarios were designed to promote exploration of the challenge of sustainability in Europe, particularly in the light of the European Union's Fifth Environmental Action Programme (CEC 1992). They are set approximately a generation into the future, and they provide three different perspectives on environmental problems and economic trends, on the meaning of sustainability, and on the policies and actions that are needed to attain it.

The three scenarios are 'Orderly Transition', which is hierarchist; 'Eco-Frontiers', which is individualist; and the egalitarian 'Values Shift'. They paint contrasting pictures of life in Europe during the early part of the next century, and outline the implications for the five selected target sectors of the EU's Fifth Environmental Action Programme. Their scope is limited to Europe, possibly one that has now expanded towards the east, but they say nothing about the conditions in North America, Japan, the newly industrialised economies or the developing world.

The scenarios are written as positive visions, setting out three alternative perspectives on the meaning of sustainability, and what is needed to attain it. Each scenario also includes a set of barriers, including the risks, fears and threats that might prevent the scenario's positive vision being attained. A summary of the EPE scenarios is presented in table 14.1, and the complete scenarios are included in appendix C.

	Scenario 1: Orderly Transition
Key Words	Sustainability, stewardship, managerialism, targets, steering, scientific expertise, international negotiation, optimisation, carrying capacity.
Summary	Environmental problems are serious, but can be solved with strong and balanced economic and environmental policies. There is a growing EU role and responsibility to co-ordinate and integrate economic and environmental policy. Partnerships are common in defining and implementing policy.
The Economy	Environmental issues are fully integrated into the WTO (World Trade Organisation) and national economies. Costs are internalised through ecological tax reform; a large proportion of national tax revenue is now from environmental sources.
Industry	The transition to cleaner energy sources and low waste production is driven by tax reform and tougher regulations. Focus on optimisation and efficiency, including industrial ecology. Regular SD assessments and audits. Multinationals grow in economic and social importance, working closely with stakeholders and forming the centre of people's lives.
Energy	There are widespread efficiency improvements, and a move from fossil fuel based systems to renewables and hot fusion. Energy systems are centralised, including combined heat and power. Europe launches R&D programme for sustainable energy to compete with Japan's "New Earth 21".
Transport	Strategies are implemented for mobility management and cleaner transport, with an optimally structured mix between individual transport, integrated, and public transport systems. Investment is made in trans-European networks. Cost internalisation has reduced traffic and helped to localise economies.
Tourism	After a decade of growing damage in 1990s, tough policies to protect resorts are based on eco-efficiency regulation and incentives. There is also growth in eco-tourism with high user fees to ensure environmental protection.
Agriculture	The role of farmers expands, to includes not just food production, but also guardianship of the countryside. Cost internalisation has promoted less polluting, more economically rational agriculture, as well as restoring competitiveness of low-input and organic farming.
Barriers	Risks arise from uncontrollability and disorder, whether from environmental disasters, economic instability or inability to build societal consensus for necessary changes, such as ecological tax reform.

Table 14.1. SD Scenarios Based on Cultural Theory

	Scenario 2: Eco-Frontiers
Key Words	Rapid change, technological innovation, adaptation, no limits, cultural diversity, maximising quality of life at the individual level.
Summary	The environmental concerns of 1990s are seen to have been greatly overstated. Global environmental degradation has not materialised, and economic growth based on the new clean industries of information economy has generated the wealth to pay for a clean and safe environment in Europe.
The Economy	Liberalisation and privatisation has continued apace. World-wide free markets drive innovation and growth. The role of governments has been redefined and focused on ensuring that markets function efficiently, e.g. through strict anti-monopoly laws and making central banks independent.
Industry	There is great diversity of scale, form and sectoral structure. Skills and learning are of central importance in the information economy. New technologies flourish, especially in communication, biotechnology, nanotechnology and robotics. Computing and cognitive technologies provide the basis of economic value added.
Energy	There are diverse energy supplies, notably clean fossil, but also renewables and inherently safe nuclear. Carbon dioxide emissions are not a problem, as research has confirmed that global warming will be minimal and non-damaging. In any case, an information economy needs far less energy than the industrial economy did.
Transport	Private modes dominate, and the remaining public networks are privatised. Clean vehicles co-exist with bicycles and pedestrians. High tech communications are ubiquitous, work is largely electronically based, through multimedia, teleconferencing and fully interactive virtual reality.
Tourism	The market acts to conserve natural, cultural and historical value, as people are willing to pay to preserve their quality of life. Tourism is increasingly based on appreciating diversity. The old fashioned idea of getting a tan is more easily achieved through technological and biotechnological means.
Agriculture	There are large increases in productivity through new chemical and biotechnological approaches, opening up large areas of the North for nature development. Increased carbon dioxide emissions benefit agriculture.
Barriers	Threats arise from a lack of ability to change or innovate, because of regulatory barriers, social resistance, or tendencies to protectionism. Another danger is growing unemployment, divisions between rich and poor, and increasing social tensions, leading to crime, violence and insecurity.

Table 14.1. (continued) SD Scenarios Based on Cultural Theory

	Scenario 3: Values Shift
Key Words	Prevention, urgency, participation, new relationship with nature, decentralisation, community, caring, spirituality, equity.
Summary	New scientific evidence, following a series of environmental disasters, shows that environmental problems are truly serious, necessitating radical industrial and economic change before it is too late. Growing dissatisfaction with government and business catalyses a bottom-up approach. Social and ecological concerns are paramount, as people recognise the value of caring, fairness and a vibrant community life.
The Economy	Steady-state economies are essential. There are major changes in consumption patterns to stay within environmental limits and share global environmental space equitably. Local economies and self-sufficiency are central, and non-market activities become increasingly important.
Industry	Business and industry focus on meeting needs - e.g. mobility, comfort, joy, communication, knowledge, rather than producing goods and services per se. Provision of needs is largely collectivised, and technologies are designed to fit closely with local surroundings rather than being globalized. There is a return to traditional skills, insights and craft work.
Energy	Carbon dioxide reductions of 80-90% in Europe are needed. Energy demand is greatly reduced through triple glazing, insulation, and high efficiency boilers, and is also reduced in the production and use of products. Small scale, low capital intensity, decentralised energy sources dominate. Wind and solar energy have replaced most fossil sources. There are large changes in energy and transport due to energy constraints.
Transport	Physical transport is minimised, and international flight is a once-in-a-lifetime experience. Trade is drastically reduced and limited to high value products. Land use patterns change to accommodate reduced mobility. Town planning designed around bicycles is common.
Tourism	Transport and especially flight - on which tourism used to depend - are enormously reduced, and the tourism industry which was based on unsustainable transport falls away, but unfortunately not before widespread destruction. Tourism is now local and based on sustainable transport, and sun-seeking has stopped because of cancer risks from ozone depletion.
Agriculture	Land degradation is avoided through traditional techniques, diets are largely vegetarian with fish, pulses and aquaculture for protein. Communities depend largely on local food sources, based on strict principles of sustainability. There are large population migrations where people find the land cannot support them.
Barriers	If environmental problems turn out not to be so serious, the Values Shift scenario would lose credibility, and most changes in the scenario - which are environmentally driven - would not occur. Another constraint is that people may not help each other or co-operate, or be willing to sacrifice any short term self-interest for the longer term social good. Societies may be unable to act in a precautionary way, and find themselves unable to respond to the scale of the environmental crises when it finally materialises.

Table 14.1. (continued) SD Scenarios Based on Cultural Theory

The scenarios have been used in stimulating a more plural and reflexive set of inputs to the Battelle SOAR project, and also in promoting discussion about resilient strategies and policies to promote sustainability in Europe. These applications and their results are discussed in chapter 15.

14.5. Conclusions

This chapter has demonstrated how cultural theory may be used as a theoretical basis for scenario development, and it has noted that the majority of scenarios that have been developed to date do not have the requisite variety offered by cultural theory, that is they do not include all three of the individualist, hierarchist and egalitarian perspectives. In the case of Shell, the company which is most closely associated with the development and application of scenarios, this chapter has shown that all Shell scenarios are either hierarchist or individualist, and do not include any egalitarian perspectives. In the light of this observation, it is perhaps not surprising that Shell should have exhibited a significant blind spot towards the egalitarian perspective in its dealings with Greenpeace over the Brent Spar controversy in 1995. The use of scenarios based on cultural theory could assist decision makers in avoiding such non-resilient strategies in future.

The chapter has also provided a summary of a set of SD scenarios developed using cultural theory, which appear in full in appendix C. The results that have been obtained through using these scenarios are discussed in chapter 15.

Chapter 15: Sustainability Scenarios - Application and Results

15.1. Introduction

Chapter 14 has argued that cultural theory provides a simple and effective way of developing a set of scenarios with broad plurality, and has introduced a set of three SD scenarios developed on the basis of cultural theory. The scenarios (Trisoglio 1994) have subsequently been used with several different groups, and the results of these applications provide an assessment of their value in improving awareness and broadening mental models of actors in the sustainability debate. This chapter considers three of these applications, which included participants from academia, business, government and non-governmental organisations (NGOs):

- *SOAR*: The Battelle-sponsored *State of the Art Report on Social Science and Climate Change* is an interdisciplinary academic project, which has drawn together a leading international group of social scientists to write a report to assess the state of the art of social science thinking as it relates to the climate change debate. The initiative is intended at least partly as a response to the dominance of economists in the IPCC Working Group III. The set of sustainability scenarios, in a slightly different earlier form from those presented in chapter 14 (Trisoglio et al. 1994), was developed and sent to the chapter authors in August 1994. The scenarios were seen by the Battelle editorial group as a means to stimulate the chapter authors to develop a plural and reflexive approach to the issues in their chapters. The scenarios received a number of comments during autumn 1994, which form the basis of the discussion in section 15.2.

- *EPE*: European Partners for the Environment is a collaborative venture comprising business, government and non-governmental institutions which are seeking to develop new, partnership-oriented approaches to further the implementation of the European Union's Fifth Environmental Action Programme (CEC 1992). The scenarios were used as the basis for a workshop with approximately 30 participants on 26-27 October 1994, and the results are discussed in section 15.3.

- *CIMI*: The scenarios have also been used as part of the Executive MBA programme at the Copenhagen International Management Institute. The programme has some 30 participants, who are professional mid-career managers, aged between 30 and 50. The scenarios were first used in an environmentally-focused module in November 1994, the results of which are discussed in section 15.4.

From a methodological point of view it should be noted that these applications are case studies rather than statistically rigorous and representative experiments set up in controlled conditions. The purpose of the case studies is not to derive quantitative experimental data, but to shed light onto the types of results that can be obtained by using a scenario based approach, and to explore how the scenarios might be improved. The three groups present a diverse test set since they are, respectively, a highly sophisticated academic/environmental policy elite; a self-selected group of individuals with interests in sustainability who come from diverse institutional backgrounds; and a group of executive 'high-fliers' on an advanced management programme who possess managerial sophistication but no particular exposure to the sustainability debate.

15.2. Results from the SOAR Application

The only set of guidelines that accompanied the scenarios in the SOAR project was an informal invitation to chapter authors, most of whom are senior academic figures, encouraging them to use the scenarios in developing their work if they found them to be helpful. Eleven written responses were received, and two additional responses to the comments were received from the cultural theorist Michael Thompson. The full texts are included in appendix D, and the key results are as follows (references refer to numbered paragraphs in Appendix D):

- *Overall reactions*: 11 of the 13 replies reported that the scenarios were either interesting or useful; one did not appear to understand their purpose (D:13), and one would have preferred them to be based on "more solid [computer] modelling results" (D:10), which also misses their purpose. Those authors who were familiar with cultural theory were particularly positive, not least because the scenarios "... [are a] superb survey instrument ... for revealing the biases of members of the elite" (Thompson, D:11).

- *Realism and Plausibility*: 4 of the 13 replies found the scenarios "unrealistic" or "unconvincing" to some degree. Perhaps the best example of this reservation is Coppock (D:1) who provides detailed suggestions on what would be required to make the scenarios more realistic. The significance of Coppock's reply is that, as Thompson (D:11) points out, he cannot grant legitimacy to any perspective other than his own hierarchical perspective: "... the individualist is first adjusted and then co-opted into [Coppock's] hierarchical vision ... The egalitarian's problem and solution definitions are now adjusted to the point where they fit neatly into the everything-caught-in-the-net hierarchical vision ... But even with all this adjustment of the egalitarian position, there is one sticking point that cannot be adjusted and will have to be barred: zero growth". In other words, rather than using the scenarios to increase the breadth of their mental models and develop new perceptions which might improve the resilience of their policy advice, authors such as Coppock seek to redefine the scenarios so that can be contained within their existing mental models. This result support's cultural theory's hypothesis that people tend to interpret reality selectively so as to reinforce their existing perspectives.

The SOAR results demonstrate that even among leading social scientists, the inability to grant legitimacy to plural perspectives is a problem, which suggests that the magnitude of the challenge might be even greater in attempting to introduce greater plurality and self-reflexive thinking among SD policy makers less versed in social science thinking.

15.3. Results from the EPE Application

The applications of the scenarios in EPE and CIMI followed a common procedure. The participants were divided into three groups of equal size, and each group was allocated one of the three scenarios. The groups were asked to suspend their disbelief, and imagine being in the world described by their scenario, and on this basis to prepare answers to a number of questions about how they would make decisions in this world. The results were presented in plenary, after which there was an open discussion about the common elements in all group responses and the differences between them. An alternative use of the scenarios, which was not explored here, is to use the scenarios as a role-playing exercise, for example to improve stakeholder dialogue.

The three EPE groups were asked to answer the following four questions: what are the barriers to SD in your scenario? What are the priorities for action to attain SD? What form might partnerships among business, government and NGOs take? What would the role of EPE be? The final question was included since the workshop results were to be used in developing a strategic plan for EPE itself. The responses to these questions appear in full in appendix D, and the key results are:

- *Priorities for All Scenarios*: Following the presentation by three groups, the plenary discussion identified six issues that were seen as important in all the scenarios, and which might therefore be seen as aspects of a resilient strategy for sustainability:

    (i) resolution of the trade and environment debate;
    (ii) promotion of the development and dissemination of 'sustainable' technologies;
    (iii) education, training and information;
    (iv) managing the social transition and redistribution;
    (v) being aware of timing issues, and reconciling a long term perspective with fast action in the short term;
    (vi) capital formation, both human and financial

- *Role of EPE*: In the light of the priorities and the scenario process itself, the group identified the following roles for EPE itself: education, information and tools, for example setting up a network, being a broker of ideas, internationally or between east and west Europe; developing pilot projects to experiment with new technologies or models of partnership; setting up mechanisms to give positive feedback to sustain and promote desirable change; acting as a centre to exchange best practice and assist in benchmarking; to develop simulations and tools to enhance thinking about sustainability, including further development of the scenario tools.

- *Broadening Perspectives*: The prevailing attitude within EPE is egalitarian with elements of a hierarchical perspective, and the group working with the egalitarian scenario felt that its problem statement reflects current reality, rather than a distant future. The group with the individualist scenario, however, was initially very hostile to the scenario, and refused to accept, for example, that global warming was not already occurring as a scientific fact. Nevertheless, after some 30 minutes discussion in which the group was encouraged to suspend its disbelief and enter into the spirit of the scenario, it was able to develop creative responses and suggestions that would otherwise have been completely filtered out. The ability of scenarios to promote creative and generative responses in situations that might otherwise be rejected or ignored can help to foster resilient behaviour.

- *Response from EPE*: EPE members found these ideas on priority issues and the role of EPE were unexpected, surprising and able to offer new perspectives on the group's work. The scenario process fostered a broadening of mental models with beneficial results. However, there are two qualifications. Firstly, the new perspectives appear to be a temporary phenomenon, since in its subsequent work EPE has continued along its former egalitarian path. Second, the results of the scenario planning exercise, while seen as valuable and important by the group involved in their preparation, have not been implemented in EPE strategies and programmes. This underscores Wack's (1985a) emphasis on changing institutional processes and structures so that they can accept the results of scenario-driven work, the benefits of which will otherwise be lost.

In addition to the results, pragmatic issues in applying the scenarios also became apparent. Only three of the thirty participants had read the scenarios, despite their having been distributed before the meeting, and a period of an hour appeared to be necessary for the participants to familiarise themselves with the future they were considering. Even then, the group tended to refer almost exclusively to the one-page scenario summary, which suggests that an alternative presentation of the information may required in order to communicate the key elements of each scenario more effectively, for example in a more visual format, or using multimedia techniques.

15.4. Results from the CIMI Application

The participants were divided into three groups as with EPE. The groups were asked to consider how changing concern for the environment could significantly redefine the successful corporation of the 21st century, the factors underlying business success in these different conditions, and the implications for companies today. Specifically, the questions were: what are the challenges and opportunities in your scenario for sectors with low, medium and high environmental impacts? What are the potential barriers to success and critical success factors? What are the impacts for corporate investment strategies, organisational designs and business functions? What are the priorities for action?

In a second stage of working in groups, the participants were asked to take account of all three scenarios, and consider the overall implications for designing resilient corporate strategies for companies in sectors with low, medium and high environmental impacts, and to consider the design of a resilient investment portfolio. The responses to these questions appear in full in appendix D, and the key results are:

- *Strategic Insights*: After only two hours using the scenario method, the group was able to generate highly insightful strategies for companies to manage the challenge of sustainability. These strategies are comparable with, and often more insightful than, typical perspectives in the business and sustainable development debate.

- *Broadening Perspectives*: Both the individualist and hierarchist groups felt that their scenarios reflected current reality, while the egalitarian group felt that the scenario "appears radically different from today, far away". Unlike the EPE group, however, the CIMI group was very comfortable with role playing and with considering the future from multiple perspectives, even if they initially found them to be quite distant. In addition, unlike the SOAR group, all of the scenarios were seen as plausible.

The CIMI group encountered similar process-related issues as EPE, notably that the full scenario texts were felt to be too long, and the managers desired an 'executive summary'. As with EPE, the evident need to reduce complexity is apparent, and illustrates how information is distilled to the bare minimum that is perceived to be consistent with effective decision making. Another general conclusion from the group was that the process was very enjoyable, and created a learning environment that fostered creative thinking and exploration of new perspectives.

15.5. Conclusions

The limited nature of the experiments means that conclusions should be drawn tentatively, but the results suggest a number of findings:

- *Plausibility*: Each scenario was seen as plausible by at least one of the groups, which confirms the cultural hypothesis, and also suggests that the scenarios are a good starting point for further development. Furthermore, the largely egalitarian EPE group felt that the egalitarian scenario was the most realistic, while the business executives at CIMI felt that the individualist and hierarchist scenarios were both realistic, although for them the hierarchist scenario is a dystopia. Perhaps surprisingly, the most critical and least open-minded group was the academic group, although even in this group most individuals were positive and constructive.

- *Effectiveness*: The scenarios confirmed that over-attachment to narrow perspectives is common, even among sophisticated participants in the SD debate. They also confirm, however, that if individuals can be persuaded to overcome their assumptions, the scenarios can foster creative and generative thinking that allows the development of more plural and resilient policies and strategies.

- *Research Tool*: As noted in section 15.2, the scenarios appear to offer a powerful research tool for testing cultural bias, by asking an individual to give his reactions to each scenarios in detail, although that was not their design objective. They may therefore be useful in further research work related to cultural theory.

- *Usability*: One of the most significant issues is improving the usability of the scenarios through executive summaries, visual presentation or multimedia approaches, since few groups appear able to absorb all the information in the full scenarios within the timescales typically associated with planning or brainstorming exercises. Given the difficulty that the groups had in absorbing the relatively low information content of the scenarios, which were also transparent and written in non-technical language, it is interesting to reflect on the true opacity in policy terms of the large-scale computer models that are currently used to advise policy making on SD or economic policy making in general.

The SOAR, EPE and CIMI applications demonstrate, albeit in an initial way, that the sustainability scenarios can play a role in helping decision makers to broaden their mental models, and develop more plural and resilient policies and strategies for SD. To this extent, they therefore represent a positive substantiation of the theoretical frameworks used to develop the scenarios and of the scenario method itself, and point towards an opportunity to develop the SD scenarios into a valuable tool for SD decision making. These conclusions are developed further in the summary and conclusions of the thesis in the following chapter.

Chapter 16: Summary and Conclusions

16.1. Summary

I. Review of Current Approaches to Sustainability

The first part of the thesis provides an overview of the typologies of SD definitions and the two main policy models for SD. Chapter 3 argues that although there are several competing frameworks to classify definitions of SD, none provides either a complete typology or a theoretical basis for the categorisation. Most approaches to understanding SD are socio-economic or political, but several authors have begun to explore explanatory frameworks based on systems theory and complexity, although these have not been combined into a convincing whole, and their application to operational questions of definition and policy making remains embryonic. Furthermore, the socio-economic and systems approaches appear to be following separate paths, and the potential insights from their integration remain untapped.

