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Opportunity and Problem in Context (OPiC). A framework for environmental management in developing countries

Tsetse, D.

Citation
Tsetse, D. (2008, November 20). *Opportunity and Problem in Context (OPiC). A framework for environmental management in developing countries*. Retrieved from https://hdl.handle.net/1887/13288

Version:	Not Applicable (or Unknown)
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Note: To cite this publication please use the final published version (if applicable).

Opportunity and Problem in Context (OPiC)

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A framework for environmental management in developing countries

PROEFSCHRIFT

ter verkrijging van
de graad van Doctor aan de Universiteit Leiden,
op gezag van de Rector Magnificus prof.mr. P.F. van der Heijden,
volgens besluit van het College voor Promoties
te verdedigen op donderdag 20 november 2008
klokke 11.15 uur

door

David Tsetse

geboren te Dormaa Ahenkro (Ghana) op 6 april 1971

Promotiecommissie:

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Opportunity and Problem in Context (OPiC)

A framework for environmental management in developing countries

David Tsetse

Leiden, 2008

Cover photo:
The polluted Chemu Lagoon in Tema, Ghana entering the sea with people going about their normal activities (Photo: D. Tsetse)

Lay-out: Sjoukje Rienks, Amsterdam

ISBN 978-90-9023371-0

Acknowledgement

This study is in fulfilment of the requirement of a PhD degree from the University of Leiden, the Netherlands. The journey has not been an easy one, and this thesis would never have been completed without the help of colleagues, policy makers and professors in Denmark, the Netherlands, Ghana and the United Kingdom.

Hans Bauer, Annelies Oskam, Gerard Barendse, Edith de Roos and other members of the Institute of Environmental Sciences (CML), Leiden University, I cannot thank you enough for making Leiden a great base for me to carry out the extensive literature search. I also thank you for giving me space, inspiration, confidence and patience to allow my sometimes chaotic curiosity and ideas to develop into this book. I will always remember the pages full of written comments which showed what it entails to write a thesis at CML.

I would like to thank all other experts and colleagues who took time to share their insights with me, in particular, my colleagues at the Science and Technology Policy Research Institute, Council for Scientific and Industrial Research, Accra, Ghana.

Lawrence Agudu, I thank you very much for making time to read and comment on my work. Your contribution is highly appreciated; it really transformed this dissertation.

I would want to thank my wife, Courage Tsetse, who has always stimulated me to do this task and never complained about it. To my sons, Bernard, David, Emmanuel and Joel, your support during times I spent without you has finally paid off. I would also like to thank my parents, siblings and friends. You have had to wait a long time for this research to finish. Thanks for your patience and support.

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List of Abbreviations

AAGS	Accelerated Agricultural Growth Strategy
AGOA	African Growth and Opportunity Act
AiC	Action–in-Context
AIDS	Acquired Immune Deficiency Syndrome
AP	Acidification Potential
BOD	Biological Oxygen Demand
CBA	Cost Benefit Analysis
CBD	Convention on Biological Diversity
CBO	Community Bases Organisation
CEC	Community Environmental Committees
CFCs	Chlorofluorocarbons
CML	Institute of Environmental Sciences
CP	Cleaner Production
CPSH+PR	Carrying, Production, Signification, Habitat + Processing and Regulation
CSA	Canadian Standards Association
CVM	Contingent Valuation Method
DA	Distributional Assessment
DAs	District Assemblies
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPC	Environmental Protection Council
EPR	Extended Producer Responsibility
ESI	Environmental Stakeholder Initiative
EP	Eutrophication Potential
ETP	Ecotoxicity Potential
GDP	Cross Domestic Product
GEF	Global Environment Facility
GEPA	Ghana Environmental Protection Agency
GIS	Geographic Information System
GPRS	Ghana Poverty Reduction Strategy Programme
HIPC	Highly Indebted Poor Countries
HIV	Human Immunodeficiency Virus
HTP	Human Toxicity Potential
ICT	Information and Communication Technology
IEM	Integrated Environmental Management
IICD	International Institute for Communication and Development

IIED	International Institute of Environment and Development
IMF	International Monetary Fund
IRR	Internal Rate of Return
ISO	International Standardization Organization
ISSER	Institute for Social Science and Economic Research
ITQs	Individual Transferable Quotas
IUCN	World Conservation Union
LCA	Life Cycle Assessment
MCA	Multi Criteria Analysis
MEST	Ministry of Environment, Science and Technology
MFA	Material Flow Analysis
MES	Ministry of Environment and Science
MoF	Ministry of Finance
NACIA 21	National Committee for the Implementation of Agenda 21
NDPC	National Development Planning Commission
NEAP	National Environmental Action Plan
NEP	National Environmental Policy
NGO	Non-Governmental Organisation
NPV	Net Present Value
NPP	National Patriotic Party
NS and T	National Science and Technology Policy
ODP	Ozone Depletion Potential
OECD	Organisation for Economic Co-operation and Development
OPiC	Opportunity and Problem in Context
PNDC	People's National Defence Council
PiC	Problem-in-Context
PLA	Participatory Local Appraisal
PRA	Participatory Rural appraisal
RFA	Resource Flow Analysis
SD	Sustainable Development
SEA	Strategy Environmental Assessment
SETAC	Society of Environmental Toxicology and Chemistry
TEV	Total Economic Value
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNIDO	United Nations Industrial Development Organization
US EPA	United States Environmental Protection Agency
WCED	World Commission on Environment and Development
WBCSD	World Business Council for Sustainable Development
WMO	World Meteorological Organization

1 Introduction

1.1 Research background and aim

In developing countries, governments, companies and individuals tend to wait for pollution related issues and problems to occur before solutions are sought. In spite of the fact that a proactive approach to pollution management is currently promoted, little has been achieved. This can be attributed to a lack of pollution management policies or enforcement of the policies in some cases. The environment in some instances is not given the necessary attention as compared to economic development. In addition, processes employed in pollution management are not sufficiently participatory, especially when designing solutions for serious pollution problems. This leads to the ignoring of the voices of pollution victims by pollution management policies and agencies. Finally, methods to address pollution problems analytically are not well attuned to the circumstances in developing countries.

On the other hand, developing countries are endowed with a great deal of opportunity such as local development initiatives, local knowledge and traditional values. When these opportunities would be properly exploited and combined with other opportunities such as ecologically sound production techniques, they could constitute a way of finding solutions to pollution problems.

The vision of this book is to draw the attention of governments, companies, communities and individuals in developing countries in order for them to analyse and deal with pollution issues by considering both problems and opportunities. It is my wish that this work will give them the opportunity to put in place measures that will prevent potential pollution problems and design appropriate sustainable solutions to existing pollution problems.

My point of depature is that to design a solution to the problem in its context, it is not enough to only consider the the wide range of disciplines from water, natural, and physical to social sciences that are present in institutions responsible for environment management. Interdisciplinary connections are of utmost importance. In many cases, however, exisitng interdisciplinary frameworks not designed for work in developing countries. In addition, the frameworks are difficult to operationalise especially in terms of identifying opportunities that will help prevent and solve pollution problems. The frameworks and tools also do not address the full range of issues of sustainable development, such as equity.

The aim the research, therefore, is to develop a practicable and balanced framework for problem analysis, problem explanation, identification of opportunities and design of solutions, geared especially to pollution management in developing countries as a part of sustainable development.

1.2 Research assumptions and research questions

Against this background, the basic assumptions in this research are:

- Disciplinary approaches, holistic approaches, concepts of governance and sustainable development systems may serve as the basis to develop building blocks for sustainable environmental management in developing countries.
- Taking a problem-and-opportunity approach to environmental issues has the potential to contribute positively to the design of implementable sustainable solutions to pollution problems in developing countries.

This generated the following the research questions:

- How can the major scientific approaches, theories, principles and concepts be used as building blocks for the development of an Opportunity and Problem in Context (OPiC) framework for pollution management in developing countries?
- What are the major tools and approaches that can be used in pollution problem analysis and explanation and how can a backbone be developed for problem analysis and explanation in such an OPiC framework?
- What are the major tools and approaches that are used to discover and realise opportunities in their context and how can a backbone be developed for the discovery and realization of opportunities in an OPiC framework?
- How should a solution to an environmental problem in its context be designed through an OPiC framework so that problem analysis, problem explanation and options for solution are integrated in a sustainable development perspective?

1.3 Research approach and methodology

An exploratory research approach is employed in the study. Even though this research result is presented in this study as a well-defined and systematic itinerary, it started as a wandering process with little expectation of leading to the desired outcomes. During the enquiry process, the why and how of the different steps taken in the study were made transparent. The starting point of the study and what was expected was always clear to the researcher but in the interplay of the original research questions, assumptions and subsequent emerging opportunities, different research approaches emerged, and all kinds of insights and research tools such as focus group discussions, interviews and observation were encountered.

1.3.1 Defining the playing ground, research questions and methods considerations

This research started out in a rather straightforward manner with a predetermined research problem and a research proposal to find the way. The point of departure was the question of how the combined analysis of problems and opportunities could contribute to the design of sustainable solutions to pollution problems in developing countries. Most frameworks developed for pollution management tend to focus on problem analysis with less emphasis on the role opportunities can play.

Methods employed here were the review and analysis of literature and consultation, and interviews with researchers and experts for their comments and suggestions. Insights gained during this process were crosschecked by using quality standards such as credibility dependability and transferability. The study was initiated in Denmark and the detailed proposal was developed during an intensive four-week stay at the Centre of Environmental Sciences (CML), University of Leiden, The Netherlands.

1.3.2 Review of literature

In accordance with the work plan of the research, the first phase started out by the researcher becoming acquainted with the research epistemologies and methodologies related to the development of frameworks for pollution management. A variety of literature was reviewed in search of theory, concepts, and principles for the development of sustainable framework for environmental management. This approach was to gain insight into the multiple views about developing a framework that seeks to combine problem and opportunity analysis. Vital literature was assessed from the Danish Environmental Protection Agency and The Netherlands Commission for Environmental Impact Assessment.

As a guide to the review, consultations were held with pollution management researchers and experts at the Department of Environment and Resources Technical University of Denmark, the Institute of Environmental Sciences, Leiden University and the Netherlands Commission for Environmental Impact Assessment. This led to the review of theories, concepts, and principles necessary for the development of frameworks for pollution management. Tools for problem and opportunity identification and analysis were also reviewed. The outcomes to this literature review were the development of building blocks for the framework and backbone for problem and opportunity analyses and were presented as working papers.

The result of the literature review was checked with comments and insights from key informants in the pollution sector. Three seminars were organised to present

findings to the staff working at the Science and Technology Policy Research Institute of the Council for Scientific and Industrial Research in Ghana. Articles were presented to conferences and critiques used to refine findings and re-orient subsequent research directions. I also had communication with fellow research students working in the same field at the Environmental Policy & Management Group, Imperial College, Centre for Environmental Technology, TH Huxley School of Environment in London. Suggestions received from this interaction assisted in the development of the conceptual framework for the study. The major part of the review of literature was done at the Technical University of Denmark with occasional visits to Institute of Environmental Sciences, Leiden.

1.3.3 Integration of theory and practice

To see how practicable the framework would be, I had the opportunity to be a facilitator of a Netherlands-funded postgraduate course on environmental management for Officers of the Ministry of Local Government and Rural Development in Ghana. This provided the author with an opportunity to link the insights of the frameworks to problems in pollution management in Ghana and gain insight into environmental management consultancy in Ghana, and organisational arrangements and structures of environmental management institutions. The link between theory and these considerations resulted in the development of a backbone for problem analysis, and a backbone for opportunity analysis and design, implementation and evaluation solutions.

After the researcher combined theoretical knowledge and practical experience to develop the framework, researchers and experts were again consulted and interviewed for their comments to fine-tune the framework. Research papers were presented at the Science and Technology Policy Research Institute, Council for Scientific and Industrial Research, Ghana. Comments and critiques from science researchers at the institute such as Dr. Gogo, Dr. Obiri Opareh, Dr. Frimpong, Dr. Tetteh and Mr. Ampadu, among others, were used to refine the conceptual framework of the study and re-orient subsequent research directions. A paper on this research was also presented at the 7th Postgraduate Forum on Genetics and Society, Science and Technology Policy Research Unit, University of Sussex, UK and inputs from fellow research students and university professors were taken into account in the development of the framework.

Interviews and discussions were also held with Mr. Amoyaw and Dr. Peter Acquah of the Ghana Environmental Protection Agency, Dr. Andoh, a World Bank Consultant and Chief Consultant of A-Development and Environmental Management Consultants, Dr. Akabzaa, Dr. Banoang, Prof. Dadzi and Dr. Ata-Peters of the University of Ghana, Prof. Henrik Brenghoj and Prof. Arne Wangel of the

Technical University of Denmark. Comments and suggestions were used to modify the study which resulted in the OPiC framework.

1.4 Structure of the book

The dissertation is structured into eight chapters. Figure 1.1 provides an overview of the structure of the book and the chapters in which the research objectives are addressed.

Chapter 1 ■ This chapter provides the introduction of the dissertation. In is made up of the background of the research and the research questions and hypotheses. The methodology adopted is presented. The chapter ends with a guide to illustrate how the book could be read.

Chapter 2 ■ Chapter 2 explores the foundation for taking a problem and opportunity approach to designing solutions for environmental problems. This involves the examination of approaches, theories and concepts such as disciplinarity, environmental theories, sustainable development and governance theory that are used to deal with pollution issues. Based on the examination, building blocks for the development of the framework are identified.

Chapter 3 ■ Here I present a number of substantive elements likely to be encountered in the contextual and macro-analysis of pollution in developing countries and Ghana in particular. A review of the socio-economic background and development in pollution management in Ghana and Tema town is presented. The chapter ends by presenting ways through which OPiC can respond to constraints in developing countries and the conditions necessary for the use of OPiC in developing countries.

Chapter 4 ■ This chapter starts with an overview of tools for pollution problem analysis and explanation that I am going to use in my framework. I later show the relevance of these tools in developing countries and where possible, illustrate their applicability in Tema town, Ghana. The section ends with a synthesis of the problem analysis and explanation tools, which I consider to the backbone for pollution problem analysis and explanation in developing countries.

Chapter 5 ■ In this chapter, I review tools that can be used for identifying and realising opportunities for pollution management in developing countries with special illustration in Tema to determine their usefulness. The importance of context of discovery for successful opportunity identification and discovery is highlighted. I end the chapter by presenting the backbone for opportunity

identification and discovery taken into account insights the different and insight gained from the illustrations of the tools in Tema.

Chapter 6 ■ The chapter begins with the presentation of the types of options for pollution management strategies and how the options could be enhanced. This is followed by a review of co-management, participation, adaptive management as the key strategic principles for pollution management in developing countries. I end the chapter by presenting present a design process for pollution management guided mainly by efficiency, equity, adaptability and sustainability principles.

Chapter 7 ■ This chapter presents an overview of the OPiC framework. First, the conditions necessary for the use of the OPiC framework are outlined. I then develop issues from the previous chapters into implementable tasks and options. At the end the chapter, I discuss how the OPiC framework could be used not only for the design of solution to pollution problems but also for various other environmental and natural resource issues.

1.5 A guide to the reader

The framework developed in this study is generic, meaning it is applicable to any locality in the world in spite of the fact that it has been developed with special attention to developing countries.

The framework looks at environmental management from the strategic level to the operational level. The model presented in chapter 3 for proposed activities could be used in place of the conventional environmental impact assessment and strategic environmental assessment. There will be the need to work out an operational manual for the different aspects of environmental management.

Figure 1.1. gives and overview of the structure of the dissertation. It shows that Chapters 4 and 5 run conceptually parallel, with the one focusing on problems and the other on opportunities.

Any reader focusing primarily on an understanding of the concepts necessary for sustainable environmental management is advised to read chapter 2. If on the other hand the focus is more on current environmental management tools used in developing countries and their relevance, you should read chapter 3, section 3.1 to section 3.5, chapter 4 section 4.1 to 4.4 and chapter 5 section 5.3 respectively. In section 6.3, I show how solutions can be designed, evaluated, implementation and monitored.