Chapter 4 argues that complexity and plurality are important themes in discussing SD policy. The two dominant comprehensive/rational and complex/adaptive models for SD policy may be distinguished using the simple / complex dichotomy, and both models highlight the importance of plural and participatory processes. In addition, complexity is seen to provide the fundamental basis for evaluating the relative merits and applicability of the policy models, which suggests that complexity should also play a more important role in definitions of sustainability. These findings from the policy domain are parallel to the two principal findings from chapter 3, namely that there is an irreducible plurality of incompatible and mutually contradictory definitions of sustainability, and that the socio-political approach to understanding sustainability has not been integrated with the complex systems approach.

In summary, the first part of the thesis identifies the need for a theoretical explanation of the plurality of perspectives in the SD debate, and also for an integration of perspectives from complexity into examinations of policy models and SD definitions.

II. New Theoretical Frameworks

The second part of the thesis introduces the theoretical frameworks of complexity and cultural theory. Chapter 5 presents an overview of the behaviour of complex and non-complex systems, and finds that the mechanisms of evolution, which are being explored through new forms of computer modelling such as artificial life, shed new light on adaptive behaviour and co-evolutionary change, and also confirm the importance of innovation, experimentation and learning in securing resilience. In addition, the fundamental role of strategies and cognition in guiding action and adaptation suggests that the definitional and cognitive problem at the heart of the SD debate is central to pragmatic policy making. Complexity also sheds light on the nature of resilience in complex adaptive systems, which is related to the diversity and plurality of possible behaviours. In SD policy terms, resilience implies plurality at the level of mental models, problem definitions, solutions, technologies, policies and institutions.

Chapter 6 illustrates the prevalence of complexity in the SD debate, by reviewing how environmental issues at global, regional and local scales reveal that the extent of complexity and non-linearity is exceeding the present ability of reductionist science and modelling to provide meaningful guidance for policy.

Chapter 7 introduces cultural theory, and its explanation of the origins of the four-fold typologies of SD definitions in the plural rationalities and myths of nature held by the different actors in the policy debate. Although cultural theory has been applied as a heuristic by numerous authors to provide valuable insights on the environmental debate, its hypothesis about the links between institutional preferences, rationalities and myths of nature has not been tested. Nevertheless, despite these reservations, the theoretical elegance and explanatory insights of the theory make it a natural candidate for further analysis of the SD debate. Cultural theory also argues that resilient policies and institutions cannot be developed unless all four perspectives are included in their design, although it does not provide an operational means of attaining such plurality.

In summary, the second part of the thesis introduces complexity theory and cultural theory, and demonstrates that they appear to hold promise for developing an improved understanding of sustainability.

III. Theoretical Application and Synthesis

The third part of the thesis applies complexity theory and cultural theory to analyse SD policies. It evaluates the theories, and then synthesises their key findings. Chapter 8 performs a cultural analysis of SD policy perspectives included in appendices A and B, and concludes that cultural theory is a useful heuristic, since cultural theory's argument that there are three myths of nature, or problem definitions, and three sets of preferred policies is largely vindicated by the policies analysed. In the SD debate as a whole, however, the hierarchist and egalitarian perspectives are dominant to the extent that sustainability might almost be considered a bipolar myth of nature. The inclusion of an individualist perspective emphasising entrepreneurship, technological innovation and the challenges of managing in an information economy would be likely to foster the development of more resilient policies and institutional structures for SD. Cultural theory's assertion that myths of nature are always associated with the same policy preferences and institutional forms is found not to hold, and the policy perspectives based on complex/adaptive myths of nature cannot be classified or interpreted using cultural theory. This suggests that most of the SD debate is still conducted in the absence of an awareness of complexity theory and its implications for understanding natural and social systems, and also that cultural theory is unable in its current form to provide explanations of a complex world or complex myths of nature, even though it provides a good summary of the pre-complex myths of nature that dominate today's SD policy debate.

Chapter 9 demonstrates that cultural theory's claims to provide an exhaustive classification, a theory of change and a predictive framework are all problematic, and that these problems are related to complexity. The theory's rigid four-fold classification obscures the diversity and plurality of real complex systems, and the myths of nature are seen to be static snapshots of reality, which omit the dynamic processes of change that are the hallmarks of complex adaptive systems. In addition, cultural theory provides little advice on suitable structures for organisational learning and adaptive change, even though it argues convincingly that a pluralistic approach to generating mental models, strategies and policies can improve organisational resilience. In summary, cultural theory is a useful heuristic for gauging resilience and plurality, but it has numerous theoretical shortcomings which are associated with its formulation in a way that does not take account of the insights of complexity theory.

Chapter 10 shows that although there is a divergence between complexity and cultural theory, the theories share significant common ground. If cultural theory's rigid classificatory system is relaxed, and the four myths of nature are seen as a heuristic typology of bias, as a description of common regularities in a complex world rather than the only archetypes for mental models or institutional behaviour, then the two theories become mutually supportive. In particular, their perspectives on uncertainty, plurality, learning and resilience are compatible with each other, yet at the same time critical of the comprehensive/rational model dominant in SD decision making. In proposing methods of increasing resilience, both theories stress the need for plurality and institutional behaviour that is simultaneously optimising within the known and exploring the unknown. The genetic and evolutionary models being developed by complexity researchers would appear to offer an interesting possibility of implementing such an approach to policy making in the longer term, but the cultural framework offers a more immediate tool to improve the plurality of decision processes and hence the resilience of decisions.

Chapter 11 summarises the status of the SD debate in the light of the theoretical conclusions of earlier chapters, and finds two principal types of approach taken by analysts when discussing sustainability. The first includes problem statements; small-scale, bottom-up approaches; and comprehensive, top-down approaches. The second emphasises the shortcomings of traditional comprehensive/rational approaches to policy making and calls for new policies based on learning and flexibility. The chapter argues that a complex systems perspective supports the second perspective, and that the issues of plurality and complexity give rise to contradictions which have not been addressed by the mainstream, and which demonstrate the need for a new approach to policy. Resilience, learning, plurality, vision-building and empowerment could provide a basis for a new policy approach, although there have been few recommendations on how these concepts might be translated into policies or institutions. An exception is the use of scenario techniques, which have been found to be beneficial in exploring alternative visions of the future, in legitimating multiple perspectives, and in developing more resilient strategies.

In summary, the third part of the thesis demonstrates that cultural theory and complexity can shed significant new insights on sustainability, and also that plurality and resilience are important aspects of policy making for sustainability

IV. Management Tools for a Sustainability in a Complex World

The final part of the thesis explores how the lessons and tools developed by management theory might be applied to sustainability, and in particular to increasing the plurality and resilience of SD decision making. Chapter 12 reviews the two principal theoretical strands in management theory and their implications for management in a complex world, including their conclusions about organisational learning and strategic resilience. It finds a close match between work on organisational learning and the complex/adaptive policy model, which suggests that the tools of organisational learning such as scenarios would also be beneficial to promoting resilience in SD policy making.

Chapter 13 introduces scenario-based techniques for decision making, and reviews their application in both business and policy-related decision making. It finds that scenarios can provide a tool for vision-building for sustainability, for improving organisational and individual learning, and also for improving the resilience of strategies and institutions. Their successful track record in improving decision making and organisational resilience in conditions of complexity suggest that they may be able to play a valuable role in improving decision making for SD. By operating at the cognitive level, scenarios allow experimentation and the development of new insights more rapidly than the trial-and-error approach of 'learning from experience'. The chief problem preventing the wider use of scenario planning, however, is the lack of a methodology for choosing the most helpful three or four scenarios for decision makers to consider from the myriad possible futures.

Chapter 14 addresses this methodological issue, and demonstrates how cultural theory may be used as a theoretical basis for scenario development. It also notes that a shortcoming of the majority of scenarios that have been developed to date is that they do not have the requisite variety offered by cultural theory, that is they do not include all three of the individualist, hierarchist and egalitarian perspectives. The chapter also provides a summary of a set of SD scenarios developed using cultural theory, which appear in full in appendix C.

Chapter 15 reports on three applications of the sustainability scenarios and the results that were obtained, which appear in appendix D. The case studies confirm that over-attachment to narrow perspectives is common, even among sophisticated participants in the SD debate, although if individuals can be persuaded to overcome their assumptions, the scenarios can promote creative and generative thinking that allows the development of more plural and resilient policies and strategies. The scenarios also appear to offer a powerful research tool for testing cultural bias, and may therefore be useful in further research work related to cultural theory. The applications demonstrate, albeit in an initial way, that the sustainability scenarios can play a role in helping decision makers to broaden their mental models, and develop more plural and resilient policies and strategies for SD. To this extent, they therefore represent a positive substantiation of the theoretical frameworks used to develop the scenarios and of the scenario method itself, and point towards an opportunity to develop the SD scenarios into a valuable tool for SD decision making.

In summary, the fourth part of the thesis demonstrates that scenarios can play a valuable role in promoting the type of organisational learning and institutional resilience which is needed for sustainability, and that cultural theory forms an appropriate theoretical basis for scenarios. It also develops a set of SD scenarios, and reports on the results from their application.

16.2. Areas for future research

Given the interdisciplinary approach of the thesis, there are many possible directions along which further research could be developed, both to build on the theoretical approaches used, and to apply and test them in more detail. One area for theoretical development is to modify cultural theory so as to address the shortcomings that have been identified. There is also scope for artificial life modelling to explore the origins of myths of nature, institutional forms, and the nature of social and institutional change. Such a project could help to bring together social scientists and complex systems researchers in new and interesting ways.

Management theory has developed a diverse range of approaches to organisational learning, strategic development and institutional resilience in the face of complexity, but it has not integrated the findings of cultural theory or complexity theory. The application of the results from complex systems theory to develop an integrated approach for management in a complex world would be a large scale, interdisciplinary research effort which could develop powerful new practical tools for decision making, as well as providing a more robust theoretical paradigm for management theory itself. At the level of decision making, drawing on the insights of complexity and cultural theory would allow the development of series of new quantitative and qualitative tools to enhance the quality of decision making and promote institutional learning.

The scenarios developed in the final part of the thesis are only a first step in developing a robust tool to help SD decision making. In particular, additional application of the scenarios could derive further data on necessary modifications to their content and their presentation, as well as exploring how they might be adapted to decision making in different contexts. For example, scenarios would be applied differently in community planning, corporate strategy, and policy development at the European level. The usability, accessibility and presentation of the scenarios, for example using more visual or multimedia approaches, could also be further developed. On a more long-term basis, there is also scope for developing computer-based tools that integrate scenario techniques with approaches from complexity research discussed in chapter 5, in order to develop a dynamic decision tool that builds on the insights of complexity, cultural theory and management theory.

16.3. Conclusions: Sustainable Development in a Complex World

This thesis has argued that the insights of complexity, when combined with those of cultural theory and management theory, provide new insights on the SD debate. These insights provide both a problem statement on the challenge of decision making for SD, and an approach to finding solutions, as follows:

- *Inherent Complexity and Plurality*: The world is complex, in terms of the behaviour of both natural and human systems, and complexity is therefore at the heart of the SD debate. Although scientific research will continue to increase our understanding of natural systems, the complexity and non-linearity of global biogeochemical systems raises serious doubts about the prospects of a policy approach to SD based on predictive modelling, optimisation and finding the one 'right answer'. The underlying complexity also permits the emergence and co-existence of plural perspectives on the meaning of sustainability, and the policies required to achieve it. The search for a single definition of sustainability will therefore continue to be fruitless, while economic attempts to assign a single value to environmental assets are seen to be equally misguided in the light of complexity and plurality.

- *Learning and Resilience*: Previous work on chaos and uncertainty supports the foregoing problem definition, and its critique of the comprehensive/rational policy model, but provides no alternative basis for decision-making. In contrast, a complex systems analysis of natural and social systems demonstrates that most complex systems thrive, adapt and evolve without top-down, predictive, or optimisation-focused decision making. Instead, they are sustained by evolutionary processes operating through partial, bottom-up strategies; significant plurality, diversity and experimentation; and the emergence of higher-order structures and processes in a co-evolutionary manner. In this light, complexity, together with recent developments in management theory, holds that instead of seeking narrow efficiency and optimisation, SD policy should aim to foster learning and resilience. The application of complexity theory, together with cultural theory and management theory, provides new insights into the types of decision-making processes that might foster such learning and resilience.

On the basis of these conclusions, it is apparent that the mainstream policy debates on sustainability, for example on sustainable consumption, ecological tax reform, trade and environment, and eco-management and audit systems, are failing to focus on the central issues of learning and resilience. The international policy fora such as IPCC, UNCSD and the WTO are similarly failing adequately to integrate plurality and complexity into their discussions on sustainability.

In particular, the SD debate is found to be dominated by egalitarian and hierarchist perspectives, and despite the generational timeframes considered in current SD policy discussions, and the espoused desire to integrate economic and environmental thinking, the debate's oversight of the issues arising from the information economy represents an important blind spot. Sustainability is closely related to social, technological and economic developments, all of which are likely to be affected dramatically by information technology in the early 21st century. Policy making for SD would therefore benefit from the inclusion of a perspective highlighting information technology, innovation, entrepreneurship, and the impacts of the information economy, which are in turn likely to increase the complexity and plurality of social and economic systems.

This thesis demonstrates that we can respond positively to complexity, since tools already exist to promote new thinking on sustainability. For example, scenario-based approaches could play a role in helping decision makers to develop a greater awareness of the complexity and plurality surrounding the management of SD in a complex world, and thereby improve the resilience of their policies and institutions for SD. The challenge now is two-fold: to help decision makers understand the implications of complexity, and to help them apply new tools and approaches in order to improve the quality of decision making for sustainability. The path to sustainability will be attained through greater understanding and its realisation in effective action.

Appendix A: Policies for Sustainable Development: Three Perspectives

Note: The numbers indicated in parentheses after quotations refer to the page in the cited document.

	INSTITUTION	Individualist (Schmidheiny et al. 1992)	Hierarchist (CEC 1992)	Egalitarian (FoE 1993)
1	Institutional Form	From 1991 to 1994, the BCSD was a group of 48 chairmen and chief executives of leading multinational companies from 26 different countries. It was organised in a fluid, network-based form with a small secretariat which was chosen on the basis of ability and performance. The document was prepared by a small core team with paid specialist consultants, and disseminated as a commercial publication.	Towards Sustainability is the agreed strategy of the 12 EC member states published in 1992. The processes leading to its production was lengthy, procedural and intensively negotiated among member state governments. The secretariat was chosen with attention to national representativeness, and the document written using inputs from experts. The results were first disseminated through official channels.	Friends of the Earth is an environmental NGO which is organised in a decentralised, small-scale, manner. The document was prepared "with the enthusiastic co-operation of a great many people" (FoE 1993) who were encouraged to participate, rather than chosen, and the results disseminated through a bottom-up process of briefings and awareness raising meetings.
2	Perceptions of Own Role in Attaining SD	"Business will play a vital role in the future health of this planet" (xi). "SD will require new technology, new approaches to spread the technology . . . and new ways of meeting needs through markets. Business leadership will be required, and expected, in all these areas" (12).	"The role of government is a determinant not only in relation to legislation . . . [but] in economic planning . . . market influence through taxation policies [etc.] . . . Governments have particularly onerous responsibilities both in respect of state owned and controlled activities and also in creating the necessary framework and conditions, in providing incentives and in removing obstacles so as to enable the individual and private enterprise to play their respective roles" (26).	"The role of [the environmental movement] will have two sides . . . to promote innovative processes in society to bring on SD . . . [and] to exert pressure on stragglers: authorities, companies and other actors that continue knowingly as before" (186).

	GENERAL POLICY			
3	Sustainable Development	"Progress towards sustainable development makes sense because it can create competitive advantages and new business opportunities" (xii).	"Development is 'real' only if it improves the quality of life" (17). SD is "linked very closely to a society's or region's prospects of continued development and success" (18).	"To indicate the practical implications of SD . . . we employ the principle that the earth has a limited amount of 'environmental space' (5).
4	Key Factors for SD	Key factors include: "economic growth . . . open and competitive markets . . . an ability to translate challenge into opportunities . . . the creative forces of local and international entrepreneurship . . . open and accessible markets, more streamlined regulatory systems . . . and efficient administration" (xi-xiii).	"[SD] entails preserving the overall balance and value of the capital stock, redefinition of short, medium and long-term cost/benefit evaluation criteria and instruments to reflect the real socio-economic effects and values of consumption and conservation, and the equitable distribution and use of resources between nations and regions over the world as a whole" (18).	"Four factors [are] crucial for SD: recycling, halving energy consumption, a new attitude towards materials and a reduction in transport" (137).
5	Idea of Fairness	*Equality of opportunity*: "Equitable chances open to all" (13).	*Managed balance*: "To strike a new balance between the short-term benefit of individual persons, companies and administrations and the longer term benefits of society as a whole" (26)	*Equal use of environmental space*: "The basic principle must be . . . equal access to the environmental space offered by the earth" (20).
6	Economic Growth	"Economic growth in all parts of the world is essential" (xi); "SD requires rapid economic growth" (8).	"Economic expansion is not an end in itself . . . it should result in an improvement in the quality of life as well as the standard of living" (17).	"Further growth in meat consumption, flights and car usage seems to be ruled out . . . [but] bicycles and objects of art do not have the same objections" (183); "No consumption growth in pounds of material weight, but the use of services or the provision of functions may grow" (183); "Growth shifts towards satisfaction of needs . . . growth can mean that less goods are wanted instead of more" (183)

7	Growth and Environment	Growth must come first: "Unless nations develop economically, they cannot protect their environments" (69).	"Increased economic growth . . . will be unsustainable unless environmental considerations are taken into account" (17).	"The ingrained belief in increase will disappear . . . the environmental space decides how far we can go" (19)
8	Are There Limits to Growth?	Constraints are social and technological, not environmental: "Growth is limited . . . by both the nature of technologies and . . . social organisation" (8).	"Environmental considerations are . . . not so much . . . a potential limiting factor [to growth], but . . . an incentive to greater efficiency and competivity [sic.]" (17).	"Environmental space . . . is limited and finite" (5).
9	Extent of Environmental Improvement Needed	"We cannot be absolutely sure of the extent of change needed" (xiii).	"Some trends . . . if not satisfactorily contained, could have significant negative consequences for the quality of the environment" (23).	"Human beings cannot go on treating the earth the way they do now" (9).
10	Is Cultural Change Needed?	Change in values seen as highly unlikely, utopian even: "We do not base our hopes for success on radical changes in human nature or on the creation of a utopia. We take humans the way we find them, the way we are all made, with all our strengths and weaknesses" (xxii).	No cultural change needed. Instead need "good knowledge and information . . . awareness campaigns . . . alternatives [such as] separate collections of waste, reliable public transport" (27), and products must be available, not more expensive, and accompanied by "neutral information" on their performance (27).	"The most important socio-cultural difference between the present society and a sustainable society will be that the ingrained belief in increase will disappear" (19). "The change in our culture that is required is along the lines of 'not more but better': a shift from quantity to quality" (186).
11	Perceived Trends	"Human history is that of expanded supplies of renewable resources, substitution for limited ones, and ever greater efficiency in their use" (xiii).	"The drive to raise living standards, alleviate poverty, increase life expectancy and improve food security places a considerable burden on the world's natural resource base" (17).	"We are using up too much of the earth too fast and we produce too much waste. We make it harder for the growing world population to lead a dignified existence" (18).
	ECONOMIC POLICY			
12	Trade	"trade policies and practices should be open" (xii).	"Trade and environment related issues are becoming increasingly important as environmental policies and strategies are strengthened and extended" (85).	"World trading policy must contribute to a better distribution of environmental space throughout the world" (167) "Unlike SD, free trade is not a goal in itself" (166).

13	Trade and Environment	Free trade should take precedence over environment: "[Environmental] agreements can and should be made compatible with existing trade rules" (73).	"Recognising that unilateral use of trade instruments for environmental purposes should be avoided in principle, [GATT] should focus on the role of international trade in promoting SD" (85).	"The GATT will become sustainable only when it not only accepts the UNCED agreements but also accords them a legal basis within the agreement" (167); "Environmental legislation . . . should be encouraged [by GATT]" (164).
14	Development in LDCs	"open trade . . . leads to the development of economies" (xii). Also "long-term business to business partnerships and direct investment . . . to transfer the technology needed for SD" (xii).	"It is necessary to increase official development aid and to mobilise new financial resources, especially private ones, to finance sustainable and environmentally sound development" (87).	"An international climate fund . . . to promote SD in the Third World . . . can be financed by a world-wide tax on fossil fuels" (161).
15	Economic instruments	Intervention should make markets more open and efficient, rather than introduce new and additional forms of taxation: "Economic instruments [should be] designed to correct distortions" (xi); "Distorting farm subsidies should be removed" (xiii).	"Prices should reflect the full cost to society of production and consumption, including the environmental cost . . . [so] the use of economic and fiscal instruments will have to constitute an increasingly important part of the overall approach" (67).	"Strong emphasis . . . [on] regulatory taxes, ecological tax reforms, obligation to provide information, obligation for producers to take back products after use, liability for environmental damage" (144), "High regulatory tax on fossil fuels" (161).
16	Transport	"Major restrictions of transportation volumes is not a viable solution, since access to efficient transport is vital for economic development . . . the goal therefore is improved efficiencies" (45).	"Transport is vital to both our economic and our social well-being . . . [but] all modes of transport have varying degrees of impact on the environment" (33). Tackle through improving infrastructure, user information, technical improvements to vehicles (35).	"Transport of goods by air and road in particular will be placed under limitations . . . a reduction of 70% in car kilometres is required in the Netherlands" (137).
17	Agricultural Policy	Make market work more efficiently: "Distorting farm subsidies should be removed . . . farmers needs access to clear property rights" (xiii).	"Strike a more sustainable balance between agricultural activity and the natural resources of the environment . . . [through] several types of financial assistance to [farmers]" (36).	"Crop diversification , local methods of erosion control, extensive agriculture . . . composting households waste, use of human waste . . . eat less meat" (10).
18	Changes in Industry Needed	"Corporations that achieve ever more efficiency while preventing pollution through good housekeeping, materials substitution, cleaner technologies and cleaner products and that strive for more efficient use and recovery	"Improved management and control of production processes . . . higher, more reliable product standards designed to ensure that the environmental impact of products during their whole life cycle is minimised . . . effective	"Reduction of the growth of the most energy-intensive sectors of industry: the chemical industry, the basic metal industry and the greenhouse sector" (9). "A rapid termination of chlorine production is necessary for sustainable

		of resources can be called eco-efficient" (xii). No sectors are excluded from this definition.	waste management . . . access to environmentally relevant data" (29). No sectors singled out.	development" (50).
19	Role of Government	Provide a framework to make markets work efficiently: "Make better use of the creative forces of local and international entrepreneurship by providing open and accessible markets, more streamlined regulatory systems with clear and equitably enforced rules, sound and transparent financial and legal systems, and efficient administration" (xiii).	"To achieve full integration of environmental and other relevant policies through the active participation of all the main actors in society (administrations, enterprises, general public) through a broadening and deepening of the instruments for control and behavioural change including, in particular, greater use of market forces" (19).	"Government policy must be screened for elements obstructing SD . . . The central task of government is to make sure that . . . a country does not exceed its environmental space and that the use of that space is distributed in a socially acceptable way" (12).
20	Role of New Technologies	"New technologies will be needed to permit growth while using energy and other resources more efficiently" (xi).	"A substantially increased and more coherent R&D effort is required in order to address the more far-sighted, cohesive and effective strategy contained in this Policy and Action Programme" (65).	New technologies are needed for a "radical ecological modernisation" and "maximum recycling efficiency" (12). Economic and growth implications are secondary.
21	Type of Technological Change Needed	Incrementalism, no targets: "Corporations that achieve ever more efficiency while preventing pollution through . . . cleaner technologies and cleaner products and that strive for more efficient use and recovery of resources can be called eco-efficient" (xii).	Although new technologies are needed, new regulations and incentives are required "so that environmentally-friendly goods and services are not at a market disadvantage vis-à-vis polluting or wasteful competitors" (8). There are no definitions, however, of what might be seen as "wasteful" or "environmentally-friendly".	Radical change and "ecological modernisation" necessary (12). Reduction targets of 60% for CO_2, 40% for water, 60% for timber usage, 80% for aluminium, 50% in household energy consumption. Also 95% recycling needed. (9-12).
22	Technology Transfer	"Technology co-operation relies primarily on private initiatives" (xii).	"Scientific and technological co-operation must be strengthened in order to reinforce endogenous technical capacities, flow of know-how and technologies must be accelerated" (85).	Since Northern lifestyles and technologies are unsustainable they should not be transferred. Instead, a "climate fund . . . financed by a world-wide tax on fossil fuels" could promote sustainable technologies in the South (161).

	ENERGY POLICY			
23	Energy	Change must wait until the future, if at all: "We cannot . . . change our energy systems drastically. All countries . . . [are] heavily dependent on fossil fuels" (35).	"The global challenge of the future will be to ensure that economic growth, efficient and secure energy supplies and a clean environment are compatible objectives" (31).	"The use of fossil fuels will have to be reduced so that the greenhouse effect is limited to a temperature rise of 0.1°C per decade" (9).
24	Climate Change Issue	Climate change may turn out not be a problem: "Improving energy efficiency . . . [makes] economic and environmental sense whether or not global warming becomes a dangerous reality" (35).	There are potential risks: "Global warming . . . [has] many associated risks - raising of sea levels, climatic disturbances, drought and desertification - which could have enormous implications for social and economic life" (82).	Damage from climate change would be inevitable: "A temperature rise of [more than] 0.1°C per decade . . . would have disastrous effects on humans and nature" (9).
25	Carbon Dioxide Emissions	No target, but unlikely to achieve stabilisation soon since: "fossil fuels are still expected to be the main source of energy well into the next century" (47).	"CO_2 stabilisation for 2000 by reference to 1990 levels" (32). With high prices, "further reductions of the order of 25% by the year 2010" could be achieved. (32).	"Between now and 2010, CO_2 emissions in the Netherlands will have to be reduced by 60%" (9) "World-wide, CO_2 emissions need to be reduced by 1 to 2 per cent a year" (9).
26	Economic Incentives for Energy Use	"The first priority must be to abolish subsidies so that the prices at least reflect the full economic costs of energy" (39) . . . "Carbon [taxes] . . .cannot achieve the goal . . . of stabilising CO_2 concentrations" (39).	"An overall strategy . . . would require that the real costs of consuming energy are passed on to the user (for example through a CO_2/energy tax)" (32).	"A high regulatory tax on fossil fuels . . . is in strict compliance with the general accepted principle that the polluter pays" (161).
27	Nuclear Energy	"Concern about global warming . . . could make nuclear energy a promising energy source" (48).	"Significant increase in nuclear power" (32), alongside "study on safety and waste aspects of nuclear energy" (33).	"Nuclear energy is not considered to be a sustainable source of energy" (9).
28	Renewable Energy	Market should choose: "Increased demand for renewable systems will . . . [make] all, especially solar, more cost-competitive" (49), no projections or targets are given..	"Further promotion of the use of renewable energy" (32), no targets are given.	With government intervention and "structural measures . . . by 2020, [solar cells] may well be providing over 30% of the global energy supply" (9).

Appendix B: Cultural Classification of Perspectives on Sustainable Development

	Reference	Classification	Comments
1	Allen (1990). *Why the Future is Not What it Was*	Complex	Analysis of evolution complex systems discussed in chapter 5. Discussion of types of behavioural strategy necessary to sustain a fishing fleet, conclusion that it involves both rational exploitation of information available today and ability to "ignore present information and to 'explore' beyond present knowledge" (p. 567) and thereby generate information. The emergent properties of strategies are seen to be linked to evolutionary dynamics of complex systems, and the rich diversity of behavioural styles and mental models cannot be explained simply in terms of cultural theory.
2	Angell (1995). *I Have Seen the Future and it Works . . . for Some*	Individualist	A wide-ranging discussion of technology and social trends. Like many individualists, he does not even consider environment as an important issue. The critical indicators of societal progress are investment in telecommunications; supporting art, culture, science and education to attract high calibre knowledge workers "not for reasons of altruism . . . but because it makes hard headed business sense" (p. 7). The individualist focus on the 'bottom line' is complemented by an evaluation that governments have become largely impotent in the face of globally mobile capital, and that the emphasis must return to "the individual innovator and entrepreneur" (p. 8).
3	Ausubel et al. (1989). *Technology and Environment: An Overview*	Individualist + Complex	The book focuses on technological developments related to environment rather than policy, but their outlook is evident when they argue that "as individuals, we do not want constraints imposed that affect mobility, life-style, convenience or purchasing decisions" (p. 19). Also an appreciation for technological evolution as a complex adaptive process, and a tolerance for uncertainty "we must also accept that in responding to many environmental questions, we may never know whether we are right or wrong even in the case of more narrowly defined scientific aspects of a given issue" (p. 20).
4	Ayres (1989). *Industrial Metabolism*	Complex	An evolutionary perspective of industrial processes as complex adaptive systems: "the biosphere as it now exists is very nearly a perfect system for recycling materials. This was not the case when life on earth began. The industrial system of today resembles the earliest stage of biological evolution, when the most primitive living organisms obtained their energy from a stock of organic molecules accumulated during pre-biotic times" (p. 23). Also references to Gaia.
5	Barney (1980). *Global 2000 Report to the President*	Egalitarian + Hierarchist	An important document in the 1980s environmental debate. Argues there are already too many people, population must be reduced, we cannot control nature and are not living in harmony with our natural environment, that we are running out of non-renewable resources, and that if present trends continue we will do irredeemable damage to our life support systems before the end of the 21st century, resulting in severe reduction of our own standard of living.

6	Beckerman (1974). *In Defence of Economic Growth*	Individualist	Defence of growth, including arguments about the efficiency of future market-driven technological change. Also argument that the issue of how consumption is spread over time (the growth issue) should not be confused with how resources are used at any moment in time, the point being that "the fact that resources are misallocated at any moment of time on account of failure to correct for externalities does not necessarily mean that the growth rate is wrong" (p. 20)
7	Beckerman (1994). *Sustainable Development: Is It a Useful Concept?*	Individualist	Strident rejection of simplistic environmental economics definitions of SD using free market economics theory. Admits "the world is faced with real environmental problems" (p. 205), but argues these are due to market imperfections, especially lack of property rights. Concludes SD is same as maximal welfare.
8	Bernstam (1991). *The Wealth of Nations and the Environment*	Individualist	Published by the free market Institute of Economic Affairs, an individualist argument that growth is good for the environment since it "can reduce pollution if it increases the productivity of resources faster than both resource output and population growth" (p. 34). This is the operation of the "Invisible Environmental Hand" in action (p. 40).
9	Bhagwati (1991). *The World Trading System at Risk*	Individualist	Like many works in trade policy, provides a clear cultural perspective. In this case, that assorted protectionist activities from managerialist hierarchists and anti-trade egalitarians is putting the individualist trading system at risk.
10	Boehmer-Christiansen (1994). *Global Climate Protection Policy: The Limits of Scientific Advice*	Unclassifiable	Detailed analysis of the dynamics of climate change research community and its production of knowledge for policy. Her description of the uptake of climate concern in different countries cannot be explained using cultural perspectives: "The UK 'greened' at an astonishing rate for political and energy policy reasons; the Germans had taken up the issue even earlier, for similar reasons, as had Norway, Sweden and France" (p. 189). Here more traditional political analysis, based on politics of interest and economic reasoning, is appropriate. Cultural considerations are secondary, not least because the above-mentioned group of nations is very diverse in terms of cultural theory's classification of national characteristics and yet had similar reasons for adopting the hierarchist myth of climate change, while other countries that were politically similar (especially the US, which was politically very close to the UK in the mid-1980s) did not.
11	Bossel (1987). *Viability and Sustainability*	Hierarchist + Egalitarian + Complex	Beginning with a description of viability of a self-organising system, which is closely related to complexity, he develops five indicators: physical existence needs, freedom of action, security, efficiency and adaptiveness. Through an elaborate, and rather hierarchist, methodology he constructs a series of 20 indicators. His analysis leads to egalitarian conclusion of regional self-sufficiency (p. 124), and yet a hierarchist desire for long term goals, clear plans, etc. (p. 126), and a hierarchist perspective that "the current path is unsustainable in the long run", rather than critical in the short term.
12	Brooks (1992). *Sustainability and Technology*	Unclassifiable (+ Complex)	Wide ranging discussion about meaning of SD especially as relates to technology. Call for adaptive management and social learning (pp. 37, 55), rather than hierarchist's belief in possibility of control. Admits most interventions unpredictable (p. 39) and surprise ubiquitous (p. 42), has individualist faith in nanotechnology (p. 40). Yet also supports hierarchist "global optimisation" (p. 48)

13	Carson (1991). *Silent Spring*	Egalitarian	Often regarded as the book that launched the modern environmental movement, a powerful attack on pesticides and their effects: "what we have to face is not an occasional dose of poison which has accidentally got into some article of food, but a persistent and continuous poisoning of the whole human environment"; "the 'control of nature' is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy" (p. 257).
14	CEC (1992). *Towards Sustainability*	Hierarchist	EU environmental strategy. Benchmark position analysed in Appendix A.
15	Cicero [106-43 BC], cited in Hughes (1975). *Ecology in Ancient Civilisations*	Individualist	An early individualist claim of the power of technology and human ingenuity: "We are the absolute masters of what the earth produces. We enjoy the mountains and the plains. The rivers are ours; we sow the seed and plant the trees. We fertilise the earth . . . We stop, direct, and turn the rivers. In short by our hands we endeavour, by our various operations on this worlds, to make, as it were, another nature".
16	Clark (1994). *Integrating Human Needs into our Vision of Sustainability*	Egalitarian	Analysis of SD as function of social behaviour and human needs. Argument that need for power and membership of important nation state "is obviously pathological" (p. 182), "our most basic needs [are] for genuinely shared meaning", conclusion that egalitarian village lifestyles such as Mexican fishermen in Yucatan, and societies based on common property such as Inuit, Cree and Japanese village fishermen are more environmentally sustainable and socially stable.
17	Cole et al (1973). *Thinking about the Future*	Hierarchist + Individualist	The University of Sussex critique of Limits to Growth. In part individualist, for example in assumptions about future rates of technological innovation, ability to control pollution and ability to recycle resources and discover new ones, but also hierarchist in policy analyses and recommendations. Main thrust is rejection of the egalitarian perspective.
18	Corson (1994). *Changing Course: An Outline of Strategies for a Sustainable Future*	Hierarchist + Egalitarian	Following a typical WRI-style introduction of trends and issues, he suggest that SD includes 12 dimensions (p. 213): environment, transport, economy, equity, social environment, population, health, education, culture, recreation, political participation and governance. To measure progress in these 12 dimensions, he produces an eclectic list of 90 policy priorities and 124 indicators, all of which are hierarchist or egalitarian. None measure individualist concerns about innovation, R&D, patents, scientists, small companies, entrepreneurship, investment in information technology, etc. A cursory analysis of some environmental initiatives is used to support a conclusion of "hope", coupled with an injunction to do "change course quickly", although the dimensions and institutions of change are typically hierarchist.
19	Daily et al. (1991). *Greenhouse Economics: Learn Before You Leap*	Egalitarian	Loose critique of cost benefit analyses of climate change. Made-up science, e.g. "there appear to be better than 50-50 odds that [climate] changes will occur" (p. 3), and loose economics "the cost of protecting coastal areas . . . would be so expensive that it's hardly worth calculating" (p. 4). Egalitarian call to arms: "we believe immediate action is required" (p. 8). More of a problem statement; ends with call for action but no policies.

20	Daly (1977). *Steady-State Economics*	Egalitarian (+ Individualist)	Blueprint for an egalitarian no-growth economy, "with constant stocks of people and artefacts, maintained at some desired, sufficient levels by low rates of maintenance 'throughput'" (p. 17). Population limited by per capita issue of transferable birth licenses (an egalitarian principle of fairness combined with an individualist market mechanism), and inequality of income and wealth is limited by setting of maximum and minimum levels, with redistribution from rich to poor.
21	Daly (1985). *Ultimate Confusion*	Egalitarian	Critique of Simon's *Resourceful Earth*, based on ideas of entropy and hard / close ecological limits. Note of Simon's views that environmentalists are speaking in value-laden terms when they speak of "wetlands lost", which Simon argues would be more objectively described as "swamps drained", a linguistic argument that supports cultural theory.
22	Daly (1992b). *Retrospect on Stockholm and Prospects for Rio*	Egalitarian	Evaluation of UN conferences on environment and development. Egalitarian positions such as "the only option . . . is a massive reallocation of existing global wealth", and that technology should be applied "to serve real human needs rather than expanding profits, warfare or national prestige" , and SD as "moral imperative to create a new vision" (p. 12).
23	Daly (1992c). *Allocation, Distribution and Scale*	Egalitarian + Plural (+ Complex + CT)	Argument that "for every independent policy goal we must have an independent policy instrument" (Tinbergen 1952), in this case for allocation (of resources among alternative product uses), distribution (among people) and scale (physical volume of throughput). Egalitarian argument that "we have moved . . . [to] a relatively full world from the point of view of human beings" (p. 187), and analysis of tradable pollution permits that regenerates the cultural perspectives: individualists are concerned about *efficiency*, hierarchists about *fairness* (initial allocation of permits), and egalitarians about *scale* (overall number of permits issued). Argument that all three perspectives are needed supports cultural theory, while acknowledgement that ecosystems have "discontinuities, thresholds and complex webs of interdependence" (p. 190) is used to demonstrate that economic ideas of perfect knowledge and calculability are unrealistic, although this note on complexity is not referred back to resolving the evident problems that emerge for allocating tradable permits.
24	Daly and Cobb (1990). *For the Common Good*	Egalitarian	A wide-ranging deconstruction of neo-classical economic theory, and a proposal for an alternative community-based model of wealth and economy, which is also seen to be much more ecologically sound. In the strength of its anti-market, anti-free trade and pro-community views, this is among the most fully developed policy statements of what an egalitarian economy and policy world would actually look like. Also has a spiritual and religious dimension provided by theologian co-author.
25	Devall (1990). *Simple in Means, Rich in Ends*	Egalitarian	A deep ecology perspective, incorporating feminism, non-violent political action and mysticism. "Practising deep ecology means cultivating a sense of the wild centre in a civilisation out of balance. Actions comes from the centre of the circle where all is condemned, potential energy" (p. 203).