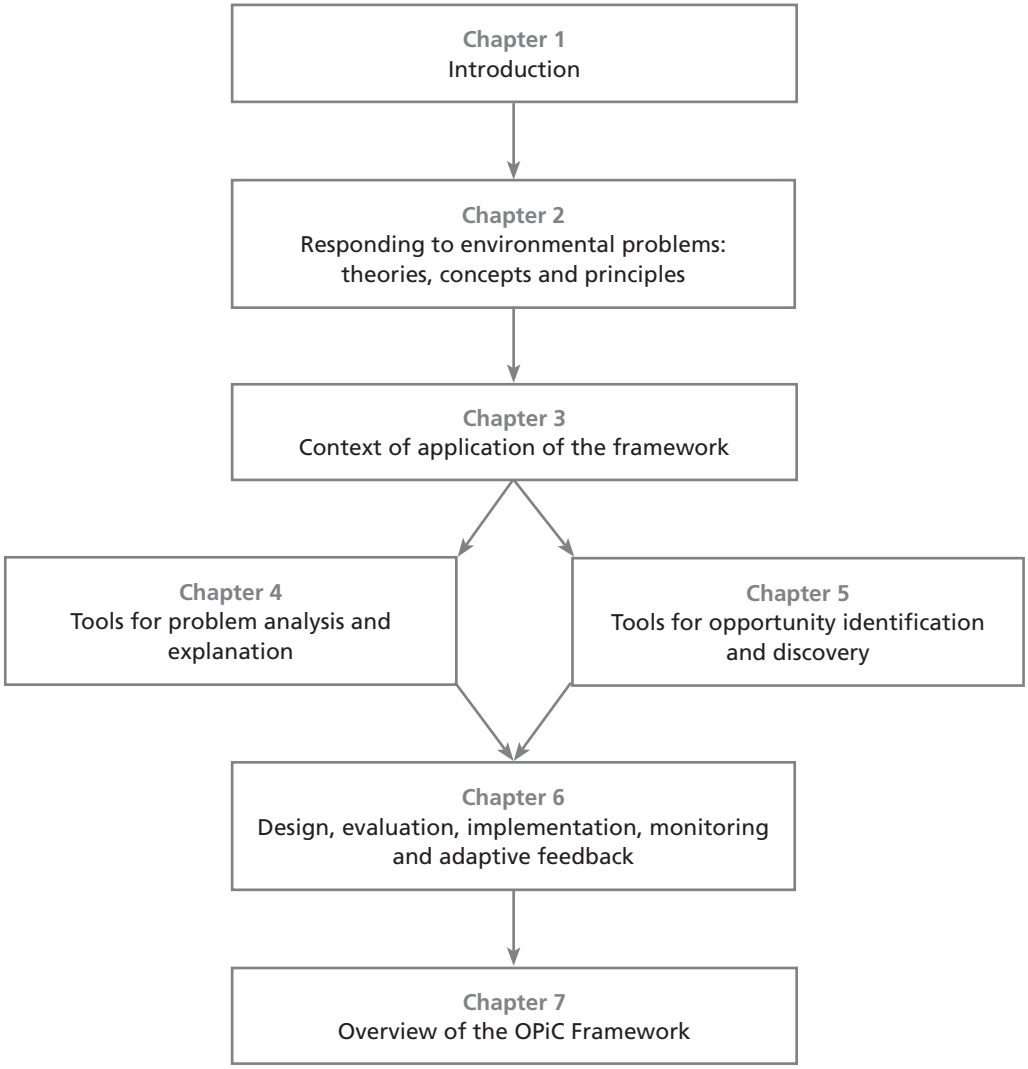


Figure 1.1 ■ Overview of the dissertation

Readers interested in the process of how the OPiC framework has been constructed could start from section 2.5 where the building blocks for the development of the framework are presented. Then you move to section 4.7 where the problem identification block of the framework is developed, section 5.5 where the opportunity identification block is also developed, and section 6.3 for the design, evaluation and implementation, monitoring and adaptive feedback component. Diagrams are presented to show the various aspects of the OPiC framework.

Readers interested primarily in the application the framework on a specific case could start out with overview of the framework in chapter 7 first and then move

backwards to chapter 6, followed by the more detailed descriptions for pollution problem analysis and explanation in section 4.7 and backbone of the discovery of opportunities in sections 5.5. After that, the reader may select further sections depending on his or her specific interest.

As I already mentioned, the framework developed in this study is not final and could be further developed to improve its implementation and practical workability, especially in the area of opportunity identification and discovery. Any suggestions, experiences and comments about the application of the framework could be sent to tsetsed@yahoo.com.

2 Responding to pollution problems

With an increasing awareness of the pollution problems, society expects a concerted intellectual leadership from the scientific community to guide knowledge acquisition and solution generation. This chapter provides and overview of the responses of the scientific community. From these, I will derive the first building blocks for the development of the OPiC framework for pollution management in developing countries.

Section 2.1 ■ Disciplinary approaches

I examine monodisciplinary approaches where all attention is given to one element or relationship. This is followed by the multidisciplinary approach where disciplines are considered side by side and usually arranged by an intuitive notion of connections. I also review the interdisciplinary approach where disciplines are strongly connected, usually by way of a systematic framework. The section ends with a review of the transdisciplinary approach.

Section 2.2 ■ Applicable offspring of the approaches

This section presents offsprings from the disciplinary approaches discussed in the preceding section that are potentially relevant for the OPiC framework. The section starts with an overview of conceptual schemes, the causal chain approach and the systems approach. I end the section with the discussion of state-and-transition approaches such as the adaptive management of complex systems, material flow analysis, cognitive switches in evolutionary approaches and how they could be used to solve environmental problems.

Section 2.3 ■ Governance of the environment

The concept of governance is defined in this section and the different forms of decentralisation are examined to see how they can be applied in pollution management. The link between governance and corruption is explored while the principle of subsidiarity is reviewed, all geared towards the identification of potential building blocks of the OPiC framework

Section 2.4 ■ Sustainable development

I start this section by examining the precursors of sustainable development and the varied conceptualization used in the scientific community. I also examine natural capital as a condition for sustainable development, and its complementarities and substitutability in an attempt to operationalise the concept

of sustainable development in pollution management. Equity issues in sustainable development are also examined in this section.

Section 2.5 ■ Conclusion: building blocks for the OPiC framework
This section presents an overview of the previous sections, focusing on building blocks for the development of the OPiC framework for pollution management in developing countries.

2.1 Disciplinary approaches

One of the major outcomes of the change in global environmental consciousness witnessed over the past three decades was its effect on the various disciplines of science. This change resulted in an academic process that led to different approaches to environmental problems. The response has been a two-way process that helped the environmental debate to benefit from insights of sciences, and for the scientific community to learn from their attempt to rise to the environmental challenge.

2.1.1 The monodisciplinary approach

The monodisciplinary approach originated within the domains of the different disciplines, leading to specialized areas within many of them (Clarke, 1993, Bromme, 2000). Fields such as environmental economics, environmental engineering, environmental law and environmental biology are the outcome of monodisciplinary approach. Today, specialised environmental disciplines constitute the core elements of environmental education and research of major educational institutions around the world.

The monodisciplinary approaches are extensions of the basic principles and theories of the disciplinary domains towards the field of the environment, which is inherently an area of complexity. This complexity leads to two major constraints of the mono-disciplinary approach. First, as a means of understanding the root causes of the environmental crisis, none of the disciplines can provide full insight in environmental problems. The second is that solutions generated within the disciplinary domains usually have a quite limited scope of application.

Notwithstanding these constraints, the monodisciplinary approaches to environmental issues have been important for three main reasons. First, they have significantly expanded the knowledge about the different aspects of environmental issues. Typical achievements of the monodisciplinary approach are the dose-effect relationship models and other stand-alone models developed for social, ecological and economic disciplines. Second, this approach has exposed some of the

basic assumptions of the traditions of science to critical examination. This has resulted in the questioning of assumptions thereby creating a forum for research that extends well beyond the traditional environmental problems. Finally, the impossibility of the mono-disciplinary approach to fully understand, let alone resolve, most of the environmental problems has opened doors for interdisciplinary dialogue.

2.1.2 The multidisciplinary approach

The multidisciplinary approach is where more than one disicpline is connected side by side to deal with a particular issue without coming to a result that is significantly more than the sum of the disciplinary contributions (De Groot, 1992; Polimeni, 1999; Nicolescu, 2005)

In the multidisciplinary approach, disciplines are connected but only weakly, as shown in Figure 2.1, where the arrows represent the contribution of each dsicpline to the ennvironmental issue while the dotted line show the weak interconnections between the disciplines.

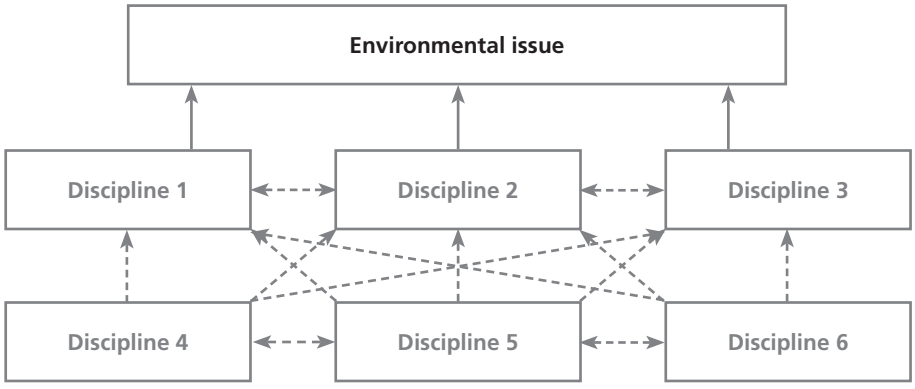


Figure 2.1 ■ Side by side connection of disciplines

2.1.3 The interdisciplinary approach

The environmental issues that are too complex to be treated within the scope of the different monodisciplines led to the evolution of the multidisciplinary approach. This in turn, led to the interdisciplinary approach in environmental education and research, exemplified by the establishment of many interdisciplinary environmental education and research centres at academic institutions. With the interdisciplinary approach, there is a strong connection between the contributing disciplines such that the result is more than the sum of the parts (Salter and Hearn, 1997; De Mey, 2000; Palmer, 2002). Thus, interdisciplinary approach is

concerned with the transfer of methods from one discipline to another, but its goal remain within the framework of disciplinary research (Klein, 1990; Nicolescu, 2005; Marilyn and Dennis, 2004)

A key move in the interdisciplinary approach is the transfer and adaptation of methodologies from one disciplinary area to another, but without the presence of an overarching body of theory, which results in boundaries between disciplines affecting how information is used and knowledge constructed (Easton, 1991; Benowitz, 1995; Jain Qin et al., 1996; Palmer, 2002). This has led to a large extent to a mechanistic combination of concepts and tools generated under the different disciplinary domains. Much attention was therefore given to how the disciplinary contributions might be connected, and at what point in the analysis and solution of environmental problems. Following the causal routes of human actions and especially of changes in the environment (e.g. pollution pathways) gave rise to the most characteristic achievements of the interdisciplinary approach, which are the interdisciplinary frameworks such as Life Cycle Assessment, Environmental Impact Assessment and the Problem-in-Context framework. A review of these tools is presented in Chapter 4.

In this approach, limitations that are observed within the independent disciplines are often transferred to the interdisciplinary approach. The two main criticisms are:

- Interdisciplinary approaches remain shallow; they do not address root causes of environmental problems.
- Interdisciplinary approaches and frameworks remain dominated by monodisciplinary lines of thought such as ecological or economic.

These criticisms may be true indeed for many framework applications in practice. Applicant institutions are often dominated by certain disciplines (leading to one-sided application) and often shy away from addressing root causes. This may not be inherent in (all) frameworks themselves, however. Problem-in-Context (PiC), for instance, offers an avenue to identify root causes and fully embraces the natural, social and normative sciences (De Groot, 1992).

It has been said that although the interdisciplinary approaches try to be inclusive, the frameworks often remain anchored within one or another disciplinary domain (Ziegler, 1997; Palmer, 2002), and although the interdisciplinary efforts gave rise to useful scientific metaphors and models such as the pressure/state/impact model and models of metabolism, they have essentially resulted in an integration of methods rather than the forging of substantive theories (Leroy, 1997; Metzger, 1999; De Mey, 2000; Bromme, 2000). This appears to be true indeed. The frameworks, efficient as they are to arrive at practical solutions to concrete problems, do not challenge the researcher to develop new substantive concepts. The frame-

works produce analyses and solutions by connecting existing disciplines (see Figure 2.2). Even though the frameworks, taken together might amount to a new 'discipline for interdisciplinarity' (De Groot, 1992), this new discipline remains only methodological. This has given rise to the transdisciplinary approach.

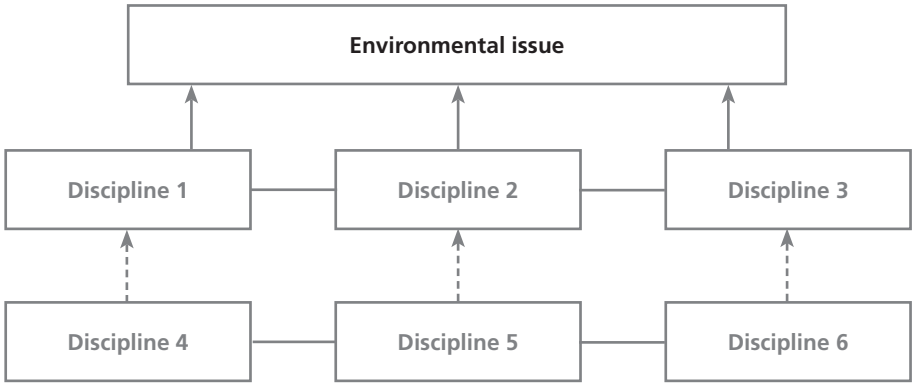


Figure 2.2 ■ Strong connections between disciplines in an interdisciplinary approach

2.1.4 The transdisciplinary approach

Several definitions of transdiciplinary approach exist (Guimaraes and Funtowicz, 2006) but in this research it is described as a form of disciplinary approach in which boundaries between and beyond disciplines are transcended and knowledge and perspectives from different scientific disciplines as well as non-scientific sources are integrated (Finterman et al., 2001; Klien et al., 2001; Guimaraes and Funtowicz, 2006; Gibbons and Nowotny, 2001; 2005; Nicolescu, 1987; 1999; 2001, 2005) According to the transdisciplinary approach, the scientific approaches to environmental problems examined above present little fundamental understanding for the management of the environment. This is due to the fact that environmental problems are complex and dynamic subjects that essentially fall beyond the reach of the reductionist scientific thinking, even if the parts are connected by way of systematic frameworks. Scientific understanding of environmental problems such as pollution requires overcoming the limitations of the reductionistic approach that is inherent in our mainstream way of thinking. This implies the need for a change in paradigm..

A paradigm is a cultural pattern of doing science, consisting of a cognitive, a perceptual and a behavioural framework (Van der Vorst, 1997). The disciplinary approaches examined, if considered individually over a temporal scale, will show an evolutionary pattern of paradigms for managing environmental problems. The outcome of the shift in reductionistic approaches is the transdisciplinary approach that is based especially on system thinking.

The transdisciplinary view arose in order to get away from the superficial notion of disciplinarity, which has not been able to solve environmental problems effectively despite the huge efforts over the last 20 years. According to the International Centre for Transdisciplinary Studies and Research (1999): 'Transdisciplinarity is not concerned with the simple transfer of a model from one branch of knowledge to another, but rather with the study of isomorphism between the different domains of knowledge'. Transdisciplinarity aims at forging the flow of information circulating between the various branches of knowledge and discipline, permitting the emergence of unity amidst the diversity (Nicolescu, 1987; Polimeni, 1999; 2001; 2006). Its objective is to lay bare the nature and characteristics of this flow of information and its principal task is the elaboration of a new language and new concepts to permit the emergence of a real dialogue between specialists in the different domains of knowledge.

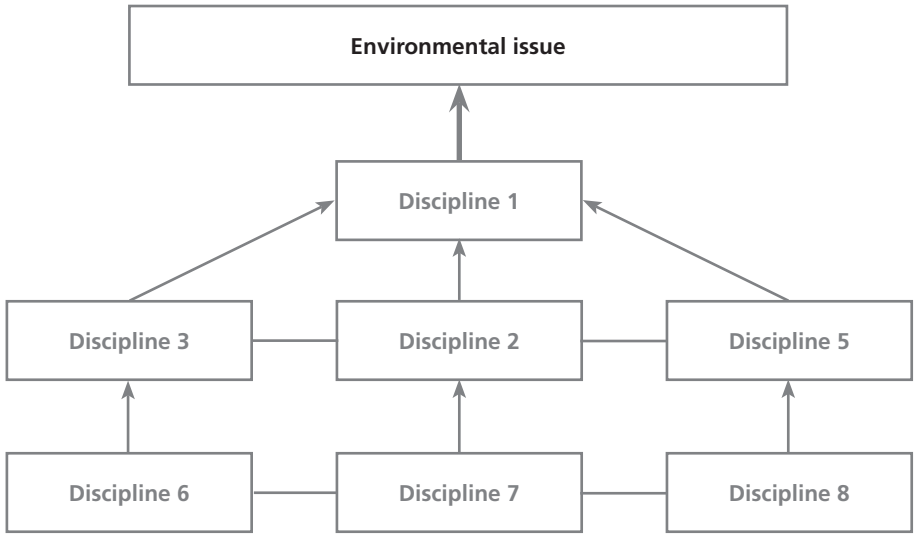


Figure 2.3 ■ Conceptual explanation of disciplines considered within a boundary

Transdisciplinarity is therefore the linkage of several different disciplines at a higher hierarchical level that are bridged and fused together with the help of a concept that is capable of propelling the evolution of a new discipline (see Figure 2.3).

The main feature of the transdisciplinary approach is its cross-sectional nature running through all disciplinary domains, which looks at the dynamic interrelationships between domains to generate solutions with maximum synergistic effect. Most importantly, the transdisciplinary view does not dissociate itself from the disciplinary domain but rather works within each domain serving as the synthesizing thread of action in the approach to environmental issues.

Prime examples of the outcomes of the transdisciplinary approach are the adaptive management approach, system evolution thinking, and resilience thinking. System evolution is presented in detail in section 2.2.3, while adaptive management is used in section 6.1 as one of the design principles for the development of a pollution management strategy. Resilience is discussed in section 4.1 as one of the key features of environmental functions.

2.2 Applicable offspring of the approaches

In this section, I examine results of the various disciplinary approaches discussed in section 2.1 that are relevant for the conceptual development of the OPiC framework.

Typical results of the monodisciplinary approach are, for instance, the many dose-effect relationships between human action and the environment established by environmental biology and other natural sciences, the insight in environmental movements gained by environmental sociology and the interpretation of environmental jurisprudence by environmental law. All of this knowledge is of obvious relevance to environmental management but its system level compared to environmental problems as a whole is too low to be expressed in the generic framework that this present study seeks to develop. We therefore move straight to offspring of the other approaches discussed in the previous section.