26	Douthwaite (1992). *The Growth Illusion*	Egalitarian	A critical analysis of growth, in keeping with the critical rationality of the egalitarian. The contents list provides a clear summary of the egalitarian policy position: "Ned Ludd was right . . . how growth damaged family and community life . . . growth must have a stop . . . innovations must only be permitted when it is clear that society and the environment will benefit . . . if the world is to have a future it must govern our actions again" (pp. v-vi).
27	Dovers and Handmer (1993). *Contradictions in Sustainability*	Egalitarian (+ Plural + CT)	Analysis of eight themes in SD which include divergent perspectives. Egalitarian tendencies shown by emphasising collective nature of challenge (p. 219) and comments on equity as equality of outcome (p. 218). Comment that modern cultures rarely confer "sacred status" on environment (p. 221). Their analysis of attitudes towards the "contradictions" itself regenerates the three cultural perspectives: pessimism (egalitarianism); seeing them as an unavoidable part of social change on the way to SD (hierarchy); ability to live with paradox is human strength, not problem (individualist)
28	Durning (1992). *How Much is Enough?*	Egalitarian	Analysis of consumption and its implications for sustainability. Egalitarian conclusion that we must reduce our wants and supposed needs to meet the biosphere's capacity. "In the final analysis, accepting and living by sufficiency rather than excess offers a return to what is, culturally speaking, the human home: to the ancient order of family, community, good work and good life; to a reverence for skill, creativity , and creation; to a daily cadence slow enough to let us watch the sunset and stroll by the water's edge; to communities worth spending a lifetime in; and to local places pregnant with the memories of generations" (p. 150).
29	Ecologist (1993). *Whose Common Future?*	Egalitarian	A series of critiques of the concept of SD: "sustainable development - now the "buzzword" of environmentalists, politicians, business leaders and strategic planners alike - would appear to cloak an agenda that is just as destructive, just as undermining of peoples' rights and livelihoods as the development agenda of old" (pp. vi-vii).
30	Ehrlich (1969). *Eco-Catastrophe*	Egalitarian	An early egalitarian scenario of doom: "all important animal life in the sea was extinct . . . dead fish created a monumental stench . . . Japan and China were faced with almost instant starvation".
31	Ehrlich and Ehrlich (1990). *The Population Explosion*	Egalitarian	Description of the population explosion and its disastrous ecological consequences. Egalitarian views confirmed by value laden description of "technological sophistication, that is the environmental destructiveness of technology" (p. 58)
32	Ekins (1991). *The Sustainable Consumer Society: A Contradiction in Terms?*	Egalitarian	A strongly pessimistic egalitarian introduction to state of environment, quoting Queen Beatrix of the Netherlands in her 1988 Christmas message "The earth is slowly dying, and the inconceivable - the end of life itself - is actually becoming conceivable. We human beings have become a threat to our own planet" (p. 247). Supports FoE's estimates of 60% CO_2 reductions in the North, and a conclusion that we require a "no-growth economy" (p. 252). The egalitarian problem definition continues, noting the breakdown of families and communities, and arguing that world satisfaction is found not in economic wealth, but in "other people, work and leisure" . Egalitarian policies: "support families, reinforce communities . . . cut through the credulous fantasies of green growth and . . . [look] beyond consumption" (p. 254)

33	Ekins (1993a). *Limits to Growth and Sustainable Development*	Egalitarian + Plural (+ Hierarchist)	A comparison of environmental debates in the 1970s and 1980s, noting that the "pessimists' [egalitarians'] conclusions are essentially unchanged" (p. 277), although he conflates the hierarchist positions of WCED and WRI with the individualism of BCSD and ICC. He presents an economic analysis based on the Ehrlich identity I = PAT (Ehrlich and Ehrlich 1990), with the egalitarian assumption "that current levels of I [environmental impact] are unsustainable", which may be compared with hierarchist concerns that they will become unsustainable. Having established that technological trends are unpredictable, he nevertheless concludes with egalitarian strategies for North and South.
34	Ekins (1993b). *Trading Off the Future*	Hierarchist (+ Egalitarian)	A trade policy paper. Argues that "patterns of economic activity are on a collision course with the global environment's ability to sustain that activity" (p. 2), that environment takes precedence over free trade "if the world's trading system were to collapse, doubtless much hardship would result. If the global environment were to collapse, the result would be much worse" (p. 6), yet despite egalitarian-hierarchist concerns, he concludes in terms of reforming trade, rather than reducing trade (FoE 1993) or abandoning trade in favour of community economies (Daly and Cobb 1990).
35	Ekins et al. (1992). *Wealth Beyond Measure*	Egalitarian + Hierarchist	A self-proclaimed "atlas of new economics", the book "seeks to expose how much current economic practice actually destroys more wealth than it creates" (p. 8), while rejecting the mainstream environmental economic techniques of contingent valuation and cost-benefit analysis as "dangerous if they imply that all environmental values can be measured in this way. As with the ozone layer, many cannot" (p. 44). Yet also includes an anti-individualist, hierarchist dystopia of the declining power of government "its ability to govern is being diminished by the growing power of non-democratic, unaccountable, centrally planned corporations" (p. 131).
36	Elgin (1994). *Building a Sustainable Species-Civilisation*	Egalitarian	"The Earth's biosphere is being severely wounded, even crippled, by humanity" (p. 234), he concludes that we must break "the cultural hypnosis of consumerism" (p. 244), but provides no practical policy advice, although he does claim that in the US, "the average person sees more than 25,000 commercials a year" (p. 242), and he quotes Simone de Beauvoir "Life is occupied in both perpetuating itself and in surpassing itself; if all it does is maintain itself, then living is only not dying" (p. 235), which he takes to imply that SD cannot be seen purely as a technocratic challenge.
37	Enzensberger (1990). *The State of Europe*	Unclassifiable	Discussion of role of political leadership following the end of the Cold War. He supports an egalitarian world-view, that "by the end of the century the question would no longer be of improving the world but of saving it . . . the most difficult retreat of all will be in the war against the biosphere which we have been waging since the industrial revolution" (p. 142), yet his institutional preferences are grounded in the hierarchical world of realpolitik, not the egalitarian communal utopias.

38	ERM (1994a). *Towards Sustainable Development*	Egalitarian + Hierarchist	Insightful review of current status of policy progress towards SD. Its orientation towards guiding EC policy necessarily forces a somewhat hierarchical approach, but most of the underlying concepts are egalitarian, notably that a "win-win development trajectory (no pain) may not exist" (p. 17), that the hierarchist analysis of CEC (1992) is overly optimistic, that our "normal way of life is . . . fundamentally unsustainable" (p. 20), and SD "will require a fundamental shift in society's beliefs, attitudes and behaviour" (p. 23).
39	FoE (1993). *Sustainable Netherlands*	Egalitarian (+ Hierarchist)	Benchmark position analysed in Appendix A. Some Hierarchist tendencies in institutional/policy choices, which are government-oriented, rather than community focused as with deeper greens.
40	Fosberg (1991). *After Zero Growth?*	Egalitarian + Complex	Conclusion that most systems are highly complex "often to the extent of being virtually unmanageable" (p. 3), so hierarchist managerialism is impossible. But he supports "the required zero-growth situation" (p. 4) as egalitarian.
41	GATT (1992). *Trade and the Environment*	Individualist	Perhaps predictably, as the organisation charged with upholding the functioning of the most clearly established example of an individualist institution, namely the world trading system, GATT argues that the importance of free trade to economic growth (the unquestioned individualist objective) means we should not risk environmental interventions in the free operations of the market, whether on the basis of hierarchist or egalitarian rationales.
42	Gladwin et al. (1995). *Shifting Paradigms for Sustainable Development*	Hierarchist (+ Egalitarian + CT)	Derivation of "sustaincentric" paradigm of SD through Hegelian synthesis of the technocentric (individualist) and ecocentric (egalitarian) paradigms. In fact, they simply succeed in regenerating the hierarchist perspective, which is "managerialist" (p. 32) and calls for cost internalisation, tax reform (p. 29) and "stringent ecological, social and economic impact assessments" (p. 28), although quite how these are supposed to be done in the face of "dynamic complexity" (p. 31) is unresolved. Nevertheless, interesting as it provides a good summary of CT myths.
43	Goldsmith, E. (1988). *The Great U-Turn: De-Industrialising Society*	Egalitarian	The title says it all. Includes an ecological explanation for the fall of the Roman Empire, and deep green perspectives on unemployment, health, education, pollution and war. Strong focus on family and community, and the final chapter calls for the "phasing out of labour-saving technology" (p. 210) and the "phasing out of consumer products" (p. 215).
44	Goldsmith, E. (1992). *The Way: An Ecological World View*	Egalitarian	A deep green tract and comprehensive statement of deep ecology in sixty-six short chapters, with titles including "ecology is a faith", "The Biosphere is one", "Gaia is alive", and "Progress is anti-evolutionary and is the anti-Way", the last of which argues that "with the globalisation of progress, we are rapidly heading towards a global Biospheric disclimax in which modern man will have effectively reversed three thousand million years of evolution" (p. 368).

45	Goodland et al. (1993). *The Urgent Need for Rapid Transition to Global Environmental Sustainability*	Egalitarian + Hierarchist	A strongly egalitarian problem definition, based on Daly's distinction between full / empty world, and egalitarian list of priorities are population stability, renewable energy, education and training, technology transfer (but labour-intensive, rather than capital-intensive) and direct poverty alleviation (p. 299). Yet the practical policy measures are hierarchist and interventionist, such as "remoulding consumers' preferences and steering wants" (p. 302), and in particular an extended call for technocratic environmental assessment. After calls for institutional strengthening and enforcement, the conclusions are purely hierarchist: "sound economic, improved use of environmental assessment, environmental accounting and direct guidelines". The dissonance with Daly's other policy recommendations, e.g. Daly and Cobb (1990), suggests that perhaps the authors felt constrained in this article by their employer, the World Bank.
46	Gorz (1983). *Ecology as Politics*	Egalitarian	Strident critique closely related to Illich: in environment, as in medicine, "capitalist civilisation leads people to consume, on the one hand, that which destroys, and on the other hand, that which repairs the destruction" (p. 149). Also includes "A possible utopia", an extended scenario of how the French government could put in place egalitarian policies on transport, culture, working less, and consuming better, including banning television on Fridays and Saturdays so as "to encourage the exercise of imagination and the greater exchange of ideas" (pp. 42-50).
47	Gowdy (1992). *Economic Growth versus the Environment*	Egalitarian	Anti-growth tract. Strong assertion that increases in population, consumption, markets and investment in developing countries are all "lethal to the environment" (p. 102). "What is objectionable . . . [is] the reality of the market system itself" (p. 103), conclusion that growth must be stopped, no policies given.
48	Group of Green Economists (1992). *Ecological Economics*	Egalitarian	Not to be confused with the academic ecological economists, the Group of Green Economists are associated with the German Greens, and draw on environmental, women's and human rights movements. Their principles include self-reliant development, the rejection of free trade, ecological balance, and democratisation of the global economy (p. 3), which will necessitate large-scale measures to regulate and control the world's multinational corporations (pp. 82-92).
49	Hardin (1993). *Living Within Limits*	Egalitarian, Complex	Literate in the functioning of ecological systems and complex systems generally, deeply concerned with population, Hardin takes an egalitarian stance in policy terms: "Every shortage of supply is equally a 'longage' of demand: Focusing on shortages encourages greed (and makes a favoured few people rich). Focusing on longages encourages temperance in making demands. The problem of balancing supply and demand is not in the stars, and the solution is not in technology: it is in our heads" (p. 310).
50	Harman (1985). *Colour the Future Green?*	Egalitarian + Individualist	Analysis of beliefs and views of the Green parties; good summary of egalitarian perspective. Supports cultural theory's argument that environmentalism splits the left/right dichotomy, quotes German Green Herbert Gruhl "We are neither left nor right; we are in front" (p. 321). Sympathetic reading of the New Age transformation scenario, but open minded about whether Green politics will bring deeper change like "Christian communities in third century Rome" (p. 327). Yet also individualist, as the source of this spiritual renewal is technology, notably information technology.

51	Hawken (1993). *The Ecology of Commerce*	Unclassifiable	Hawken is a successful individualist and entrepreneur with egalitarian beliefs. His suggested guidelines for sustainability include both "reduce absolute consumption of energy and natural resources in the North by 80%" and "honour market principles . . . we have to work with who we are . . . we can't just ask people to save more to save the planet" (pp. xiv-xv). Part of the classification problem arises from internal contradictions in the text, for example he is pro-market, yet against the GATT process of market liberalisation (pp. 98-100). Many of his policy prescriptions for new regulations and ecological tax reform are incompletely understood and recycled from hierarchist policy think-tanks.
52	Heinen (1994). *Paradigms on Sustainable Development*	Egalitarian	Interdisciplinary view of SD, quoting materials from social sciences, eco-philosophers, natural scientists and applied scientists. Yet although these perspectives are balanced in a disciplinary sense, they are unbalanced in the sense that they are all egalitarian: green economics, deep ecology, etc.
53	Heinen and Low (1992). *Human Behavioural Ecology and Environmental Conservation*	Egalitarian	Application of behavioural ecology to study environmental debate. Begins with a sociobiological approach, but does not carry analysis through to policy discussion. "Much apparent 'progress' may be an illusion" (p. 105), policies should aim for long term good of all people (p. 108), emphasis on community (p. 112), criticism of government and argument that NGOs have driven most environmental change.
54	Henderson (1994). *Paths to Sustainable Development: The Role of Social Indicators*	Egalitarian (+ Hierarchist)	An analysis of indicators to measure 'progress' in society, based on alternative indicators and green GNP type work. Based on her earlier work on quality of life indicators in Jacksonville, Florida (Henderson 1991), she has indicators in 9 categories: economy, public safety, health, education, environment, mobility, government, social environment and culture (p. 132), but, like Corson (1994) has no individualist indicators: all are hierarchist or egalitarian. The same applied to the "country futures indicators" she proposes (p. 133), arguing they include "all major categories and subcategories that I deem necessary" (p. 136). In this sense, the selection of indicators, or three scenarios of the future, as in Marien (1994a), provides a useful heuristic for rapid cultural classification. Her rejection of environmental economics and the impossibility of pricing resources appears anti-hierarchist, and she endorses ecological tax reform. A final example is her citation of Southern NGO estimates at UNCED that the north's "pollution debt to the world [is] between $15-20 trillion" (p. 135)
55	Hirsch (1976). *Social Limits to Growth*	Unclassifiable (+ Egalitarian?)	Argument that social limits to growth arise from the increasing importance of positional goods (p. 27) and the breakdown of individual morality (p. 141), with general argument that "economic growth undermines its social foundations" (p. 175). Yet although critical of the individualist argument that current economic systems do not need changing, he is equally critical of egalitarian environmentalists, arguing that "the concern with limits to growth . . . voiced by the Club of Rome . . . is strikingly misplaced" (p. 4). By rejecting the beliefs of all major rationalities, he renders himself unclassifiable in cultural theory terms, although he may perhaps be seen as an egalitarian who does not share the myth of nature being highly precarious and the need for urgent precautionary action.

56	Hirschhorn and Oldenburg (1991). *Prosperity without Pollution*	Hierarchist + Egalitarian	A technologically and technically rich perspective on pollution prevention, written by two former employees of the US Government Office of Technology Assessment. Recommended policies include pollution and waste taxes, bans of chemicals and products, labelling, and changing government purchasing (pp. 346-354). Despite the hierarchist solutions, the tone is stridently egalitarian "there is no safe spot on planet Earth anymore" (p. 356), "All nations must replace the search for a middle ground between ecology and economy with a pollution prevention strategy that puts ecology first" (p. 357).
57	Hueting (1986). *An Economic Scenario for a Conserver Economy*	Unclassifiable, Plural	Argues that economic growth does not mean GNP growth, but does mean increase in welfare, which has seven components" production, environment, employment, leisure, working conditions, income distribution and safety of the future (pp. 243-244). This set of indicators suggests a plural approach that cannot be clearly classified within any cultural type.
58	ICC (1990a). *The Business Charter for Sustainable Development*	Individualist	An archetypal individualist approach: a set of voluntary principles for corporations to adopt in moving towards sustainability (developed in order to preclude the possibility of hierarchist, government-imposed environmental codes of conduct for multinational companies being promulgated by UNCTC in the late 1980s). Growth is the objective and itself the source of SD: "Economic growth provides the conditions in which protection of the environment can best be achieved, and environmental protection . . . is necessary to achieve growth that is sustainable".
59	ICC (1990b). *The Greening of Enterprise*	Individualist (+ Hierarchist)	A series of essays by leading business figures before environmentalism became a mainstream corporate issue, most of which are reports of initiatives undertaken and progress achieved, rather than policy analyses or recommendations, although the tone is individualist and wary of further regulation. Also has an early speech by Schmidheiny before the conception of the BCSD, which can be used to trace the evolution of his thinking and that of industry in general.
60	Illich (1973). *Tools for Conviviality*	Egalitarian	Not primarily environmental, but very much egalitarian: "I choose the term 'conviviality' to designate the opposite of industrial productivity. I intend it to mean autonomous and creative intercourse among persons, and the intercourse of persons with their environment; and this in contrast with the conditioned response of persons to the demands made upon them by others, and by a man-made environment . . . I believe that, in any society, as conviviality is reduced below a certain level, no amount of industrial productivity can effectively satisfy the needs it creates among society's members" (p. 11).
61	IUCN/UNEP/WWF (1991). *Caring for the Earth*	Hierarchist (+ Egalitarian)	A "global strategy for sustainable living", emphasising ecological preservation and improving quality of life while staying within carrying capacities. Environmental concern, but the tone is preservationist (hierarchist) rather than anti-growth catastrophism (egalitarian), and its proximity to hierarchist positions is confirmed by IUCN's view that "Caring for the Earth contributed to, and complements, Agenda 21. The two could well be used together" (IUCN and IIED 1994, p. 26)

62	Jacob (1994). *Sustainable Development and Deep Ecology*	Egalitarian + Hierarchist	Comparative analysis of SD (in the hierarchical, WCED sense) and deep ecology. Although obviously sympathetic to the egalitarian perspective, she concludes that the solution "may very well lie in a perspective that is able to synthesise the information in all of the available perspectives into a coherent worldview" (p. 487). No mention of individualist view.
63	Jasanoff (1993). *India at the Crossroads in Global Environmental Policy*	Egalitarian + Hierarchist (+ CT)	Analysis of the environmental debate in India. Strong affirmation of cultural style of analysis by observing links between cognition and institutional commitments in debates such as forest protection and hydroelectric power, and also in North / South issues, e.g. climate. Interestingly, there is no discussion of the individualist perspective (e.g. Indian entrepreneurs).
64	Kelly (1994). *Out of Control*	Individualist	A survey of trends in complexity, science, economics and biology that are producing new human artefacts which combine technology and biology. Optimistic view of trends and possibilities, demonstrating tremendous progress in technology, and producing a sense of unlimited opportunity. Chapter on artificial biospheres, following progress of Biosphere 2, takes the individualist perspective that recreating worlds is within the grasp of man. Nature is not simply to be managed, but recreated. Perspectives on biotechnology are similar.
65	Lovelock (1988). *The Ages of Gaia*	Complex + Egalitarian	Gaian description of the history and evolution of life on earth, which is closely related to complexity theory. The last chapter deals with policy implications, and he presents a personal perspective which is decidedly egalitarian "the recent act of destruction of the English countryside is a vandalism almost without parallel in modern history" (p. 228), although he sees the focus of the environmental movement as "more against authority . . . than for saving the countryside. They sometimes noticed poisonous sprays, for they were the product of the hated multinational chemical industries" (p. 229).
66	Macrae (1994). *The Next Forty Years*	Individualist	Republication of prescient 40-year forecast of trends in business and society first published in 1972. Critique of hierarchist planning (p. 383). Strong individualist arguments for benefits of liberal markets (p. 184), promise of information technology (p. 387), and view that innovation is becoming "exponential" (p. 389). Also individualist on environment "prophets of ecological disaster grossly underestimate the mounting elasticities of substitution and production" (p. 385), and that "we are probably creating . . . too many anti-pollution measures" (p. 383).
67	Mannermaa (1986). *Futures Research and Social Decision Making*	Egalitarian	Analysis of role of futures studies, includes case study of Nordic Alternative Campaign, which promotes an egalitarian vision of society (p. 665), including co-operation instead of competition, ecological balance, production based on human needs instead of commercial purposes, self help, self-sufficiency and local communities, and new relations between North and South. The policy measures are also a paradigmatic egalitarian vision, including radical decentralisation, etc.

68	Marien (1994a). *Infoglut and Competing Problems: Key Barriers Suggesting a New Strategy for Sustainability*	Egalitarian + Hierarchist	An interesting survey of two trends in futures though, one of the "information society" (which is driven by individualist technological progress), the other of the "sustainable society" (driven by egalitarian concern over environmental decay). Yet in generating three possible future scenarios (pp. 252-253), he has "false success" (which is a hierarchist/ egalitarian hybrid), "more of the same" (hierarchist) and "evident regress" (egalitarian), omitting an individualist future of overcoming problems through innovation and technology, not least the information technology mentioned earlier. This use of scenarios suggests their power in helping to analyse assumption and myths of nature in a robust manner.
69	Markley (1994). *Rethinking the Legacy of Columbus*	Egalitarian	Drawing on concerns that contemporary futures work is white, male, American and neo-colonial, he develops a new model that does not have these features, and is essentially egalitarian. He also notes the increasing speed at which we are approaching ecological limits (p. 773), citing Meadows (1972, 1992). He sees the key as learning to exchange "the *patriarchal patterns of domination and greed for more egalitarian ways of co-operative partnership" (p. 780).*
70	McKibben (1990). *The End of Nature*	Egalitarian	A story of the greenhouse effect, biotechnology and their implications, emphasising that the environmental is no longer "natural", as it is everywhere controlled, manipulated, influenced and polluted by man: "The carbon dioxide and trace gases act like glass on a greenhouse. But it's more than that. We have built a greenhouse, *a human creation*, where once there bloomed a sweet and wild garden" (p. 84, emphasis in original). "The problem is that nature, the independent force that has surrounded us since our earliest days, cannot coexist with our numbers and our habits. We may be able to create a world that can support our numbers and our habits, but it will be an artificial world, a space station" (p. 156).
71	Meadows (1991). *The Global Citizen*	Egalitarian (+ Complex)	A series of personal reflections and short essays on environmental problems and also on systems thinking and systems dynamics. "optimism and pessimism are just two different forms of surrender to the same simplicity. The world isn't simple" (p. 268); "an ecologically deranged earth is at the end of the path our current society is hotly pursuing" (p. 277).
72	Meadows et al. (1972). *The Limits to Growth*	Egalitarian	An archetypal egalitarian prognosis of global collapse occurring unless there is urgent action: "the most probable result [of reaching the limits to growth] will be a rather sudden and uncontrollable decline in both population and industrial capacity" (p. 23). Its policy recommendations are not sufficiently wide-ranging for it to be used as a benchmark.
73	Meadows et al. (1973). *A Response to Sussex*	Egalitarian (+ Complex)	A rebuttal of the University of Sussex's (Cole et al 1973) criticisms of *The Limits to Growth.* The dynamical systems critique of traditional modelling is valuable in establishing a complex systems perspective, although the assumptions made by the authors are egalitarian, especially for technology "We do oppose the present trend of technological 'progress'" (p. 144), a perspective which may indicate why technology is poorly represented in the World3 model.