2.2.1 Overview schemes

Multidisciplinary approaches have the natural urge to put side by side the contributions of the various disciplines in a systematic manner. Here I present two of those multidisciplinary overview schemes that are of special relevance for the OPiC framework. The schemes are the CPSH+PR classification of environmental functions and the classification of participatory research methods.

The CPSH+PR classification of functions of the environment

Functions of the environment can be used as a classifying concept to make a systematic analysis of everything the environment means to people and nature in a particular context. Such a classification can support a problem analysis in complex cases (e.g. covering a whole region), or act as a basis for economic valuation of the environment. The classification presented below is adapted from De Groot (1992). It lists the major tasks performed by the environment as a result of contributions from several disciplines. 'CPSH+PR' stands for the first letter of the different functions of the environment which are presented as listed in Table 2.1. The plus sign in-between indicates that the last two functions causally underlie the first four; care should therefore be taken to avoid double-counting when applying

the full list. The CPSH+PR classification is employed in section 4.1 as a tool for pollution problem analysis in the OPiC framework.

Table 2.1 ■ CSPH+PR classification showing contributions from several disciplines. (Adapted from De Groot, 1992)

Function	Disciplines	Characteristics
Carrying functions	Anthropology, waste management, construction, transportation etc.	Characterised by the environment providing space and substrate to contain human activities.
Production functions	Fisheries and aquaculture, energy, agriculture and nutrition, water, forestry and agroforestry, medicine etc.	Joint production functions are characterised by that human inputs are a dominant factor. In natural production functions, on the other hand, humans only harvest what the environment produces.
Signification functions	Geology, history, biology, culture, philosophy etc.	The environment produces and human beings are the beneficiaries in the cognitive and spiritual realms. (Science, play, spiritual participation etc.)
Habitat functions	Biology, culture, philosophy etc.	Provides ecological home to non-human valuable inhabitants of the earth.
Processing functions	Geography, biochemistry, hydrology etc.	Relationship in which human beings benefit from the capacity of the environment (e.g. processing, dilution and transformation of waste)
Regulation functions	Hydrology, soil science, entomology, physics etc	Refer to the capacity of the components of the environment to dampen and shield harmful influences from other components of the environment.

Participatory Rural Appraisal methods

Participatory rural appraisal (PRA) methods are used to analyse local people's understanding of environmental issues and the way it is managed. Two central characteristics of this method are the pursuit for optimal ignorance and the use of triangulation, emphasising a diversity of sources and means for gathering data. Participatory rural appraisal methods focus on local people's analytical capabilities, local and traditional knowledge systems in environmental management (Mitchell, 2002); see Table 2.2. Natural sciences such as agronomics and ecology often play a role here too, supporting the development of discussion issues and the understanding of what people are saying.

In participatory rural appraisal methods, the role of the outsider is one of a facilitator rather than one of an expert. Other key features of participatory rural appraisal methods are participatory and empowerment of local people and the development of location action and institutions. Behaviour change and experiential training are the main innovations that result from the use of this method. Par-

ticipatory rural appraisal methods are applied both in the problem identification and opportunity discovery of the OPiC framework in chapter 4 and 5.

Table 2.2 ■ Participatory Rural Appraisal methods showing contribution from several disciplines

Tools and methods	Disciplines	Characteristics
Secondary sources	Anthropology, history, culture, philosophy, environmental ethics, etc.	Include books, journals, reports, maps, news paper stories, project documents, photographs used to identify important issues and potential data sources and key people to contact
Visual models	Mathematics, sociology, anthropology, etc.	Include participatory modelling- local people use ground, paper or other materials to construct social, demographic or resource maps showing ownership, shared uses, existing pattern of uses and capacity of different uses. Other tools are transect walks, seasonal calendars, institutional Venn diagrams etc., identifying important actors and their relationship depicted, timelines and trend/change analysis.
Income and Expenditure Matrix and Wealth Ranking	Economics, sociology, mathematics etc.	Identify and quantify the relative importance of different sources of income and expenditures on basic needs, to investigate perceptions of wealth differences in a community. To identify and understand local indicators and criteria of wealth and well-being, to map the relative position of households in a community.
Semi-structured interviews	Sociology, anthropology etc	Conducted in the usual surroundings of the informant without a questionnaire but key ideas and formation taken. This can be conducted for individuals or groups in the form of focus group discussions.
Workshops	Sociology, anthropology etc.	The data collector meets with informants to examine information collected, share analysis and interpretations, consider opportunities and possible actions and search for preferred initiatives.
Direct observation	Sociology, ecology, anthropology etc	Involves systematic observation of events, processes, relationships and patterns to verify insights obtained from secondary sources and from semi-structured interviews.

2.2.2 The causal chain approach

The causal chain approach takes its roots from the law of universal determinism that every event has a cause but the functional relationship between the events is not necessarily deterministic and what is important is when two events belong to one causal chain, the earlier may be said to 'cause' the latter (Harpaz, 1996).

Causal chain approach is a typical offspring from interdisciplinarity because the chains connect the disciplinary fields and are understood not merely as one event having one cause, but also as one event having more causes. A causal relationship means that variables at a certain point in time are affected by others, at earlier

points in time, in a material flow or behavioural adjustment (Faber and Proops, 1990). Causal chain approaches concentrate on issues that connect the elements into a relationship to help define a link between the cause and effect of events. The most important thing is how or what is the effect or outcome in a particular situation and through what mechanism the causal link works.

Causal chain approaches link the causes of problems to their effects with lines without boundaries in the form of causal 'stories' that never end. The application of the causal chain approach in environmental problems analysis identifies two main causal lines, the causal line of facts or effects and the causal line of values or norms (De Groot, 1998), which run parallel to each other and may be compared to assess the environmental problem. Even though the first is empirical and the latter normative, both involve the interpretation of reality. The functional relationship between cause-effect may be either empirical in the form of correlations (associations) or theoretical (causation) in the form of a generic relationship based on knowledge of the phenomena involved. In environmental cause-effect relationships the phenomena are physical and social. For instance, the policies being imposed on developing countries by international donor organisations cause social effects, which influence human land use activities, which also influence environmental parameters and finally human parameters such as health and economy. These, jointly with various values and norms (such as economic values and health standards) determine the character and magnitude of environmental problems.

Causal chain approaches ten to discard the exact ingredients of the meaning of an event since in most cases we fail because of their complexity. This has been the basis for criticizing the causal chain concept in that it ignores the social context where people acquire information about events to determine their meaning. The basis for this critique is first, that the detailed information of the cause of a particular event does not seem to have a critical role to play in the causal connection between events. Second, that the causal chain theory ignores critical thinking since there is no idea that will help verify the event and also contribute to understanding the complex detail of events in the causal chain (Harpaz, 1996). I disagree with this critique to some extent because as soon as actors are involved in causal chains (i.e. when people respond to environmental change or actions of other actors), their interpretation of these events is exactly what triggers their responses.

A key feature of causal chain approaches is that they do not have defined geographic or system boundaries. This is because the factors influencing responses in the chain are both within and beyond any predefined and bounded ecosystem or society. This therefore, calls for appropriate attention to the movement of people, resources and ideas across to whatever boundaries ecosystem, society, and cul-

tures are thought to have, and may imply dealing with loose, transient and contingent interactions rather than focusing only on system responses (Vayda, 1983).

Causal chain approaches view the world as a series of conversion processes, linked together by inputs and outputs that do not need to address the question of system or geographic boundaries. The causal chain of processes is endless. However, they have the environmental problem at their core position, and cut-off points are usually chosen somewhere causally upstream and downstream of that problem. On the upstream side, it is proposed to distinguish between the normative, physical and social context of the environmental problem (De Groot, 1998) which are necessary to identify the link between causes and effects of pollution.

Since pollution management is concerned with short time and long time horizons, present and future generations, economic growth and environmental processes, it is necessary to consider causal relationships between variables as one of the basis for a holistic approach. In spite of that causal chain theory is not perfect it can help solve lots of pollution problems, which is sufficient for me to adopt this theory, in addition to other ones, as a basis for the development of the OPiC framework for pollution management.

Causal chain approaches help to present the context of pollution management in terms of governance, traditions and rules and the objects of pollution management such as communities and industries. Causal chain approaches explain the influence of context based on actors. Here, the focus is on using progressive contextualisation (Vayda, 1983) to analyse problems from both community and individual angles. It involves a procedure that focuses on significant human activities or people-environment interactions by placing them within progressively wider context (Vayda, 1983:265). This means studying specific activities performed by specific people in a specific location at specific times and then trace the causes and effects of these activities outwards, including the factors impinging on them, without defining the boundaries of the system. How the causal chain approaches should be applied to the OPiC framework is presented in chapter 4 and 5 where the Problem-in-Context framework as whole and a detailed review of Action-in-Context are identified as tools to determine the influence of context in pollution management.

2.2.3 System approaches

Environmental system approaches are offspring of the transdisciplinary perspective on environmental problems. The word 'system' as used here refers to a whole of interconnected elements with a well-defined boundary and with system level characteristics of its own. Systems may be isolated, closed or open in terms of the relationships that pertain across the boundaries of the system with the surround-

ing environment. Thus, any scientific thinking that employs a system definition is based on system theory. The following are the two common characteristics of systems:

- All systems have some structure and organisation, which show some degree of integration.
- There are functional and structural relationships between units of systems which are connected by the flow or transfer of material which is driven by force or sources of energy.

Systems are categorised into three, based on their complexity and randomness. The first type of systems is simple and well organised; these are accessible by traditional scientific assumptions and exclusions. The second type refers to systems that are complex but are sufficiently regular to be studied statistically. The third type of systems are too complex for reductionist simplification and too organised for statistics and can only be understood though system analysis (Weinberg, 1975). Most environmental issues fall under the third class of organised complexity of systems, making them less amenable to reductionist simplicity and statistical treatment.

The concept of system reflects the ability of the human mind to perceive or see things as wholes, which is a collection of parts that are organised in some way, with connections and links between the units. According to system theory, systems analysis should not be limited to the processing of many variables but take into account the dynamics of the variables as well. Senge (1990) pointed out that 'mixing many ingredients in a stew involves detailed complexity, as does following a complex set of instructions to assemble a machine, or taking an inventory in a discount retail store. But none of these situations is especially complex dynamically'. Dynamic complexity is characterised by factors such as dramatically different effects of an action in the short and long run or actions with one set of consequences and very different set of consequences in another part of the system with obvious interventions producing non-obvious consequences. In this context, one can say that the real leverage in the management of complex situations lies in understanding dynamic complexity, not detail complexity (Senge, 1990; Clayton and Radcliffe, 1996; Shih-Liang Chan and Shu-Li Huang, 2004). An important feature of system approaches is the understanding of a simple concept of 'feedback' that shows how actions can reinforce or balance each other. The system thinking builds on the ability to learn to recognise types of structures that occur again and again. Eventually, it forms a rich language for describing a vast array of interrelationships and patterns of change. Ultimately, system theory simplifies life by helping us to see the deeper patterns lying behind the events and details (Senge, 1990).

According to the general mode of organised complexity (Checkland, 1993), there exists a hierarchy of levels of organisations, each more complex than the one below, each system level being characterised by emergent properties at the lower system level. This hierarchy in organisations refers to an arrangement of descending order with the higher levels having control over those directly under them. Thus, properties of a given system have either a horizontal hierarchy or vertical hierarchy. However, this subordination between levels is always incomplete and each level has its own rules of behaviour and its own specific concern. Thus, entities that are whole at one level of the hierarchy simultaneously become parts of the higher level of entities. Thus, a given system exhibits the properties of being a whole and a part at a given time. For instance, an individual person is a whole on his own and a part of a family, which is the higher system in the social hierarchy. Hence, the existence of a specific level in the hierarchy is strictly dependent on the existence of the earlier levels in the vertical and/or horizontal hierarchy. Therefore, horizontal hierarchy depicts the system hierarchy that is divided into ecological, social, and economic subsystems in the order of their precedence and the ecological subsystem is the basis for existence of the whole system, while the economic subsystem is the last element in the hierarchy. The vertical hierarchy on the other hand depicts the hierarchy within the subsystem. This means the output of a system, be it 'whole' or 'part', has two-dimensional effects both in the horizontal and vertical direction of the system hierarchy that keep the whole system together.

The discussion above gives us a fundamental idea of what is essential for managing pollution. It is not surprising that there have been a number of recent studies emphasizing systems thinking. Here I review two characteristic results from system thinking, to be used as building blocks of the OPiC framework.

Adaptive management of complex systems

One typical offspring of the system approach is the adaptive management of complex systems which involves dealing with ecosystems and their interaction with human society. The main characteristic of complex systems is they tend to be self-regulatory and resilient (Kessler, 2003).

Holling (1995) defines adaptive management as 'the release of human opportunities that require flexible, diverse and redundant regulation, monitoring that leads to corrective action and experimental probing of the continually changing reality of the external world'. It is a management approach suitable to deal with complex systems at any scale, and allows self-regulation to reach defined management goals through careful and limited guidance. Adaptive management makes use of diversity of complex systems to adapt and be resilient without reducing or controlling the diversity or complexity of the system. The approach is characterised with organisational learning and a high responsiveness to contextual changes and societal demands through monitoring.

The adaptive management approach aims at maintaining and/or strengthening human capabilities and sensitivities to respond to signals from ecological and social systems. In section 6.2, I present ways in which adaptive management could be used in the OPiC framework.

Material Analysis of systems

Another typical achievement of the system approach is Materials Flow Analysis (MFA) which applies the concepts of industrial or societal metabolism to study how materials and energy flow into, through, and out of a system (Ayres and Simonis, 1994). With the concept of industrial or societal metabolism, environmental problems are viewed as problems of material and energetic relationship between society and nature (Fischer-Kowalski and Hulter, 1999). According to the classification principles of Fischer-Kowalski and Hulter (1999), material flow analysis can be classified by four criteria:

- A comprehensive perspective with focus on a socio-economic system and/or the ecosystem
- A reference system such as biosphere, a national or regional system or function unit, like household or sector
- An examination of material flows in the form of total material metabolism, energy flows or specific materials in the system
- A time aspect of analysis in the form of occurrence of the material flow in a system.

The above criteria guides material flow analysis of environmental problems such as climate change, degradation of nature and wildlife, addressing environmental health issues, preservation of natural resources and waste management by providing insight into the structure and change over time of the physical metabolism of economic systems. Key to this is the use of indicators to determine resource use, productivity and eco-efficiency in the system.

Material flow analysis consider systems as a metabolism where materials are continuously flowing through and do not disappear but majority of materials released back into the environment in the form of waste and emissions after transformation. This established the fact that the quantities of material inputs in a system also determine the amounts of subsequent waste and emissions. It is therefore imperative that any framework for the management of environmental problems focus on controlling the wider burden of the material throughput, to bring it to the level and composition which could be sustained without jeopardizing the quality of life for current and future generations. Tools that are used for analysis include: life cycle assessment (LCA), material flow accounting/analysis (MFA), product flow accounts, material balancing, and bulk material flow accounts (Bourman et al., 2000). In subsequent chapters, tools from material analysis will become building blocks of the OPiC framework.

2.3 Governance of the environment

2.3.1 Defining the concept

The term 'governance' is not a word that has been used extensively in the past by political scientists, and its recent appearance in popular usage has not been very rigorous. It has been, in many ways, both all-embracing and vague. According to the *Oxford dictionary*, governance means 'the act or manner of governing, of exercising control or authority over the actions of subjects; a system of regulation'. This system includes the state but also many other institutions that regulate people's behaviour. Young (1996) notes, 'governance is a social function whose performance is crucial to the viability of human society; it centres on the management of complex interdependencies among actors who are engaged in interactive decision-making and taking action that affects others' welfare'. This makes it difficult to have one ideal model for governance (Haeley et al., 2002; Pieterse, 2000; Stoker 1998), but it always encompasses a complex set of values, norms, rules, procedures and institutions. It includes the whole range of actors within civil society and the relationship between society and the state.

Two things about governance are important in relation to environmental management (Hyden, 1992).

- Governance subsumes both 'government' and 'leadership' and it does not imply that real political authority is vested somewhere within the formal-legal state institutions (Lofchie, 1989). Therefore, the concept allows us to transcend limitations such as limited state capabilities inherent in the state-society relations' approach that dominated much of the thinking on developing countries. Governance explained this way acknowledges that the state is rarely the sole harbinger of power and that society is rarely free from the apparent shortcomings of the state.
- The connection between governance and 'regime'. A regime is a form of political organisation made up of a set of fundamental rules and institutions that guide political behaviour about organisation of the public realm and also the normative framework for on which policies are made. Governance then is the conscious management of regime structures with the view to enhancing the legitimacy of the public realm (Hyden, 1992).

The debate about governance has emerged from two different schools of thought. The first school are critics of conventional liberal democracy who call for empowerment of groups and organisations outside government institutions. The other school of thought stresses the need for decentralisation, privatisation and consumer orientation. A common ground for both schools however, is hostility to central governments (Crook and Manor, 1995) and the move towards 'good governance'.

2.3.2 Decentralization

Should environmental management be an affair of the central state institutions or of mixed and more local arrangements? This issue can be approached through the concept of decentralisation. Decentralisation means different things to different people or different governments and they oppose or support the concept for different reasons (Wolman, 1990). Different concepts stimulate the debate on decentralisation (Pickvance, 1997; Manor, 1999; Schuurman, 1997; Zsamboki, 1996). Emphasis is on shifting responsibility downwards from central government to local governments or shifting responsibility from government to the private sector or community organisations, or a mixture of governmental reform and market forces to stimulate 'social market' responses. Pickvance (1997) distinguishes the following elements of decentralisation:

- the range of functions carried out at the local level;
- the degree of autonomy about how these functions are carried out;
- the degree to which the local government is funded from its own resources rather than from central grants; and
- the degree of private sector participation in decision making and service delivery.