74	Meadows et al. (1992). *Beyond the Limits*	Egalitarian	Essentially a restatement of their 1972 conclusions: "[The possible paths into the future] do not include continuous growth. The choices are to bring the burden of human activities upon the earth down to a sustainable level through human choice, human technology and human organisation, or to let nature force the reduction through lack of food, energy or materials, or an increasingly unsound environment". A testament to the capacity of strongly-held myths of nature to be maintained and strengthened over long periods of debate, scientific advance and policy development.
75	Milbrath, L. W. (1994). *Stumbling Blocks to a Sustainable Society*	Egalitarian	Development of an egalitarian "new environmental paradigm" on the basis of "physical and social systems imperatives", which he contrasts with the "dominant social paradigm". Calls for "co-operative, gentle, caring society" (p. 122), and has as his "top priority . . . a structure for controlling science and technology", in view of its potential damage to nature.
76	Morris, W. (1970). *News from Nowhere*	Egalitarian	First published in 1890, a vision of 21st century Britain as an egalitarian, communist world, told by a man transported through time and taking a walk around London as it has become. Although not particularly about environmental concerns, it offers a detailed vision of economics, politics, history, philosophy and work in an egalitarian utopia.
77	Nierenberg (1993). *Science, Policy and International Affairs*	Individualist	Beginning with a study of the scientific controversy over DDT, he concludes that most environmental policy is unscientific. Individualistically, he argues that climate debate "Ignores what is possibly the most potent factor, and that is the advance of technology" (p. 196) He also demonstrates how great scientists and political leaders such as Millikan, Rutherford, Roosevelt, Churchill and Bonaparte have consistently underestimated technological progress, "even as late as 1956 the British Astronomer Royal felt that space travel was 'utter bilge'" (p. 197).
78	Orr (1992a). *Ecological Literacy*	Egalitarian	Deeply egalitarian discussion of need for new awareness and education, and detailed suggestions on how to do this. Not a policy analysis. Includes discussions on postmodernism, spirituality, consciousness, human nature, appropriate technology, deep ecology and social change. Emphasis on the "software of sustainability" (p. 181), the changes needed at a personal and spiritual level.
79	Orr (1992b). *Pascal's Wager And Economics in a Hotter Time*	Egalitarian	Call for action on climate change, drawing analogy to Pascal's weighing the existence of God and arguing that belief was the best strategy since "if you gain, you gain all; if you lose, you lose nothing". Vigorous egalitarian critique of Nordhaus' work on climate change, particularly on the use of cost-benefit analysis as immoral in biospheric issues (p. 5)
80	Porritt (1984). *Seeing Green*	Egalitarian	An eloquent statement by an acknowledged leader of the greens, includes a striking contrast between the "politics of industrialism" and the "politics of ecology" (pp. 216-217), which provide an excellent overview of the egalitarian position. For example, some illustrative contrasts he draws are between materialism and "a move towards spiritual, non-material values"; high income differentials and low ones; ever-expanding world trade and self-reliance; employment as means to an end and work as an end in itself; dependence upon experts and participatory involvement; domination over nature and harmony with nature; environment managed as a resource and resources regarded as strictly finite.

81	Redclift (1988). *Sustainable Development and the Market*	Egalitarian	Review of "environmental change under capitalism" (p. 636), argument that "managerialist" (i.e. hierarchist) approaches are failing. Clear and sympathetic outline of egalitarian position, especially political questions such as "who is to do the 'managing' of the environment?" (p. 644). Conclusions are of academic/analytical nature rather than policy relevant.
82	Redclift (1994). *Reflections on the 'Sustainable Development' Debate*	Egalitarian	Examination of various economic, political and epistemological uses of SD. Concludes that SD is "contested domain" (p. 3), provides detailed critique of World Bank's hierarchical approach, and takes a political approach to questioning how SD leads to tension and conflict. Unusual for its egalitarian critique of hierarchy, rather than individualism, which is barely mentioned.
83	Richards et al. (1994). *The Greening of Industrial Ecosystems*	Complex	Systems-oriented perspective on industrial metabolism and organisation, and central focus on problems of complexity. For example, they show that making a "rational choice" on environmental grounds between plastic, paper and ceramic drinking cups is highly complex, and sensitive to numerous assumptions about use and re-use, patterns of washing, and other consumption practices (p. 1).
84	Richardson (1985). *The Resourceful Earth: Optimism and Confrontation*	Hierarchist	He analyses the technological optimist -vs.- pessimist debates of the 1970s and early 1980s, and concludes that they were confrontational and counterproductive, that we now need an integrative approach that serves policy officials and the public in securing "the goal which is shared by all of us: the goal of a human society that is more humane, more materially sufficient, more equitable and more empowering". He lacks the urgency of egalitarian and optimism of individualist, and by staking out the middle ground, essentially recreates the hierarchist position, much like Gladwin (1995). He specifically mentions cultural theory as an explanatory tool, mentioning Caputo's (1984) use in analysing the debate on energy policy.
85	Schmidheiny et al. (1992). *Changing Course*	Individualist (+ Hierarchist)	Business perspective on SD. Benchmark position analysed in Appendix A. Some Hierarchist tendencies in discussion of cost internalisation, but clear preference for free trade above environment demonstrates individualism at root. Also fails to include the radical individualist / entrepreneurial faith in the power of new technologies, particularly information technology.
86	Seabrook (1988). *The Race for Riches*	Egalitarian	An impassioned tract against growth, and the "soulless system" that is the source of our problems. "The rich eat up the substance of the poor at the same time as they seek more elaborate forms of escape from their own inner desolation - that mirror of the tormented and ruined landscape without" (p. 5).
87	Shearman (1990). *The Meaning and Ethics of Sustainability*	Egalitarian + Hierarchist	Ultimately unsuccessful attempt to provide framework for SD definitions. Hard to classify in cultural theory terms, since the argument is often diffuse and inconclusive, and there are no policy recommendations. At various stages, however, the egalitarian and hierarchist perspectives are both adopted, and the WCED definition is cited with approval, but there is no discussion of individualist perspective.

88	Simon (1981). *The Ultimate Resource*	Individualist	Rejection of Limits to Growth pessimism, arguing that man's creativity earns him the title "the ultimate resource". Population growth is to be welcomed, not least because with 4000 births there is more chance of getting another Mozart or Einstein than with only 400. Emphasis on adaptability, creativity and market-driven innovation and change, strong support of individualist policies.
89	Simon and Kahn (1984). *The Resourceful Earth*	Individualist	A lengthy rebuttal of the Global 2000 report, arguing that on present trends "the world in 2000 will be less crowded (although more populated), more stable ecologically . . . the world's people will be richer in most ways than they are today" (p. 2), they support nuclear energy, a free market, and no fundamental changes to current lifestyles.
90	Slocombe (1993). *Environmental Planning*	Complex (+ Egalitarian)	Discussion of mainstream ecology, complex/ecosystems science and environmental planning. Critical of the hierarchist environmental impact assessment / World Bank style approach, and proposes a process-oriented, participatory approach which is essentially a complex/adaptive policy model. Egalitarianism, e.g., in calls for better appreciation of limits (p. 298)
91	Smil (1987). *A Perspective on Global Environmental Crises*	Individualist	A rebuttal of environmental "catastrophic faddism" regarding deforestation, acid deposition, global warming and nuclear winter. A robust defence of biospheric resilience, and a clear individualist defence of adaptation for global warming. Notable primarily for its presentation of scientific evidence that contradicts egalitarian positions.
92	Speth (1989). *Can the World Be Saved?*	Hierarchist	Although the title suggests an egalitarian concern, the policy measures are archetypically hierarchist: "no hidden hand is operating to guide technology. We must think hard about the interventions that will be needed" (p. 295), science "must provide us with early and accurate assessments of possible technological innovations and their consequences intended and unintended" (although he does not explain how the unpredictable will be predicted). Also, the hierarchist approach of new co-operation among business, government and NGOs; "upgraded international environmental agencies"; internalising externalities (p. 296), all the while accepting that economic growth is inevitable and desirable (p. 299).
93	Tinbergen and Hueting (1991). *GNP and Market Prices: Wrong Signals for Sustainable Economic Success*	Unclassifiable (Egalitarian + Individualist)	Arguing that "society is steering by the wrong compass", the authors (including a Nobel prize winning economist) move via the egalitarian assumption that "rising production and consumption cannot be sustained forever in a finite world" (p. 53), but they argue that this is not a problem because "environmentally benign activities are remarkably cheap", e.g. a bicycle is cheaper than a car, so "saving our planet is indeed possible" (p. 53). Yet their policy priority is correcting market mechanisms so they function better (individualist), despite their four key policies being egalitarian: new cleaner technologies, stop production growth in the North, stabilise population and improve international income distribution.
94	UN (1992). *Agenda 21*	Hierarchist (+ others)	Overall a benchmark hierarchist position, but in its effort to be inclusive, and as a function of the Rio negotiation process, there are many parts that reflect egalitarian and individualist perspectives, although these paragraphs are clearly distinct from the rest of the document. A more detailed overview of the contents may be found in Grubb et al. (1993)

95	UNEP (1992). *Saving our Planet: Challenges and Hopes*	Hierarchist	The hierarchist approach is immediately apparent given that every paragraph of this book is numbered. In addition to endorsing the hierarchist Brundtland Report (p. 177), the policy conclusions are couched in terms of international regulation, new international institutions, comprehensive assessment and monitoring, and integrating natural resources in national accounts (pp. 178-179). There is little evidence of individualist or egalitarian policy prescriptions.
96	Viederman (1993). *A Dream of Sustainability*	Egalitarian	An encouragement to "dare to dream" about SD futures. His own is egalitarian: equity and ecology as keys to all policy; humility and restraint with precaution; "sufficiency will replace efficiency, and we will be able to distinguish between needs and wants" (p. 178); right scale and community will be seen as policy foundations; diversity - both human and biological - "will be preserved, defended and encouraged". These five principles are an egalitarian archetype.
97	Wallace and Norton (1992). *Policy Implications of Gaian Theory*	Unclassifiable + Plural + Complex	A detailed overview of Gaian theory espoused by Lovelock, Margulis and others, confirming the resilient, self-regulatory nature of Gaia, a perspective that can only fit with the individualist myth of nature resilient. They reject simplistic biocentric arguments that "moral obligations to Gaia . . . override obligations to protect human individuals" (p. 113), and develop a complex systems / hierarchical perspective of ecosystems. They argue against the utility of cost-benefit analysis on a single hierarchical scale, and conclude that a "pluralistic system of analysis" is called for since "the world of experience is unavoidably complex, and there are many valid perspectives and scales upon which to describe and evaluate nature. There is no unitary picture of reality against which a paradigm can be compared" (p. 116). They develop a complex/adaptive policy model of "developing second-order criteria for determining which rules to apply in particular situations", which is parallel to Holland's work on classifier systems discussed in chapter 5. The conclusion is that once a plural, complex description of reality is entertained, as here, simple cultural classifications are not possible.
98	WCED (1987). *Our Common Future*	Hierarchist	The Brundtland Report, an hierarchist archetype. In particular, emphasis on complementarity between growth and environment: SD needs "a new era of economic growth - growth that is forceful and at the same time socially and environmentally sustainable",
99	Weizsäcker (1994). *Earth Politics*	Unclassifiable	An egalitarian problem definition, with full acceptance of the need for 80% CO_2 reductions in the North, yet the solutions are not based around less consumption and a return to a small-scale society, but instead a call for new extremely efficient technologies (the individualist solution) and a large-scale restructuring of incentives and institutions through an ecological tax reform (the hierarchist solution of massive intervention in markets). Although the has a high awareness of technological possibilities and new thinking in environmental policy, its egalitarian inclinations are revealed through calls for education to be restructured to teach responsibility, and for "a new view of civilisation and culture . . . [and] a credo of . . . long-term thinking, of a slower pace of life . . . of things beyond financial worth, of self-reliance, of communal solidarity and a sense of the value of the commons" (p. 211)

100	World Bank (1992). *World Development Report 1992*	Individualist + Hierarchist	The World Bank is an extremely procedural, hierarchical institution, yet its activities revolve around the individualist goal of promoting development through improving the efficiency of markets and economic policies. Regarding the environment, the Bank takes a WCED-style approach of acknowledging that some problems are exacerbated by growth (p. 7), while arguing that others stem from lack of development. It argues that there are many "win-win policies" where promoting growth promotes the environment, and fewer where "there may be trade-offs between income growth and environmental protection" (p. 1). In most cases, the policy conclusions are very similar to other mainstream individualists like the BCSD.
101	WRI (1992). *World Resources 1992-93*	Hierarchist	Unlike egalitarians, who argue that limits have already been exceeded and so growth must be stopped, hierarchists see a series of *potential* risks calling for hierarchist intervention and management: "the world is not now headed towards a sustainable future, but rather toward a variety of potential human and environmental disasters" (p. 2). The volume as a whole provides a detailed technocratic, managerialist perspective on the extent of the problem and need for intervention, and concludes, like WRI's President Speth (1989), that hierarchist policies can save the day while growth continues.
102	Young (1992). *Sustainable Investment and Resource Use*	Hierarchist	Focuses on how governments can bring about SD through changing the incentives that drive investment and resource use. Provides a set of approaches, such as the offset principle, polluter pays principle, user pays principle and beneficiary compensates principle, which can be harnessed to bring about the "3E's" of environmental integrity, economic efficiency and equity. The hierarchist content is consistent with the book's genesis in a UNESCO research programme.

Appendix C: Three Sustainable Development Scenarios

C.1. Introduction

This appendix contains three scenarios of a sustainable Europe, set approximately a generation into the future:

Scenario 1:	Orderly Transition;
Scenario 2:	No Limits;
Scenario 3:	Values Shift.

The scenarios provide three different perspectives on environmental problems and economic trends, on the meaning of sustainability, and on the policies and actions that are needed to attain it. They paint contrasting pictures of life in Europe during the early part of the next century, and outline the implications for the five selected target sectors of the EU's Fifth Environmental Action Programme. Their scope is limited to Europe, possibly one that has now expanded towards the east, but they say nothing about the conditions in North America, Japan, the newly industrialised economies or the developing world.

Each scenario is structured in the following way:

Summary	·	Key words
	·	Summary
	·	The Economy
5 Target Sectors	·	Industry
	·	Energy
	·	Transport
	·	Tourism
	·	Agriculture
Barriers	·	Risks, Fears and Threats

The scenarios are written as positive visions, setting out three alternative perspectives on the meaning of sustainability, and what is needed to attain it. Each scenario also includes a set of barriers, including the risks, fears and threats that might prevent the scenario's positive vision being attained.

C.2. None is best - All are best

As discussed in chapter 5, sustainability forces us to base our understanding less on traditional linear forms of thinking, and more on systems thinking. The way that the parts of a system link together to form a whole pose challenges to simple ideas of right/wrong and best/worst. It is like being asked which of your heart, lungs or immune system are most important in keeping you alive. None is *most* important - or alternatively, they are *all* most important, as you cannot do without any of them. Keeping this example in mind will help users to get the most out of the scenarios of sustainable development.

Sustainable development has succeeded as an idea because it is inclusive. Different groups and sectors can interpret it in different ways, and all feel that they are moving in a positive direction even if their end-points are not the same. For example, cleaner technologies, better environmental policies and more environmentally-active communities can all contribute to sustainability. Not everyone will agree on which of these is the most important, or where the priorities for action lie, but all can play a positive role in moving towards sustainability.

Each of the perspectives in the scenarios can be found in any country in Europe today, although they are rarely considered together at the same time by the same people. While none of them has a monopoly on the truth, each contains an important element of wisdom and understanding. The reader may find one or another of the scenarios more to his or her taste, and see others as unrealistic or undesirable. But the real benefit of these scenarios will not be derived from debating which is right. Indeed, choosing one scenario and ignoring or rejecting the others defeats the whole purpose of the exercise - which is to build a wider, more inclusive understanding of sustainable development, and then to apply that understanding in vision-building, planning and decision-making. In building a shared vision of sustainability, we are more likely to succeed if we include the perspectives, problem definitions, priorities and solutions of all partners. These scenarios are designed to assist this process.

Scenario (1) **Orderly Transition**

Key Words

Sustainability, stewardship, managerialism, targets, steering, scientific expertise, international negotiation, optimisation, carrying capacity.

Summary

The environmental and economic plans of the 1990s were an important first step, but did not prove adequate to the management and control challenges posed by sustainability. Improved plans and new policies are now in place to correct social and environmental market externalities, using an optimal mix of regulation, economic instruments and voluntary agreements to steer the world onto a sustainable path. The role and responsibility of the European Union has grown, to ensure effective co-ordination of economic and environmental policies.

Governments draw widely on the expertise and skills of industry, academia and the public in ensuring optimal decision making, and the pursuit of cost-effective policies. Economic and environmental objectives are carefully balanced. Careful stewardship enables continued but modest economic growth, and policies deliver the best possible world for the greatest number of people.

Environmental problems are serious, but can be resolved without major social and economic upheavals, as countries muster the international commitments to identify the changes needed, and to implement those changes in a controlled and enforceable way. Improved integration of environmental and economic planning and policy-making at the national level is needed to provide sustainable economic policies in areas such as employment, trade and consumption patterns. Ecological tax reform is being introduced on a controlled and gradual basis, as governments have realised that its phased introduction provides the best way to tackle the environmental threat without damaging the economy. Indeed, the early experience suggests that overall economic growth and employment figures have actually increased.

The Economy

The late 1980s and early 1990s were a period of win-win eco-efficient solutions for industry, but the most cost-effective environmental improvements were rapidly put in place before the year 2000. Further improvements rapidly became costly and unprofitable, hitting jobs and profits, and additional voluntary improvements by industry could not be justified in the face of domestic and international free-riders.

The transition to a cleaner economy has therefore required government intervention, both to ensure strict and evenly applied standards, and to prevent "eco-dumping" from countries that do not apply similarly strict - and costly - environmental standards. The World Trade Organisation has full procedures and rules to regulate how trade restrictive measures may be applied on the basis of environmental performance. The World Environmental Organisation has been set up to bring the growing number of international environmental agreements under one structure, and to co-ordinate environmentally sound technology Cupertino with developing countries. Negotiations are underway to create a World Sustainable Development Organisation which will integrate the WTO and WEO. At the European level, the Sixth and Seventh Environmental Action Programmes have focused much more on the economic issues associated with environmental policy, including competitiveness, trade, employment and consumption patterns. A comprehensive system of regulation and economic instruments is in place to internalise environmental costs, including large scale ecological tax reform. The revenues make up a substantial portion of tax income, and are redistributed through a number of environmental programmes and subsidies. This gives rise to many trade distortions, which are unfortunate but unavoidable given the priority of attaining environmental and social goals, including tackling unemployment, across Europe.

Scenario (1) 1. Industry

The transition to a cleaner economy is being steered by technology forcing, through a combination of regulation and ecological tax reform to promote alternative cleaner sources of energy and low waste production processes. But the transition was not entirely smooth. Although business leaders saw the opportunities early on, the industry mainstream resisted change for a long time. As societal pressures mounted and governmental determination to regulate became clear, industry realised that its efforts were not cost effective, and changed to a more partnership-oriented approach in which it co-operated with government and was given leeway on how to achieve environmental objectives.

Technological systems tend to be large-scale and centralised to optimise economies of scale and ensure maximum efficiency, for example through combined heat and power and industrial ecology. There is detailed sustainable development assessment, which has evolved from EIA, for new technical and economic developments to ensure their environmental and economic compatibility. There is a comprehensive system of permitting, labelling and regulatory control at the EU level, and there are also EU standards for production processes, products and management systems.

Information and communications technologies are central to environmental management systems at all levels. There is mandatory environmental reporting, together with full disclosure of environmental liabilities and expenditure in annual financial reports. Sophisticated computer technology, including advanced artificial intelligence and neural computing, is used to produce carefully regulated and optimal solutions, and also to ensure monitoring, and to allow sophisticated product tracking and life-cycle assessment. There is also growing use of technology to control criminal activity and black markets, such as illegal waste shipments.

Strategic government planning in close co-operation with industry, including R&D subsidies and incentives, succeeds in developing the key cleaner technologies for energy and industry, as well as ensuring that European industry is able to compete internationally. Consortia of multinationals form to provide the necessary economic weight to compete effectively on world markets, and to invest in the costly research and development that the transition to sustainable development requires.

Companies are increasingly concerned about their employees, local community and other stakeholders. They have introduced extensive social, community and environmental management programmes. Large multinationals are central in most sectors, and form the centre of most people's lives, a community as well as a place of work. They provide a high degree of protection and quality of life, in exchange for the loyalty and service of employees. Corporations now adopt voluntary "partnership" style environmental agreements with governments, allowing a smooth controlled transition to sustainability.

Scenario (1) 2. Energy

While energy sectors have made steady progress in dealing with local and regional environmental issues such as acid rain, the negative impacts that would result from climate change require action. The most important, and cost-effective, approach over recent years has been widespread efficiency improvements. With the introduction of ecological tax reform, clear long-term signals have been provided to suppliers and users of energy, and a shift is underway from fossil fuel based systems to renewable and clean energy systems, ultimately towards hot fusion. Energy systems are centralised for optimal efficiency.

Energy use will increase, especially in the South. The increase will go hand in hand with meeting the challenge of securing efficient and secure energy supplies while protecting the environment. In responding to this challenge, Europe has launched its own energy research and development agenda to parallel Japan's "New Earth 21" programme. As well as developing nuclear fusion, third generation CFC substitutes and safer nuclear power, Europe's programme is concentrating on carbon dioxide fixation and reutilisation technology, and enhancing terrestrial and oceanic carbon sinks. The first space solar power generator was launched early in the 21st century, and manned and unmanned space programmes are undergoing a new period of growth because of their value in developing solutions for global environmental issues.

Scenario (1) 3. Transport

Transport is vital to the distribution of goods and services, and to trade and regional development. During the 1990s, transport trends included greater congestion, pollution and health impacts, and transport grew steadily alongside economic growth and expansion towards Eastern Europe. Governments have developed strategies for mobility management, with an optimally structured mix between individual transport, and integrated and public transport systems.

The internalisation of costs through ecological tax reform and widespread intelligent road pricing has led to reduced use of roads, and has reduced international trade in high-weight, low-value materials and commodities. Together with increased recycling and use of secondary raw materials, this has led to new development challenges for the commodity-based developing countries.

In addition to the effect of economic incentives, transport patterns have also been altered through improved land-use and economic development at all levels, from Europe-wide to local. Tax reform has also restored the cost advantages of public transport, and there has been large-scale government investment in trans-European networks for physical and information traffic.

Scenario (1) 4. Tourism

The steady growth of tourism led to a doubling of solid wastes and waste water in the Mediterranean by the year 2000, and a similar increase in the land occupied by hotels and resorts. Although initial policies focused on information, awareness-raising and media campaigns, the pressures of mass tourism necessitated an alternative approach to promote ecologically sound tourism.

This has involved a two track approach, including incentives and regulations to promote eco-efficient resorts, and also eco-tourism based on the use of areas of ecological and environmental interest. Access to tourist locations - whether natural, cultural or historical - has to be carefully regulated to minimise destruction and damage. The high user fees necessary to control access have also had the desirable effect of providing an economic disincentive against mass tourism of low-quality.

Scenario (1) 5. Agriculture

Europe's farmers have taken on a broadened role, encompassing not just food production but also stewardship of the soil and care for the countryside, including preservation of biodiversity and genetic resources for food and agriculture. The economic and trade impacts of previous agricultural assistance programmes, as well as their negative environmental consequences, have led to policies for more sustainable agriculture. As with other aspects of policy, the internalisation of environmental costs has promoted a more rational system of agriculture, and also restored the competitiveness of organic and low-input farming, which is now widely practised.

Farmers no longer receive subsidies on the basis of output, but rather for acting as guardians of the countryside. Increasing use of biotechnology improves productivity, and large proportions of rural Europe are now designated natural or cultural preserves. Agro-tourism is also a growing source of revenue.

Large-scale development co-operation programmes achieve good results in preventing deforestation in developing countries, and also tackle land degradation, soil erosion and more efficient use of water. At an international level, agreements and protocols are put in place for the management of oceans, fresh water and enclosed coastal seas. Different protocols are developed for different levels, but they are consistent and integrated, and include a highly developed system of quotas and economic incentives. An internationally-negotiated Land-Use Protocol provides a common approach for land-use management and planning, promoting sustainable agriculture and minimising international agricultural trade distortions.

Scenario (1) 6. Barriers

The major risks and threats associated with the scenario *Orderly Transition* stem from uncontrollability and disorder. This disorder could take many forms. Environmental disorder might take the form of a sudden deterioration in the global climate system, leading to storm and flood damage that would disrupt coastal communities, and to changes in temperature and rainfall that could devastate the agricultural sector, and might also disrupt tourism. There could also be epidemics and outbreaks of disease. If climate change is sufficiently rapid and serious, the insurance industry might become bankrupt, precipitating a world-wide banking and financial collapse. Environmental disasters might also occur in many other ways, ranging from nuclear and industrial accidents, to the discovery that other apparently benign chemicals have serious health or environmental effects (as with CFCs). In any of these cases, there would probably be significant social and political instability, as the general public reacted to the events.

Economic disorder could stem from growing speculation and increasing fluctuation on the equity, bond and commodity markets. Or it could arise from growing protectionism, unilateral trade actions and the gradual erosion of the multilateral, rules-based trading system. European governments might find it politically impossible to restrain public borrowing and spending as unemployment continues to grow in the face of international economic competition, fuelling inflation and economic instability.

Uncontrollability could also be brought in by technological change. The arrival of the information economy and the seemingly unstoppable acceleration in innovation are likely to make many of today's industrial, economic and social structures redundant. It is unclear whether a fluid, technologically mediated global information economy could be subject to much in the way of traditional controls.

The scenario *Orderly Transition* would also run into difficulties if it is difficult to build societal consensus on the measures needed to attain sustainability. The experience of the Maastricht agreement, the common currency, the reform of the Common Agricultural Policy and the proposed introduction of ecological tax reform shows that consensus can be difficult to achieve. With the growing internationalisation of finance and business, governments may find themselves increasingly unable to govern. They may find themselves unable to implement policies that might decrease their attractiveness to investors, or the competitiveness of their industry, which would mean that their environmental policy making would become steadily less effective.

Perhaps the biggest barrier to *Orderly Transition* is that we have never done anything like it before. The difficulty of managing change has been expressed well by William Ruckelshaus, who was a member of the Brundtland Commission, has twice been Administrator of the US Environmental Protection Agency, and is currently chief executive of Browning-Ferris Industries: "Can we move nations and people in the direction of sustainability? Such a move would be a modification of society comparable in scale only to two other changes: the Agricultural Revolution of the late Neolithic and the Industrial Revolution of the past two centuries. Those revolutions were gradual, spontaneous, and largely unconscious. This one will have to be a fully conscious operation, guided by the best foresight that science can provide . . . If we actually do it, the undertaking will be absolutely unique in humanity's stay on the Earth."

Scenario (2) No Limits

Key Words

Rapid change, technological innovation, adaptation, no limits, cultural diversity, maximising quality of life at the individual level.

Summary

The environmental concerns of the 1990s were clearly overstated. Global environmental degradation has not materialised, and economic growth based on the clean industries of the information economy has generated the wealth to pay for a clean and safe environment in Europe.

With the planet seen to be resilient, humanity is free to concentrate on maximising quality of life. Free markets drive innovation. New technologies, especially in information, computing, biotechnology and cognitive science, revolutionise economic activity and lifestyles. A clean environment is pursued as part of a high quality of life, and enjoyed during the free time that is liberated as the average working week becomes shorter.

There is a wide diversity of lifestyles and kinds of work. At one end of the spectrum are low-consumption lifestyles, featuring preventative approaches to health, 3 days' work a week, and time for arts and leisure. At the other are high-income, hard-working professionals, with wealth to spend on exotic technologies and pursuits. Clean growth in the South has led to early demographic transitions, while economic growth and employment in the North has been revitalised as entire economies begin to re-tool and rebuild with clean technologies and knowledge-based industries.

The Economy

The liberalisation and privatisation of the 1980s and 1990s has continued apace. World-wide free markets and trade drive innovation and growth, and the role of government has been redefined and focused on ensuring that markets function efficiently, for example through strict anti-monopoly laws and making central banks independent, and providing a safety net for the less fortunate.

Policies focus on ensuring equality of opportunity and the maintenance of a level playing field. But while the opportunities may be equal, people choose to take advantage of them in very different ways, corresponding to different perspectives on what constitutes quality of life. Some work hard, putting in 80 hour weeks and becoming rich in material terms. Others work less, taking on a three day working week to allow a greater focus on leisure, learning and becoming rich in community, spiritual, artistic, educational or health terms. New forms of economic and societal indicators, which are ways of measuring progress towards improved quality of life, gradually replace the limited monetary and material bias of the system of the 1990s.

Scenario (2) 1. Industry

Business and industry show great diversity of scale, form and sectoral structure. Companies are flexibly organised, avoiding the structure of large bureaucratic multinationals, which proved unable to innovate rapidly or keep costs sufficiently low, or were broken up in anti-trust cases. The move to an information-based economy has meant that skills and learning are of central importance, and employees have become highly valued for their knowledge and abilities. The learning industry is one of the most dynamic sectors of the economy.

Even the most traditional industry sectors have been transformed, as their competitiveness depends on increases in managerial, organisational and technological efficiency that are based on better application of knowledge and information. There are new and diverse technologies at appropriate scales - big or small to suit the task - especially in communication, biotechnology, nanotechnology and robotics. Computing and cognitive technologies that enhance brainpower continue to advance, forming the cornerstone of value creation in the information economy.

Environmental performance of technologies is a key issue, as a clean environment is a central component of quality of life. Environmental problems are addressed by new technologies to remove pollution, with increasing use of recycling, remanufacturing and closed-loop systems. Technology also does most of the work in the environmental clean-up. The pollution of the late 20th century is cleaned through advanced biotechnologies for remediation of soils and water. Ongoing environmental maintenance and cleaning is carried out by autonomous micro-scale mobile robots, nanotechnologies and biotechnology.

Scenario (2) 2. Energy

Energy supplies are diverse, notably clean fossil technologies, but also renewables and new clean, inherently safe, nuclear power. Coal is reinstated as an important energy source, especially through fluidized bed combustion and high efficiency approaches. Carbon dioxide emissions are not an important problem, as scientific understanding of the atmospheric system has demonstrated that the climate sensitivity towards carbon dioxide is very limited, so global warming will be very slight.

The wide availability of cheap energy combined with the technological advances in products, including efficiency and conservation technologies, means that comfortable living facilities are universally available, and architectural talents become focused on creativity and individual expression.

The information economy is far less energy and transport intensive than the industrial economy was, and the increasing trend towards miniaturisation and precision, including nanotechnology, has further reduced materials flows. New technologies allow very precise manipulation of matter and highly controlled application of energy, revolutionising manufacturing and greatly reducing demand for energy and materials, as well as allowing re-use and recycling of previously unusable wastes.

Scenario (2) 3. Transport

Private modes of transport dominate, and the remaining public networks have been privatised. Vehicles are clean, and co-exist with bicycles and pedestrians. Given the receding threat of climate change, the highest priority in transport design has been to eliminate emissions of particulates, hydrocarbons and NO_x that had been responsible for urban air pollution. This has been achieved through technological improvements, and by banning older vehicles.

Noise and air pollution have been minimised, and city centres have been cleaned, regenerated and revitalised. Both cities and countryside are attractive places to live, offering different lifestyles. Cities offer great diversity of entertainment, such as nightlife and restaurants. Country villages offer nature, peace and calm. Whether urban or rural, people increasingly work from home, in electronic communities, for quality of life reasons such as reducing or eliminating commuting, or spending more time with family and local community.

High-tech communications facilities are ubiquitous. Since work is largely electronically based (through multimedia, videoconferencing and fully interactive virtual reality), and artificially intelligent multimedia entertainment is available at all homes, similar lifestyles and opportunities are available to people wherever they are. Computer-based home shopping based with immersive, full-sensory virtual reality and home delivery have replaced supermarkets. The need for transport has therefore been greatly reduced (see also "tourism" below).

Scenario (2) 4. Tourism

Once-threatened natural resources such as coral reefs, wetlands, mangroves and fisheries have are preserved by markets because of their increasing scarcity and acknowledgement of their economic value, notably for tourism and leisure activity. Natural, cultural and historical environments are preserved, restored and improved in recognition of their important contribution to quality of life, and because people are willing to pay to enjoy them.

Tourism is increasingly based on appreciating the diversity of local cultures, heritage, nature and biodiversity. For those who desire it, the objective of getting a tan can be much more easily achieved through technological and biotechnological means.

Much of the "world" is now in cyberspace, and many people lead their lives largely on the Net. As part of its exponential growth, the Net (which started out as the Internet) has become a virtually limitless source of interest, culture, information and entertainment. Many people choose to spend their leisure time engaged in electronic tourism, exploring the entertainment and education possibilities on the Net, or interacting with other on-line explorers in virtual resorts. Others explore the real world from home, through immersive virtual reality.

Scenario (2) 5. Agriculture

There are large increases in agricultural productivity, through new chemical and biotechnological approaches, opening up large areas in the North for nature development. In the developing countries, these productivity advances successfully address malnutrition.

Other economic values of forests are recognised, especially uses based on leisure and tourism, leading to the slowing of deforestation and increased regeneration. This is particularly true for tropical forests and the biodiversity which is central to the vigorous biotechnology industry. Demand for fish is increasingly satisfied by fish farms, restocking the oceans if necessary.

Increased carbon dioxide emissions lead to climate change, but the low climate sensitivity means that changes are gentle, slow, and non-destructive - at the lowest end of projections made during the 1990s. Ecosystems are resilient, and agriculture benefits from the increased carbon dioxide.

Scenario (2) 6. Barriers

The scenario *No Limits* is based on the assumption that technological innovation will provide solutions to today's environmental problems, and that there will not be serious new problems tomorrow. Barriers would arise if these assumptions were not true. The first type of problem might be that technological solutions simply cannot be found, perhaps because the necessary R&D is unprofitable or not funded, or that they are too costly or have too many negative side effects. A second type of problem might be that technologies become available, but that the changes in lifestyles and socio-political systems required to implement them are too great.

Many things can reduce the ability to change, innovate and adapt. The most common types of obstacle are regulatory and institutional: too much "red tape", bureaucracy or hierarchy. These might stifle innovation, or make it economically impossible. But adaptation is essentially social at its root. If the public is unwilling to accept the kinds of change that technological and competitive pressures demand, there may be a backlash. This could range a new generation of Luddites, who would aim to protect jobs and workers against new technology and international competition, to a growing fatalism and withdrawal from political and economic life. There are few signs that the pace of technological innovation is slowing, but there could be growing resistance from many people to undertake the necessary learning, retraining and changes in personal lifestyle that might be necessary to adapt.

In addition, environmental problems might turn out to be much more serious than expected, as with the barriers in the scenario *Orderly Transition.* The technological approach in *No Limits* could presumably be extended to develop and implement solutions to these additional problems, but the additional scope of change required would mean an increased likelihood of encountering the sorts of barriers to change listed above. As Donella Meadows and her colleagues note in *Beyond the Limits*, the real barrier to achieving sustainability through technological solutions may in the end turn out to be a lack of capital to invest in developing and implementing the solutions. For example, space scientists tell us that even today we have the technology to build a lunar colony or send a manned flight to Mars. But it isn't going to happen, as no government can afford it.

The individualistic information society may have serious negative consequences for people's sense of community, national and cultural identity. If people do not feel they share anything with their neighbours, they are unlikely to share the fruits of their work or shoulder what they perceive to be unnecessary burdens. The divisions between rich and poor would continue to grow, and in the worst case could lead to a complete breakdown of society, as the growing numbers of "have-nots" resort to violent crime, drugs and nihilism, taking the law into their own hands as they perceive that society no longer has anything to offer them. Under these conditions, the dream of pluralism, liberalism and opportunity could turn into a nightmare of division, violence and perpetual threat.

Scenario (3) <u>Values Shift</u>

Key Words

Prevention, urgency, participation, new relationship with nature, decentralisation, community, caring, spirituality, equity.

Summary

New scientific evidence on global environmental issues, following a series of environmental disasters in the late 1990s, demonstrates conclusively that environmental problems are truly serious, necessitating a radical change in direction before it is too late. At the same time, governments fail to resolve growing economic problems such as structural unemployment, growing public sector deficits, inability to finance health services and pensions, and widening economic gaps between rich and poor. The economic growth of the developing world, where a population many times the size of Europe's is willing to work at a fraction of the pay, has required increased cuts in pay, unemployment and social provisions in an effort to maintain Europe's ability to compete. Growing dissatisfaction and distrust of government and big business, combined with increasing corruption, catalyses a new bottom-up approach to decision making and action.

The message of NGOs, grassroots initiatives and spiritual groups becomes widely popular: many people now view humanity as an intrinsic part of the natural world. We must live in harmony with nature, and the growing inequalities in society must be reduced. The limited environmental space must be shared equitably. Societal organisation focuses on communities and groups rather than rigid hierarchical structures. Groups promote fairness and solidarity, forbidding the exploitation of fellow man or nature. This allows the regeneration of an active community that reduces the gaps between rich and poor, and between employed and unemployed. Rather than being caught up in a pattern of wasteful and destructive consumerism, people take a greater interest in their communities and in their inner lives, and realise that this is the source of true quality of life.

Different communities evolve different responses. Some emphasise the use of sophisticated technologies and tools to minimise environmental impacts and improve social functioning. Others are more fundamentalist, rejecting technological 'progress' with all the social and environmental damage it has brought, and adopting simpler and more holistic approaches to work, community, education, and the environment.

The Economy

Steady-state economies are essential. To stay within environmental limits, there are major changes in consumption patterns, to ensure that environmental space is shared equitably. For example, by 2010 meat consumption per world citizen is 30 grams per day, with 500 ml a day of milk, a reduction in Europe of 60-80%. The sustainability of environmental systems and community solidarity take precedence over narrow economic considerations. Any projects and activities have to demonstrate that they have no undesirable environmental or social impacts. Changes in lifestyles and high-tech conservation reduce demand for energy, water and materials 5-10 fold compared to 1990s. Extended community services, from libraries to social and sports facilities, create community while reducing the need for personal mass consumption. Pollution of any sort is not tolerated. Undisturbed nature is highly valuable, and plays a spiritual role for many people as a teacher of life, and as a way to reach out to the divine.

Governments are widely believed to be incapable of achieving results or responding to the scale and urgency of economic or environmental challenges. Communities increasingly seek to develop local economies to provide jobs and meet the needs of local people. The emphasis is on equality, not only sexual and racial, but among different members of a community. All kinds of temporary coalitions, alliances and partnerships are formed for regional issues, including environmental ones, evolving from present networks and NGOs. Although such arrangements may lack long-term stability, they prevent bureaucracy and ensure a vital and active involvement of communities in political affairs.

E-mail and computer-based democracy ensure a highly transparent and democratic political system. Over time, higher institutional levels become vestigial, and exist solely to support the community level. E-mail has created a global village, with the potential for global democracy, but for all practical purposes, the local physical community is the centre of activity.

Scenario (3) 1. Industry

Consumption is needs driven, and hence much lower than in the 1990s. There is a spiritually motivated emphasis on non-material activities such as work satisfaction, participation, personal growth, relationships and meditation. Conspicuous consumption once seen as a sign of status becomes socially unacceptable, much like smoking and fur coats in the 1990s.

Business and industry are focused on meeting needs - for example mobility, comfort, joy, communication, knowledge - rather than producing goods and services per se. The provision of needs is largely collectivised and localised, for example with public transport and district heating. Where technologies are prevalent, they emphasise subtle and sophisticated ways of working with nature, such as wind turbines based on tree design, the use of medicine in harmony with bodily clocks or integrated pest management techniques. Rather than global uniformity, technologies are designed to fit closely with their surroundings, maximising social and environmental harmony. Industries also focus on the spiritual rather than the material, with greater focus on traditional skills and insights, and craft work.

The economy is greatly dematerialised, with reduced materials flows. This is consistent with the growth of the information economy, where value is based on content rather than bulk. Toxic metals such as mercury, nickel and cobalt are phased out, despite the difficulty of finding substitutes, whereas substitutes are found for copper, silver, zinc and tin. Other less hazardous metals such as aluminium, iron and silicon are controlled through closed-loop processes.

There is great emphasis on low resource intensity and self-sufficiency. In combination with lifestyle changes, resource flows drop by factor of 10 to 100. High-tech applications such as solar cells and electronic devices are manufactured at a larger scale. Manufacturing and retail are run as community-based co-operatives, along the lines of Migros, Switzerland's largest supermarket chain in the 1990s. Since owners and consumers are the same people, there are incentives for low prices and good service, rather than high profits. The system also distributes resources much more fairly.