Most authors agree that decentralization in democratic governance involves a transfer of authority and responsibility from an individual or an agency in central government to some other individual or agency, which is closer to the public, based on territorial conditions and functional conditions. Such transfer of authority is of three main types. The first example is when the delegation is within formal political structures, for example, when the central government delegates additional authority to local government. The second example is the transfer of authority within public administrative or special structures such as from the headquarters of different ministries to their district offices. The third is when the transfer of authority is from an institution of the state to a private agency, for instance when a particular national asset is sold off to private shareholders. The above distinctions result in their combination to recognise six main forms that policies of decentralization may have (see Table 2.3). This helps us to explore the concept of decentralisation even though in reality, decentralisation is often more complicated as 'mixed authorities' can occur between the different forms of decentralisation. For instance, the establishment of a council in which both elected representatives and public servants have voting rights.

Table 2.3 ■ The forms of decentralization

Nature of decentralization	Territorial	Functional
Devolution	Political decentralisation, (local government,)	Interest group representation
Deconcentration	Administrative deconcentration (field administration)	Establishment of new, more specialised structures
Privatisation	Privatisation of devolved functions (deregulation, contracting out)	Privatisation of national functions (divestiture, deregulation, economic liberalisation)

Devolution

The devolution of power to sub-national units of government is seen by many academics as the ideal form of decentralization as it combines the promise of local democracy with technical efficiency. Sub-national governments include local governments and authorities, which vary in size and between and within countries; they can either be single–tier or multiple-tier; and their responsibilities may range from a large number of important functions to minor functions. The main notion of devolution is that local governments take greater responsibility for the effects of their decisions and initiate local restructuring and reform policies. Devolution in this sense involves the transfer of political and administrative authority to local level governments that already have resources to provide a specified set of social services. This can be by either territorial devolution or functional devolution. Territorial devolution takes place mainly in the form of political decentralisation, local government, and democratic decentralisation while functional devolution involves transferring authority to interest groups and representing them in local level decision-making. A fundamental feature of devolution is a clear, legally recognised geographical boundary over which authority is exercised and functions are performed with particular attention to legislation. That is, devolution requires a clear and comprehensive legislation mandating central governments to decentralise the public administration of services to lower level governments.

According to Mawhood (1987), 'the classical model of devolved local government, which was advocated in the 1950s and 1960s as the blueprint that newly independent countries should pursue, has five main features:'

- The devolved government should be a local body that is constitutionally separate from central government and responsible for a range of significant local services.
- The devolved government should have its own financial resources and substantial authority to raise its own revenue.
- The devolved government should employ its own competent staff whom it can hire, fire and promote.
- Central government administrators should serve purely as external advisors and inspectors and have no role within the local authority.

- An elected council, operating on party lines, should decide policy and determine internal procedures.

The full application of the above features is a long-term and a difficult task. As Ranis and Stewarts (1993) noted, serious attempts to implement the classical model have been rare. This has caused most devolution efforts to maintain considerable central government influence over sub-national governments.

Deconcentration

Under deconcentration, the central government retains its hierarchy authority, but redistributes responsibility to lower-level administrative structures with less legislative requirement compared to devolution. That is, the deconcentration process involves administrative structures delegating responsibility and authority to new and more specialised structures and institutions to perform certain functions and to field level actors in specific territories. It is important to note that during deconcentration one sees decentralised decision-making and power from the headquarters of the administrative systems, and the delegation of power to an official who is appointed by and accountable to the central administration rather than to a representative of the local community who is accountable to that community. Thus, deconcentration can pursue the objective of technical efficiency, leading to greater effectiveness but not automatically to popular participation.

Although some academics hold the view that choices about field level administration responsibilities are made on the basis of managerial parameters, decisions to deconcentrate are, in fact, highly political for two main reasons. Firstly, the political interest of those who control state power are often the prime concerns when central governments decide to transfer authority to field level administration rather than devolve it to the local government level. Secondly, field level duties often involve political concerns of the central government such as maintenance of political stability at the field level, the obstruction of opposition political groupings, ensuring that the decision of sub-national authorities follow central policies and at the same time monitoring the political loyalties of field workers (Smith, 1985).

Most decentralisation efforts fall under the following three main options (Smith (1985):

- *Functional systems* – where senior representatives of the state bureaucracy are in charge of functional state services. The functional systems emphasize vertical communication, technical expertise, specialisation, uniformity of service provision and co-ordination between central and regional levels but no central government representative at field level.
- *Integrated prefectoral systems* – where considerable power is in the hands of a general representative of the central government acting as a prefect and re-

sponsible for good governance within the territory. This system allocates political functions to the field administration, thus limiting the autonomy of sub-national governments. This option emphasizes coordination above specialisation.

- *Unintegrated prefectoral systems* – these systems involve a prefect with less power who is usually responsible for coordination, but is not the administrative superior in the territory. Similarly, the prefect advises but does not direct the local authority. Such a system involves both vertical and horizontal communication.

In adapting any of the above options, deconcentration should be geared towards bringing the problem and its solution as close as possible to the problem actors. This will let the actors realise the seriousness of the actions and find ways collectively to deal with pollution problems, since actors are involved both in the decision making process in identifying problems and solutions, taking into account local situation and condition.

Privatisation

Privatisation is a term used to describe a range of different policy initiatives designed to alter the balance between the public and the private sector with the notion that performance of services and goods provided by the public sector are not efficient.

The three main approaches to privatisation are: a change in ownership from the public to the private sector, denationalisation that takes the form of joint ventures or liquidation of public enterprises and franchising, where provision of goods and services are transferred from public sector to private sector (Ostrom, 2000). The term privatisation should be limited to decentralisation to market parties since decentralisation to user groups or other local groupings (except local government) is functional devolution making methods such as community-based management and co-management forms of devolution and not privatisation.

Therefore, privatisation is a transformation of the property regime with rights of control reallocated such that the public decision making structure, now becomes concentrated on a single private person, private organisation or shareholders. This transformation process takes two forms. First, by transforming the whole service or good towards private control depending on different degrees and levels of effectiveness and second, by transforming different parts of the good or service in an infrastructure's value chain.

Pros and cons of decentralisation

For a long time, there has been a tendency to discuss the advantages of decentralisation without any distinction made between devolution, deconcentration

and privatisation. Recently, there have been attempts to focus separately on the devolution, deconcentration and privatisation aspects of decentralisation. Reagan (1993) identified two main advantages of decentralisation: popular participation in decision making by locally based staff promoted by devolution, and efficiency and responsibility of locally based administrations promoted by deconcentration. Olowu (1995) identified the advantages of devolution as political rights, civil liberty, institutional pluralism and pluralism in policy choices, which are expected to lead to greater citizen participation, higher levels of accountability, political integration and reduction of corruption. About deconcentration, he identified the transfer of responsibility, strengthening of field agencies and reform of administrative organs as the advantages. Privatisation on the other hand is taken to be a more efficient form of decentralisation because the private sector is considered to be more geared toward using resources in an efficient and profitable manner.

Although the above mentioned advantages may exist indeed under certain circumstances, it is clear is that they are not articles of faith. To take decentralization as an axiom or guiding principle without regard to its limiting conditions may produce situations that have just the opposite effect. In this respect, I argue that the advantages of decentralisation can only be realised:

- Under situations in which the centre is fully committed to a decentralization process and believes that administrators at the centre cannot succeed in what they are doing unless some of their responsibilities are transferred to lower-level units of governments under circumstances where existing hierarchies are not too strong to overcome.
- If the design of the structure of local-level organisation involves interaction among stakeholders in development it must ensure for democratic governance and at the same time define separate responsibilities for development committees and political institutions which are well coordinated and integrated.
- Local and small organisations are highly dependent on incidental leadership and are not inherently stable. Moreover, capacities to handle complex and large-scale issues and systems are limited. It is logical, therefore, that the central state retains basic rights to safeguard minimum standards of equity, sustainability and accountability.

The optimal degree and form of decentralisation therefore is an open issue to be handled according to the prevailing circumstances of the given situation. In the OPiC framework, principles to define the optimal degree and form will be specified (see section 6.3). One guide in this respect is the principle of subsidiarity.

2.3.3 The principle of subsidiarity

Here, I focus on the principle of subsidiarity in governance. This is not to say other good principles such those in the Rio Declaration are not relevant in this context but it is because this is the key thing for me here.

The principle of subsidiarity, elevated to an explicit principle of political and philosophical thoughts in the middle of the last century, is found in both political liberalism and catholic social theory. The principle later appeared in the international circles in 1991 in the Maastricht Treaty negotiated and adopted by the European Union in 1987 and related specifically to environmental issues, although the term had hovered on the edges of European debate throughout much of the previous decade (Wilke and Wallace, 1990). In the context of this study, the principle of subsidiarity is used to analyse the respective powers of different levels of government and their possible redistribution of power and responsibility. This makes the subsidiarity principle serve not only as a guideline for defining and assigning powers and responsibilities, but also as a tool for their realization. Although the principle of subsidiarity allows for various interpretations, it is legitimate to advocate for its application in accordance with its original meaning which is that, 'to the greatest extent practicable, affairs are managed as closely to the citizens as possible and the principle is departed from only for reasons of absolute necessity (Council of Europe, 1994). In line with this, the definition adopted here is that of the European Charter of Local Self-Government, which states, 'Public responsibility should be exercised preferably by those authorities that are closets to the citizen.'