Communities have energy and industrial systems largely based on sustainable renewable resources. Eco-principles, like near-complete cycling of human-induced resource flows, dominate resource use and design, in areas from industry and transport to housing and household goods. There is an emphasis on small scale, low capital-intensity solutions.

Scenario (3) 2. Energy

An equitable sharing of environmental space allows an annual carbon dioxide budget of 1.4 tonnes per global citizen. This has meant a reduction in carbon dioxide emissions of around 80-90% in Europe. The demand for heating is greatly reduced through cavity wall, roof and floor insulation, using double and triple glazing, high-efficiency glass and high-efficiency boilers. The energy demand for products is reduced, both in increased efficiency leading to reduced direct demand during use - and indirect demand for making the product, which is achieved through improved industrial process efficiency, longer product lifetimes, increased recycling and closing process loops.

There is an emphasis on small scale, low capital-intensity solutions. Sustainable power sources such as wind power and solar water heaters are widespread, and have replaced most fossil sources. Communities have energy and industrial systems largely based on sustainable renewable resources. The constraints on energy availability require large changes in transport patterns (see below).

Scenario (3) 3. Transport

The need to reduce carbon dioxide emissions results in major changes of transport modes. By 2010, each citizen will only be able to use one litre of petrol per day, which will (given foreseeable technological progress) equate to 25 km by car, 65 km by train, 50 km by bus or 10 km by plane. As a result, physical transport is minimised and public transport is the only solution for long trips. Vehicle occupancy is increased, through car sharing and increased use of public transport. An international flight is a once-in-a-lifetime experience. Other international communications, for example to share solutions to technical, economic and other issues, are based on E-mail and computer communications.

In addition to a change in transport modes, the total distance travelled has also decreased significantly compared to the 1990s, as public transport only accounts for some 5% of passenger miles travelled in the 1990s, and even just doubling the size of the rail network takes many decades.

Land-use patterns are changing to accommodate reduced mobility. Bicycle-designed town planning is common. Re-use, remanufacturing and highly durable, long lifetime products become the norm, as is deep recycling based on separation by the consumer. This involves significant changes in transport patterns, and there is a much greater focus on collection, in addition to the traditional use of transport in distribution. The need for transport is reduced as industrial activity becomes more based around localised economies. Land-use patterns which required greater transport, such as out-of-town shopping centres, have been reversed.

Industrial trade has been greatly reduced, and is almost totally in high-tech products; food and building materials are largely derived from local resources. This is partly possible because of advances in using local biomass for fertilisers, plastics, etc. The international exchange of goods is partly trade, partly aid based on principles of solidarity and justice. There are also a number of local exchange systems, based on barter rather than currency.

Scenario (3) 4. Tourism

Since transport and especially flight - on which most of tourism used to depend - are enormously reduced, the tourism industry that was based on unsustainable transport falls away. Unfortunately, this is not before there has been widespread ecological and cultural destruction in the popular destinations of mass tourism in the 1990s and 2000s.

Tourism is much more local, and based on sustainable forms of transport. People tend to make longer expeditions by bicycle, and coach tours have become popular for longer distance tourism. Sailing is back in vogue for longer travel, as an international flight is a once in lifetime experience. Sun seeking tourism has also drastically declined because of increased and widespread ozone destruction, and the high likelihood of contracting skin cancers.

Scenario (3) 5. Agriculture

Agriculture must continue production but halt land degradation, which was running at over 16 million hectares per year in the 1990s (about 1% of the total world arable land). Food security is given the highest priority. Other possible uses of land (such as textiles for clothing, tobacco, oil, dyes, luxury goods and foodstuffs) are restricted to any remaining land.

Land degradation is avoided through a combination of techniques, including crop rotation and diversification, closing nutrient cycles on very small scales, re-introducing human fertiliser as a source of nutrients, and indigenous techniques to combat erosion. The use of artificial fertiliser and chemical pesticides is stopped.

In view of the reduction in textiles production and the environmental damage caused by man-made fibres, clothing is designed to last much longer, and people expect to buy far fewer items of clothing during their lives. The role of the fashion industry is dramatically reduced.

Diets are largely vegetarian, with animal supplements depending on the local environment. Meat consumption must be reduced by at least 80%, as it requires so much fodder, and the balance will shift: less pork and poultry relative to the number of cattle (which need little more than grass). In more technological communities, the supplement is a biotechnological broth which uses trace minerals and sunlight. Fish is a valuable food resource, all fisheries are managed sustainably. Forms of aquaculture are also used to provide highly productive protein sources. Communities depend largely on local resources for food, with land management based on strict principles of sustainability. Some also produce food for export to nearby communities.

Ecosystems are managed sustainably at the local level, some emphasising sustainable harvesting, others a return to wilderness. There are significant population migrations as people find they cannot live sustainably in many parts of the world that previously supported urban and industrial life. The shortage of land is particularly acute in Asia and China. At the same time, the remaining cities are made sustainable by city shrinking, pioneered in the Bay Area of Northern California in the 1990s.

Scenario (3) 6. Barriers

The negative forces in the scenario *Values Shift* could arise from either the scenario's environmental pessimism, or from its social optimism. If environmental conditions turn out not to be as bad as current predictions, for example if global warming turns out not to be a threat at all, then business and the general public would have little time for stringent environmentally-driven change. A much more laissez-faire approach would emerge, and environmental groups would lose their credibility for having cried wolf too loudly and too often. Since many of the changes in this scenario are driven by environmental concerns, this vision of the future would change dramatically if those concerns were to disappear.

Another possible constraint on this scenario is that it assumes a willingness for people to help each other and co-operate with each other. Not everyone may choose to respond to impending environmental crisis in the same way. Many might choose to continue with their existing ways, arguing that they may as well enjoy life while it lasts. Even today there are many signs that parents are becoming less interested in supporting each other or their children. If this is happening in the closest human social unit, then we might expect a similar lack of concern about the other members of a community, city or country. In addition, this scenario requires that individuals must enter into some sacrifices of their short-term self-interest for the longer-term social good. It is not clear to what extent people are willing to make such sacrifices unless they can no longer deny the need to. In other words, it may be unreasonable to expect any precautionary action. Perhaps we will have to wait until there is widely visible crisis, and people feel its effects, before significant change is possible. And perhaps it will then be too late to build the kind of society pictured in this scenario.

Appendix D: Sustainability Scenarios - Results

D.1. SOAR - The State of the Art Report on Social Science and Climate Change

The following written responses were received:

(1) Rob Coppock, World Resources Institute, USA (4 August 1994)

"Comments on [individualist scenario]:

An individualist might well see environmental concerns as well-founded, but believe that society is moving effectively to address those problems. This is much closer to the position that would be taken by this worldview as I understand it, since an individualist exercises control over both needs and resources. It is this capacity to adjust that provides the basis for extensive adaptation. Human ingenuity, in combination with the resilience of the natural system, provides a powerful basis for optimism. It is this same capacity for adjustment that leads to the diversity of lifestyles you describe. More is needed to realise this potential than just free markets. It also requires the emergence of a capital formation and allocation system that both recognises the potential of decentralised and individualistic solutions and consistently supports them over time.

The detailed descriptions miss a few current developments consistent with and supporting this position. Electricity production, for example, is apparently decentralising with smaller-scale operators feeding the grid from non-utility sources . . . Information technologies are 'flattening' industrial and retail organisational trees (there are no management levels between the store manager and the headquarters product manager in the WalMart organisation - middle managers are an endangered species), leading both to quicker pricing and product offering responses.

Comments on [hierarchist scenario]:

This scenario misses the most important ways in which current technological and managerial innovations could contribute to better control systems. For example, there is now the technical capacity to compare information about food purchases with detailed data about energy consumption (whether freeze-dried food is cooked with conventional or microwave oven) for a specified area, say a zipcode, so as to optimise energy production much more efficiently than in the current system. Rather than encouraging centralised control, the . . . [hierarchist] strategy would lead to decentralised control mechanisms where very precise applications of small amounts of force and energy, for example, promise tremendous efficiency gains. This principle applies in general: to manage our way to sustainability we must establish ubiquitous, decentralised control systems. Everything must be caught in the net, however, which is why individual prerogatives we know as 'rights' would be replaced, or at a minimum strongly moderated, by shared responsibilities.

Comments on [egalitarian scenario]:

My understanding of this worldview would give greater emphasis to reducing consumption as such (rather than the more general human intervention in ecosystems) in the 'solution' statement. It seems to me that an additional attribute of economic activity would be a shift of focus from sale of products and services (for example, of transportation instead of cars - a natural extension of the German buy-back approach). The requirement of a steady state economy is unconvincing. The economy could continue to grow to the extent hat economic volume is decoupled from energy and materials flows (because it would then have little or no impact on carrying capacity). It seems to me that the leitmotif of this scenario should be the redirection (and reduction) of consumption to meet psychological and spiritual needs. In essence, it calls for a redefinition of economic valuation. It might be worth trying to tease out the implications of this in the various topic areas."

(2) Mary Douglas, University College London, UK (23 August 1994)

". . . [the scenarios] were extremely welcome and helpful to . . . me in writing the Needs and Wants chapter . . . we will be able to use it as a reference point, and we will be able to fill in from real scenarios quotations that show people really do talk like you have described them . .

Individualists and Hierarchists crowd each other and it should not be difficult to separate them out. You have now got Individualists as against big government and against institutional obstacles, while Hierarchists rely on national and international government and institutions. That is a good clear distinction.

Expertise: Though both Individualists and Hierarchists use it, heavily, there is a difference: Individualists need it because they do not accept any other authority, so they are bound to look for the highest level of certification in their choice of experts; Hierarchists need experts as part of accountability to outsiders, (not to settle disagreement among themselves), so they mind much that their chosen expert can be trusted, is 'one of us', than for formal qualifications.

Decision making is an important, discrete moment in the organisation of individualists, but goes on more continuously and unobtrusively among Hierarchists.

Needs and Wants: Individualists do not make much of any difference between the two; any want can become a need; Hierarchists recognise a gamut of diversified and graduated consumption styles, rightly reflecting the diverse compartments of a hierarchised society; but Hierarchist lifestyles are traditionalist; they do distinguish needs and wants, on the basis of virtuous and immoral expenditure, e.g. on gambling and drink. You have thought that Hierarchists would want to spend on education regulation and economic incentives to bring consumption styles round to the right pattern, but no, this is quite unnecessary and unlike a hierarchical system where people learn what to do by seeing it done and doing it. It is individualists who are against traditions and who need to keep educating everyone and giving them incentives.

There is an important difference on scientific knowledge and decision making. True, Individualists are doing the innovating, but the Hierarchists are much more committed to maintaining a status quo, so their main anxiety about knowledge is to control it. 'Stewardship' (which you mention) is a key word for Hierarchists.

On population and health: Hierarchists have a double or even you could say two-faced approach. They are really worried that their own national population is declining; so why are they not prepared to follow the Individualists who think market solutions will create a transition period and then a world-wide demographic decline? We know why, they are not keen on market solutions. The only reason that I can see that the Hierarchists are so keen on blaming over-population and pressure on human needs for global warming is that this enables them to blame outsiders. 'Abroad' is the trouble.

Trade distortions, 'unfortunate but unavoidable': there is an equivalent disaster being swept under carpets in each of the scenarios. Human detritus clutter the pavements of the Individualists' new world . . . unfortunate, but what can you do if people don't want to help themselves?"

(3) <u>Jae Edmonds, Battelle Pacific Northwest Labs, USA</u> (2 August 1994)

". . . In general I like the scenarios. But . . . I feel they capture only a small portion of potential reality. If these scenarios are to be potential boundaries to reality space, then they need to include the possibility that each of the world views as leader must deal with a heterogeneity of world of followers. That is the followers will be a mix of world views. If we don't do that we will end up with three utopian scenarios, none of which should be taken as a serious vision of the future . . ."

(4) <u>Dean Graetz, Gondwana Laboratory for Global Change, CSIRO, Australia</u> (17 October 1994)

". . . I found what you wrote very interesting . . . I found your scenarios a little lacking in impact because I could related them to anything on a global/continental scale. I've tried to do this in this paper [an attached paper "The Futures of A Wide Brown Land: Thriving or Surviving", unpublished draft]"

(5) Landis MacKellar, IIASA, Austria (15 November 1994)

"... [Comments on individualist scenario] Uncertainty in the old Frank Knight sense, is ignorance, and ignorance is never a good thing. We individualists love risk, but we despise and fear uncertainty. I would say that the individualist perspective is that science can steadily chip away at areas of uncertainty, converting uncertainties into risks which can be managed.

The individualist perspective on public institutions, both domestic and supra-national, is that they are swamps in which rent-seekers breed like mosquitoes. Any individualist utopia would see a reversion of such institutions back to their nineteenth-century roots. As practical examples, the UN could revert to its role as a forum for security consultations and joint military action. Specialised agencies such as WHO would be stripped of the "development agency" functions and revert to being clearinghouses of technical information. NGOs such as the Red Cross would be stripped of governmental sanction (and tax exemption) and forced to compete among themselves in the market for compassion.

[Comments on hierarchist scenario]

A lot of the hierarchist's world view can be summarised in the proposition that individuals and small institutions do not have the information necessary to make wise choices. In other words, there are economies of scale in information production. The system of environmental taxes you describe sounds closer to the individualist's prescription - set taxes which accurately reflect environmental costs ("Pigovian taxes", in the jargon; this shows you that the idea goes back a least to 1911 when Pigou's *Economics of Welfare* was published) and let individuals make consumption, production and factor input decisions accordingly. What sets the hierarchists apart, I suggest, is the matter of scale and urgency. Herman Daly and his adherents, for example, support the immediate imposition of a massive, centrally-administered (World Environment Agency, say) extraction tax on natural resources. I have grumbled in print that there is nothing non-Pigovian about this, and certainly nothing to have justified the addition of a new "ecological economics" paradigm to the American Economics Association speciality list, where it competes with the already-existing 'natural resource and environmental economics category'.

The purpose of a tax is to alleviate trade distortions, not magnify them. Daly et al., for example, justify their proposed tax on the grounds that the circular-flow accounts have failed to take entropy into account; thus natural resource prices consistently under-represent true scarcity values. I think that what you are really saying is that the precautionary motive is a dominant factor in hierarchical thinking. Thus, "Let's tax the devil out of natural resources. At worst the result will be a trade distortion penalising resource-intensive activities and favouring capital and labour-intensive ones; this will, of course, represent an efficiency loss for the world as a whole and unfairly distribute income away from countries with substantial natural resource endowments. This is a risk we can live with, because if our worst fears are justified, this tax may save the world.

[Comments on egalitarian scenario]

Has the gap between rich and poor been growing rapidly? Perhaps so, but some of this may reflect emerging gaps within broad income classes. Thus, for example, the gap between the super-rich and modestly rich has widened, as has that between the borderline poor and the desperately poor. What makes the headlines is the growing gap between the super-rich and the desperately poor, which may disguise rather different dynamics at the finer-grain level. Chad may still be Chad, but Mexico has joined the OECD for example".

(6) <u>Landis MacKellar, IIASA, Austria</u> (22 November 1994)

"... The main question [from other reviewers of the scenarios] seemed to be whether the very low population figures in the one scenario were realistic. I found them actually quite apropos, because this Carrying Capacity Network NGO associated with David Pimentel has gotten [sic.] enormous publicity by arguing that the carrying capacity of earth is about 2.5 billion people and suggesting drastic measures to reduce population to that level ... Pimentel is a first rate scientist ..."

(7) <u>Tim O'Riordan, University of East Anglia, UK</u> (17 November 1994)

". . . We recently had a meeting of the authors of chapters 1, 2, 5, 11, 12 in London. The consensus was as follows: scenarios are useful in that they map out combinations of economy and culture that at least can be compared. So we are happy that the job was done, and that clear images resulted;

Scenarios are also simplifications, sometimes caricatures and often misleading because they do not always allow for cross-over between patterns of culture and the economy. We felt that combinations of outcomes may prove more realistic for our purposes;

This task is awkward enough without trying to establish too many 'straightjackets' however good the intention. So we will use them as a background, but will not develop them implicitly to drive our chapters. We all appreciated the effort you went to. This was a tremendous job. It must not be ignored. We will do our best not to do so."

(8) <u>Lucas Reijnders, The Netherlands</u> (2 August 1994)

[transcription of e-mail message received from Rob Swart, RIVM, The Netherlands]
"So far, I have got one reaction to my request for suggestions from 'friendly reviewers', namely Prof. Lucas Reijnders, 'guru' of the Dutch environment movement. His main point: two crucial issues are missing: (1) prices and (2) attitudes towards future generations. He suggests in [the individualist] scenario low market prices, in [the hierarchist] scenario high prices and environmental costs, and in [the egalitarian] scenario 'stopping' market prices because of very high environmental costs and the necessary distinction between necessary 'basic' needs and luxury [items].

With respect to the attitude towards future generations: future generations are of no interest in the individualists' case, dependent on the opinion of the voters (how much are they willing to pay) in the hierarchists' case, and setting the preconditions of decisions in the egalitarians' case."

(9) Nick Robins, IIED, London (15 July 1994)

[summary of telephone conversation]

Nick Robins understood and liked the idea of the SOAR scenarios, and suggested additional dimensions that might be included, such as art and the role of women in the different scenarios. He also commented on the similarities of the three SOAR scenarios with three scenarios he had written for the NEF (the New Economics Foundation) regarding the future development of the European Union, which also had individualist, egalitarian and hierarchist scenarios [Robins 1992].

(10) Detlev Sprinz, Potsdam Institute for Climate Impact Research (14 October 1994)

". . . The three visions chosen are barely justified in analytical and practical terms. Personally, I think that the time horizon for policy planning (short term to infinity) is much more interesting, and I would have looked at the level of policy formulation and implementation (from world government to the individual; similar to level of analysis thinking in the social sciences) . . . Given the mission of a scenario approach, I would have expected usage of RIVM or other models. The report does not report any results in the latter sense, thus it appears to reflect a high degree of imagination of the authors, but not solid modelling results. Otherwise a broader normative basis with alternative dimensions would have merited consideration . . ."

(11) Michael Thompson, Musgrave Institute, London (8 August 1994)

"Comments on Rob Coppock's comments

What a superb survey instrument the three scenarios are for revealing the biases of members of the elite!

[individualist scenario]

He redefines the individualist as accepting the hierarchist's definition of the problem and then providing the hierarchy with the basis for 'extensive adaptation'. This adaptive solution , however, will not work on its own; the hierarchy is needed to provide the guidelines for the market's operation. In this way, the individualist is first adjusted and then co-opted into the hierarchical vision.

[hierarchist scenario]

That stuff about freeze dried food and microwave ovens is hierarchy at its most pathological. Big Brother has got your zip-code! Decentralisation is the egalitarian's (and the individualist's) preference, and it means what it says: no (or at the very least, less) centre. But here we see it hijacked into the hierarchist's vision, because 'everything must be caught in the net'. This control imperative then requires massive intervention by the centre so as to delegitimate rights (to bid and to bargain, in the individualist's case, and to an equal share, in the egalitarian's) and impose responsibilities (needs and resources by rank and station).

[egalitarian scenario]

He redefines the problem as 'consumption out of control', and the solution, therefore, as the bringing of consumption under control. He speaks of re-direction (by a centre, of course) and a redefinition of economic valuation (again by a centre). The egalitarian's problem and solution definitions are now adjusted to the point where they fit neatly into the everything-caught-in-the-net hierarchical vision. But egalitarians see high consumption as just a symptom, not the source, of the trouble. The real problem, for them, is how we live with one another and with Mother Nature. Get that right (and that is what their solution is aimed at) and the symptoms will disappear, without any re-direction or re-evaluation.

But even with all this adjustment of the egalitarian position, there is one sticking point that cannot be adjusted and will have to be barred: zero growth. Without growth the hierarchy will not be able to attract and retain followers, nor will it be able to justify unequal distribution. But even this barring is dressed-up as adjustment, because the de-coupling renders the zero growth stance irrelevant to environmental health: de-coupling enables continued economic growth without exceeding carrying capacity. 'Carrying capacity', as we have so often pointed out, is a hierarchical give-away, and de- (as is de-enabling) simply confirms Rob Coppock's (and WRI's) bias: 'much used in civil service jargon in coining words expressing undoing or ridding (Chambers Twentieth Century Dictionary).

From all this, I conclude that the 2050 project is in desperate need of . . . [help]" (emphases in original)

(12) Michael Thompson, Musgrave Institute, London (24 August 1994)

"[additional response to comments by Rob Coppock, Jae Edmonds and others regarding the realism and credibility, or perceived lack of realism and credibility, of the scenarios]

How to be realistic

No one of the culturally preferred futures ever arrives. The future is always some resultant of these contending visions, with the proponents of each doing what they can to put in place the new developments that, they believe, will lead to their preferred future and, at the same time, doing what they can to prevent the proponents of the other futures putting their preferred developments in place. So it is unrealistic to assume (as does so much policy advice) one vision and exclude the other two. Being realistic means, first, granting legitimacy to all three visions of the future and, second, insisting that the path we actually go down will be decided by the interaction of these diverse sets of commitments. The point we are making is that you can't begin to be realistic - that is, focused on these interactions - until you have an adequate description of the visions of the future that are doing the interacting. And providing that description is just what the scenarios are all about!

How these visions interact can (and has been) modelled, using artificial life methods, and this is worthwhile if only to show that there is an infinitude of paths down which we could find ourselves going. More useful, however, are existing cultural theory studies that clearly show how the exclusion from the decision making process of one or two visions has resulted in us going down paths that are much less desirable (by the varied criteria of all three 'ways of life') that the one (or ones) we would have gone down if we had ensured that our decision making process incorporated the requisite variety.

It is therefore unrealistic to try to predict the path we will go down (or even to model the paths we can choose between). It is realistic to develop methods for reducing surprise, husbanding consent, increasing technological flexibility and eliminating the blind spots that are eliminable (that is, clearly visible from one of the perspectives that happens not to be yours).

In the context of the SOAR exercise, it is becoming more and more evident that the decision making process (the IPCC, for instance) does not incorporate this requisite variety. Revealing that, and indicating how, across all the [SOAR] chapters - from how ood science for public policy should be done through 'technology as a social and cultural process' to how to incorporate 'non-state actors' into a view of international relations that is too exclusively focused on the nation state - the requisite variety can be achieved, is our understanding of what it is that we are trying to do . . ." (emphasis in original).

(13) Gary Yohe, Wesleyan University, USA (14 October 1994)

". . . I don't know what to suggest . . . As an author, quite frankly . . . I tried to remember the scenarios as I worked through the material, but the material dominated my thoughts and I certainly did not (probably could not) organise the chapter [on economics] along scenario lines . . ."

D.2. EPE - European Partners for the Environment

The following comments are the transcriptions of the brainstorming exercises performed by the three scenario working groups on 26-27 October 1994, which were originally presented on flipcharts. They are therefore in note form.

1. Individualist Scenario (working group facilitated by Alex Trisoglio)

1.1. Barriers

- The market acting alone won't value the environment (under current consumer and voter behaviour), so we need to change patterns of demand.
- There is an important question of trust of new technology - people don't in many areas (e.g. biotechnology) or there may be social resistance.
- The R&D is not in place today to generate the kind of technological breakthroughs implied in the scenarios (given the lead times).
- The current concern for environment has implications for R&D, privatisation, liberalisation and way they are done.
- In order to stimulate this trend, we need investment in SD now, there isn't enough.
- MNCs [multinational corporations] have too much influence, often protect markets and prevent innovation.
- If MNCs don't believe in the environmental problem (most don't), then there won't be enough innovation.
- Unemployment or competitiveness may be "distractions", diverting political, economic and social energy in the short term that should be focused on innovation and preparing for change.
- Current EU policies (especially structural, cohesion, etc. funds) don't support environmental investment.
- Structural shifts in industry will create political and social barriers to change and innovation, for example due to the unemployment and social upheaval that will accompany massive technological change.
- All wealth creating activity under current model has social and environmental externalities that show up somewhere in the system later or in distant parts.
- There is a lack of education, lack of awareness on SD and ignorance in all sectors.
- Individual consumers don't care enough (so there is no effective demand).
- Companies only see environment as niche - their mainstream products and development are still unsustainable.
- Capitalism itself may be a problem in terms of increasing inequity, concentration of wealth, concentration of power, etc.

- Additional barriers are presented by advertising and 'corporate brain washing', even the attitudes of some religions.
- North - South divisions will remain, and may even get worse.
- Return on investment is an issue - will it be attractive to invest in SD in the EU when other world markets provide much better returns? Is cleaning up ever as good a business prospect as growth in new and expanding markets?

1.2. Priorities

- Education and training are key in order to change demand and voter behaviour. We also need to include education for the financial sector).
- We need R&D now for SD (given time lags, cycle times).
- We need active participation by all people at all levels.
- We need to link individuals together, given that this is very individualistic scenario. We need to connect them somehow to a view of being members of a society, and taking interest in society as a whole.
- Policies to manage industrial restructuring (e.g. social impacts, which might otherwise result in undesirable crime and social decay that could damage future growth).
- Mechanisms to create positive feedback, which is a fundamental process that drives the operation of markets.
- Innovation demands a competitive industry - we need to focus government policy on conditions for innovation and competitiveness, and reduce bureaucratic intervention.
- We need information, which is key to the functioning of all markets.
- New co-operative business structures.
- More is needed money for SD (cf. Meadows' comments in Beyond the Limits that capital will be the ultimate constraint) - so we need investment and also changing market rules to favour innovation and investment (cf. tax, accounting, long-term thinking, cf. Japanese model).
- MNCs should disseminate good practice to SMEs, e.g. through their supplier policies.
- Leadership is key - we need to create and communicate good examples.
- Technology transfer is key - disseminating innovations and good ideas widely.
- We need to be aware of social issues and equity

1.3. Desirable Partnerships

- Create a network to share good ideas.
- Promote development of technology for SD - the necessary skills may exist, but not together in same place, at the same time. So bring 3 elements together (a) skills for vision/design, (b) skills for development, (c) adoption and use of technologies, e.g. through NGOs to stimulate awareness and market demand.
- Development feedback loops with carrots (incentives).
- Work to create demand, work with users above a critical size (e.g. cities, create co-operatives) - no point working with government per se unless they are purchasers (which they usually are not).
- Involve all sectors in technology design and development.
- Create markets (e.g. co-operatives, dispersed groups of environmentally interested people who together constitute a big enough market to be interesting for technology developers) (in a technology/market driven scenario, creating markets is key).
- Facilitate information flow.
- Partnerships for equity (to counteract the potential downsides of the scenario in terms of growing inequity)

1.4. Things for EPE to do

- Identify applications and R&D for SD, create partners/loops.
- Broker and fund technological development for SD.
- Matchmaker.
- Monitoring equity.
- Pilot projects (from concept to funding), including to Eastern Europe and LDCs.
- Education - broker (for courses, information, educators), distance learning (network based).
- Curriculum development.
- Policy advice.
- Prizes, dissemination of best practice (in management, technology, partnerships, whatever).

- Foresight function/service on key issues.
- Dialogue and exchange with other networks (e.g. further information, best practice exchange).
- Experiment.
- Respect and encourage diversity of approaches and solutions.

<u>Summary Presented by Working Group 1 to Plenary</u>

<u>Summary 1.1. Barriers</u>

- No incentives, demand.
- Long lead-times.
- Lack of investment capital.
- Unemployment etc. - distraction.
- Awareness, knowledge gap.
- Small companies disadvantage.
- Environment is niche.
- Consumers don't care.
- Other investments higher return.

<u>Summary 1.2. Priorities</u>

- Education, training, information.
- R&D now for SD.
- Positive feedback.
- Investment / conditions.
- Create markets / demand
- Transfer technology / best practice.
- Be aware of social issues / equity.
- Conditions for innovation, competitiveness.
- Way to share views, learn.

<u>Summary 1.3. Partnerships</u>

- Network to share good ideas, best practice.
- Technology development.
  - vision /design
  - development
  - adoption
- (cities, co-operatives).
- Create markets.

<u>Summary 1.4. Role of EPE</u>

- Identify SD applications - create partners/loops (concept to funding).
- Broker, matchmaker.
- Pilot projects (including N/S).
- Education / information broker (network based).
- Prize, best practice exchange.
- Policy advice.
- Foresight- key issues.
- Monitor equity.
- Dialogue - other networks.
- Experiment - respect diversity.

<u>2. Hierarchist Scenario</u> (working group facilitated by Sascha Kranendonk, Wuppertal Institute, Germany)

<u>2.0. How does business as usual differ from scenario?</u>

[note: the working group spent a lot of time on this stage and therefore encountered time problems in later stages]

- Environment - problem displacement, no improvement, worsening in all media (different at local and global levels).
- Economy - non agreement, liberal trade will continue, no change until social and environmental consequences too bad.
- Waiting for global agreement - before change of tax system.
- Industry - environmental improvement, e.g. co-generation, social audit eco-labelling, environmental reporting as marketing tool if brings competitive advantage.
- Transport - increased transportation, mainly by road.
- Tourism - increased tourism to Mediterranean countries, despite environmental degradation or global warming, but mainly for poorer people (due to degradation) - richer people will go further afield.
- Intercontinental flights will become cheaper.
- Agriculture - less rural population, farmers moving into forestry, organic agriculture and energy, and tourism business, new businesses for farmers.
- Desertification and land degradation will continue, especially in South Europe.
- Increased aid and retraining.

2.1. Barriers

- Trade - there is no possibility for environmental and social standards in current free trade agreements.
- Energy prices - international agreement on border compensation (GATT).
- Political and social will is needed for ecological tax reform.
- Information - there is no accepted role for people to explain problems, government afraid of panic.
- Not one-sided group, no push for diffusion.
- Little or no funding for "neutral" science (!).
- Too little proactive attitude.
- Agriculture - need reform of CAP and GATT.
- Difficulties of introducing tax on nitrates and phosphates.
- If there is no international agreement on introducing carbon taxes, transport is too cheap.

- No legislation on hormones
- Low health standards.
- Low energy prices.
- High labour prices.
- Little consumer awareness.
- Little consumer information.

2.2. Priorities

(the group didn't complete this section of the exercise)

2.3. Partnership opportunities

- Trade barriers - partnerships which show that environmental and social standards are good and acceptable (!).
  - e.g. case study of pharmaceuticals company and dye producer (!)
  - e.g. joint promotion of eco-labels.
  - e.g. environmental reporting checked by environmental NGOs.
- Data-base showing changes in material substitution from non sustainable to sustainable, between industry and schools.
- Joint statements on need for environmental standards from EPE, to create societal leadership.
- Free trade from EPE partners to government (?).

3. Egalitarian Scenario (facilitated by John Elkington, SustainAbility, UK)

3.1. Barriers

- Scientific uncertainty - how will we know that a crisis is upon us? will people believe scientific explanations even then? (and will such explanations be able to overcome sceptics etc.?).

- Belief - is this scenario really a worst case? (some in group thought things are already as bad as this!).
- Consensus is slow - how to build consensus on what priorities are and what programmes are needed? In bottom-up scenario, have greater fragmentation, so need mechanisms to generate consensus.
- Problems of vested interests.
- Low growth slows economic and social renewal and transition.
- Equity problems.
- Cultural change is very hard.
- Disasters are often needed for big social change - but what if we manage to control disasters and end up instead with progressive degradation that doesn't motivate in same way?
- Sheer scale of social change - value change, basic needs, equity - that is likely to be very slow.
- Precautionary principle - failure to implement (e.g. uncertainty can always be dismissed).
- In time of uncertainty, there is fragmentation, and special interest groups move in to seize control of the agenda.
- More polarisation, perhaps resulting in the rise of an eco-führer.
- Education - lack, especially of efficient education, especially for people to integrate.
- Co-operation - weaknesses - people don't know how to do it, not used to working together.
- Lack of integration in policy.
- Scenario is too positive- if those problems arise, the polarisation will be much greater, will complicate task of responding - e.g. the point on cycles -vs.- cars is too optimistic, people will fight for their cars!

3.2. Priorities

- Trade - GATT, NAFTA, etc. (which are currently anti-environment) - trade very important here, into global frameworks (John Elkington said he felt the group thought of the hierarchist scenario)

- Science and technology (i.e. need new technologies), building blocks for the transition.
- Education and information.
- Social aspects of restructuring (e.g. unemployment, loss of momentum) - how to manage (who will do it? and dislocations come through far faster than benefits, so this undermines support for whole SD transition).
- Timing - important to understand priorities, phasing etc., also sense of urgency - idea that delay is inevitable - so "who programs" in this bottom-up scenario?
- Learn from experience - as projects roll forward, important to find ways of learning.
- People - we need to focus on people currently in their 20s and 30s.
- Structures to promote new forms of decision making, action, etc.

3.3. Role of partnerships

- People wanted definitions of partnership (they were not sure what it meant in a scenario so different from business as usual).
- If there is a crisis situation, partnerships may be seen as too slow, not solution.
- Prevent eco-führer - strong leaders take control in crisis times, not necessarily communal societal response (real danger of eco-fascism).
- Enable flows of information to shift values and needs.

3.4. Role of EPE

- Diversity / commitment - here we all assume diversity is strength, in the egalitarian scenario, need to test diversity, divergences, etc. before acting - i.e. explore diversity.
- Catalyst for change.
- Source of information - credible, timely, relevant - needed to shift values (which are slow to change).
- Some said avoid clashes of opinion - others said EPE can help avoid clashes, others feel want to explore clashes in controlled and moderated way.
- Look at, learn from organisations that have achieved their objectives (e.g. GATT - against huge pressure, GATT agreement was signed, i.e. process rather than organisation).

- Laboratory role, leading to action, EPE should create, catalyse partnerships (e.g. clean SD technology).
- Benchmark organisation (set example in its own behaviour).
- Create / track partnerships.
- High status, and possible audit role (for other organisations to test their sustainability).
- EPE should have working group on causes of key environmental symptoms - i.e. social causes, e.g. media and agenda setting, how affects politics, etc.
- EPE should not just be laboratory - need action - only by working with people do you see whether you share agenda.

<u>Summary - Common Themes of the 3 Scenarios</u> (27 October 1994)

<u>Priorities for All Scenarios</u>

- Resolve trade & environment.
- Sustainable technologies.
- Education, training, information.
- Managing social transition.
- Timing - long term, fast.
- Capital formation.

<u>Role of EPE</u>

- Education, information, tools - network / broker, international / East Europe.
- Lab, pilot projects, technology, models.
- Positive feedbacks.
- Best practice, benchmark.
- Simulations, tools for thinking.

D.3. CIMI - Copenhagen International Management Institute - Executive MBA Programme

The following comments are the transcriptions of the brainstorming exercises performed by the three scenario working groups in November 1994, which were originally presented on flipcharts. They are therefore in note form. There were two sessions each of which had three working groups.

D.3.1. Session One

Individualist Scenario

The group noted that the scenario was much like business today: Survival of fittest, a few get the most . .

Implications for sectors with high environmental impact:

Challenges	- competition, declining markets (energy)
	- ability to adapt to new technologies
Opportunity	- privatisation

Implications for sectors with medium environmental impact:

Challenges	- capacity
	- distribution channels
	- trade conflicts
	- internationalisation
	- networking
	- R&D
Opportunity	- everything is expanding - i.e. expanding market is key

Implications for sectors with low environmental impact:

Challenge - education (for other sectors too)

Opportunities - markets we don't even know about today

- society split A/B - few elite / many unemployed need to help
- demand for elite education in every aspect

CSFs (critical success factors)

- investment - priority for medium/low
- higher focus on ROI (no energy constraints etc.)

Organisational implications

- education - scenario is extreme service society, technology driven
- ability to change
- requirements for skilled workforce

Functional impacts within a company

- R&D
- marketing / distribution - society is very consumer-oriented

Comparisons with today

- many similarities with trends today - just around the corner
- increasing differences between people

Priorities

- education - focus on human resource - high tech society
- challenge for society - to achieve greater equality -need stability
- i.e. need to transfer money or whatever

Implications for Europe

- if society in West has its needs fulfilled, but not in eastern Europe
- could lead to immigration etc.
- wall has gone down - but has it just gone east/south
- cf. France / Algeria

Hierarchist Scenario

The group reported that it was hard to get started, as the scenario was like Denmark today!

Implications for sectors with high/medium/low environmental impact:

the group found it hard to pinpoint problems, to see where changes would affect medium impact industry - so focus on high/low risk industry. Used 2x2 matrix contrasting approach of industry (high/low tech) - vs. - opportunity.
- e.g. old technology - will have low rate of success - so needs to be very technology driven to have success
- in an industry with more indirect effect, older technology can still give considerable market success - but real benefit will need newer technology too
- i.e. this scenario stresses a new approach, especially for high risk industry

Barriers
- existing technology tradition
- education and training / attitude
- inconsistent legislation (barrier in legislative society) would cause barriers

CSFs (critical success factors)
- innovation - especially in high risk areas - this is key
- capital - we didn't agree! can be benefit or disadvantage !
- size
- management
- positive approach to environment from management needed
- need ability to set up vision, mission
- environmental regulation impacts speed of development

Egalitarian Scenario

The group commented that the scenario is post industrialist, post consumer - "hard for materialists like us"
Implications for sectors with high environmental impact:

- what to do with energy cost?
- restructure to cope with reduced demand
- workforce migration
- nationalisation threat
- A sense of urgency allows rapid change which otherwise be impossible

Implications for sectors with medium environmental impact:

- focus on needs instead of products/services
- high distribution costs - decentralised production, small scale
- close customer contact
- recycling of products, reducing industrial growth

Implications for sectors with low environmental impact:

- structural adjustment to smaller retail units
- large scale entertainment - focus
- no tourism - get to know neighbour & wife & daughter (!)

CSFs (critical success factors)

- we must all become social democrats, i.e. green is beautiful
- all are equal, some more than others
- we should sit down and touch each other

Investment - shortage of funds, interest rate will rise

- strategy - decentralise, small scale
- indicators - interest rate

Organisational implications

- flat, participatory
- strategy - involvement
- need to develop management indicator of participation

Functional impacts within a company

- R&D is key
- production
- distribution
- raw materials
- strategy - divest?
- what are suitable management indicators?

The group felt that this scenario is radically different from today, and seems far away.

Barriers - lack of willingness to sacrifice short term self interest for long term social good

Priorities - switch to renewable energy
- invest in new production processes
- learn to cycle!

D.3.2. Session Two

In session two, the groups were asked to consider appropriate strategies for three different types of industry sector - those with low, medium and high environmental impact.

Sectors with low environmental impact

Strategy - network of competence
- human resource development
- adaptation to market - quick response
- understand core competence = use in multiple markets/legs to survive in all 3 scenarios (key)
- play a responsible role in society - e.g. in co-operation public/private
- R&D and marketing

- Overall focus - key is educating people, learning - giving them the skills

Investments - easier to find 300 places where wouldn't invest!

Sectors with high environmental impact

Strategy

- key is innovation - no matter which scenario
- frame in which to work is similar to business today - but used in very different way
- need binoculars, a scouting function in company to make sure you're not run over
- thinking cap to come up with new ideas, then decision, implementation, optimisation
- an ever moving circle
- flexibility and adaptation are key
- unlike today, where these sectors are slow moving
- this is life or death criterion
- some are trapped already - e.g. steel
- others e.g. chemicals have the opportunity to for example replace hazardous chemicals etc.
- innovative players will change the rules of the game
- innovation is core
- processes = optimise resource consumption
- capital = focus on return on assets, flexibility
- products - recyclable, LCA, documented
- functions = flexibility is key, more educated people, fewer blue collar
- image profile, communications, also in marketing
- CSFs - low cost, and low environmental cost - and high quality

Investments

- companies must have resilient strategy re environment - that is first priority (even if they are in high impact sector, e.g. chemicals)

- would evaluate company to find that (and need information, green financial statement etc.)
- in different companies - would select on basis of innovation power

Sectors with medium environmental impact

Strategy
- waste - reduce packaging (no side effects in any of the scenarios)
- recycling - form alliance with complimentary companies in high/low impact industries (in egalitarian scenario no side effect, in others there is an economic side effect)
- energy - save energy - production/offices (no side effects)
- government regulation - stay ahead of regulations and keep CEO out of jail (no side effects)
- not too decentralised, not too centralised - keep balance

Process & products
- flexible process & products (for individualist scenario is too expensive, economic scale, for egalitarian it is a competitive advantage)
- products - design & produce ecologically (for individualist scenario is problem since it adds unnecessary costs, for egalitarian an advantage)
- products should be recyclable
- LCA strategy

Business functions
- marketing - stay close to customers
- "whole society" consideration
- flexible employees (training)
- R&D cycle time (should be shorter)

Investment
- 45% of portfolio in sectors with low environmental impacts

10%	service
5%	finance
15%	entertainment

15% education (including software, CD-Roms etc.)

- 25% in medium impact

  5% light manufacturing

  15% information technology

  5% construction

- 30% in high impact

  15% oil (as oil is limited resource)

  15% chemicals (will always be in demand)

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