The definition of the principle of subsidiarity in terms of allocation of competence is not fixed. However, it brings new impetus to power relationships between the centre and the periphery, and at the same time an organising principle of society through exercising power and skills by individual citizen and social groups. In the EU for instance, the application of the principle has resulted in challenges related to integration with other concepts, implementation and enlargement of the principle, and the allocation of tasks across the administrative levels of governments (Jordan and Jeppesen, 2000). Notwithstanding the fact that most developing countries have problems with the implementation of environmental policies, the principle of subsidiarity is pertinent to the improvement, especially in the development of new environmental policies.

As noted in section 2.3.2 that central state retain basic rights to safeguard minimum standards of equity, sustainability and accountability, the subsidiarity principle stresses that management authority and function should be vested in the lowest possible organisation. In some situations, however, decision-making responsibility should rest with the regional, national and international levels. This

means that local institutions should be acting as mere agents for decision that are made at regional, national and international levels but they should be a part of the decision making process. The subsidiarity principle makes government responsible for building and supporting institutions at the local level continuously, not just to establish the institution once and for all.

The subsidiary principle also states that the burden of proof of centralisation rest on organisations operating at higher levels since they have an obligation to help facilitate decentralisation at the local level. This means that lower level organisations do not need to justify why they should decentralise. The subsidiarity principle pertains to the local autonomy of local-level organisations to take decisions without taking instructions from high-level authorities. This is why it was important to distinguish between delegation and decentralisation in section 2.3.2.

I therefore propose that the proper application of the principle of subsidiarity in developing countries should be an organic part of the democratisation process since it has great influence in changing the style of public administration. This is because the principle of subsidiarity confirms the tendency of building society from the bottom to he top, which is a concept expressed in the constitutions of most developing countries. On the other hand, it is necessary to avoid the over-application of the principle of subsidiarity because in societal development, the state is a democratically controlled public power that is responsible for the transformation of society. In short, the principle of subsidiarity must be realised in its full complexity by entailing decentralisation of powers, material and intangible conditions within which these powers are exercised. This will then make the principle of subsidiarity one of the key elements of decentralisation in pollution management in developing countries.

2.3.4 The co-management approach

The co-management approach is a form of functional devolution. It has come about because of the limited success of top-down and bottom-up approaches to environmental management and the feeling that local people were not treated fairly in the past. The term loosely defined means ‘the sharing of power, responsibility ad benefits with respect to the management of the environment among governments and individuals or collectives’. Co-management requires that management function be delegated to some degree to user-organisations. The issue is that autonomy, delegation and deconcentration may vary between levels. A co-management approach should be guided by rules (Schlager and Ostrom, 1992).

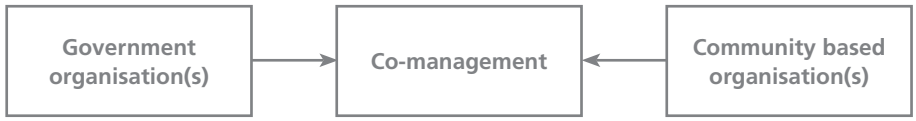


Figure 2.4 ■ Interaction between two groups of actors resulting in co-management

There are various definitions of co-management which are about partnership between the state and user groups, with sharing of responsibility and roles in the management process. The definition of co-management adopted in this study is 'the sharing of responsibility and authority between local communities and the government to manage natural resources' (Persoon and Van Est, 1999). Here the sharing of responsibility refers to the various environmental management functions and each of these functions' rights and responsibilities that are co-managed by both parties (see Figure 2.4). The balance of responsibility and/or authority that the state and the user groups at the local level may be expressed in the following management styles (Kessler, 2003):

- Consultative styles where the state consults local actors and their institutions before taking decisions but take its own decision;
- Cooperative styles where the state and local actors are partners and they share roles and responsibilities that lead to consensual decision-making; this is co-management in the strict sense.
- Advisory styles where the state advises the local actors to take their own decisions.

Co-management links up to a new paradigm of democratisation and decentralisation, involving an increase of authority of local level decision makers and organisations. The approach is about creating linkages between local level and higher level interest (Uphoff, 1998) with focus on developing management rights and responsibilities for both levels. The rise of the co-management concept has come about largely through the interplay of the following factors (Pomeroy, 1996; Persoon and Van Est, 2003):

- Failure of the centralised approach to manage environmental and natural resource problems;
- The process of democratisation in many developing countries where great prominence was given to local interest;
- The rise of international organisations and NGOs with strong financial resources advocating local peoples' interest and participation in the sustainable use of resources;
- Ethnic awareness and identity that provides the basis for the revitalisation of traditional management adjusted to present-day circumstances;
- Environmental justice issues that are incorporated into environmental and natural resource management along side poverty alleviation

- Food and environmental security issues for which new management arrangements at the local level are considered a potential way to deal with the situation.

Co-management approaches, especially those of the cooperative kind are often linked to property rights. Even though it can be applied to all kinds of property regimes, the critical element is the sharing of responsibility among the government and user groups in the management process, usually the form of contracts between government institutions and user groups (Persoon and Van Est, 2003). These contracts are locally negotiated, adapted to the capacities at the local level and the nature (e.g. the vulnerability and scale) of resource.

2.3.5 Integrated environmental management

Co-management is usually focussed on a small number of resources and actors. For instance, government and fishermen in the fisheries industry. Integrated environmental management (IEM) is the term often used for devolution where more sectors and more actors are involved than co-management. With that, it is usually more area-based or ecosystem-based. One example is the Integrated Protected Area System in the Philippines (World Bank, 1996) that entails the establishment of multi-actor management boards to govern protected areas. The integrated approach to environmental management is one of the several area-based approaches to environmental management. IEM is based on the concept that environmental units, at any scale or level need to be managed in an integrated manner through collaboration and participation of different sectors, actors and institutions (Margerum, 1999). The idea is that strong interaction between different actors and their participation, will help build up trust and mutual understanding to solve environmental problems (see Figure 2.5).

This approach helped in the generation of interdisciplinary insights for environmental management. That is, all actors try to identify possible ways to solve environmental problems and they themselves can collaborate or participate effectively in the management process. Actors normally go through the process of identification, analysis and appraisal of all relevant natural and human processes and their interactions. This is to identify environmental problems and design solutions based on the current and future state of environmental and social resources, taking into account spatial and temporal scales for effective implementation of the solution, and its monitoring and evaluation. By so doing, integrated environmental management considers the social, economic and institutional dimension of proposed interventions (Margerum, 1999).

Figure 2.5 ■ The interaction between multiple actors in integrated environmental management

IEM considers social, economic and institutional issues at different levels of decision-making. The following are identified as success factors for the implementation of Integrated Environmental Management (Kessler, 2003):

- Existing laws and policies should support an integrated approach, with policy objectives that allow for changes and inputs from actors through an interactive process;
- The actors should perceive a potential benefit from improved collaboration and participation in solving environmental problems. This could be for them to acquire resources or know the benefits they will get from solving the environmental problem and how their decisions can influence policy;
- There is the need for a facilitator who should be acceptable to all actors or parties and who should also have good communication skills and a clear knowledge of the problem and the context;
- Availability of rules, instruments and tools required for open and transparent communication, decision, education, information dissemination, public consultation and conflict resolution;
- An action oriented approach should be taken in the integration process so that implementable actions and interventions could be undertaken with clear responsibilities and roles assigned to actors;
- Infrastructure (financial, technical and human) is required to start the process and support the activities that would be implemented.

Integrated environmental management may be broken down into a number of co-management arrangements if it is realised that two parties can effectively solve the environmental problem. That is, adopting an integrated environmental analysis can lead to the identification of specific issues that can be dealt with a co-management approach. The applicability of integrated environmental management and co-management in the OPiC framework is demonstrated in section 6.2.

2.3.6 Governance and corruption

This section deals with the complex and sensitive issue of corruption in governance in developing countries. The section starts with the definition of corruption and its various forms. It examines the causes of corruption and its effects on institutions responsible for pollution management in developing countries and presents measures to curb corruption in institutions responsible for pollution management.

Corruption is a broad term, subsuming a wide variety of illegal, illicit, dishonest, irregular, and/or unprincipled activities and behaviours. However, most definitions of corruption share an emphasis on the exploitation of public position, resources or power for private gain. In practice, though, it can often be difficult to draw clear distinctions between 'public' and 'private,' which impedes attempts to treat corruption as a clear-cut category (Johnston, 1997). All the same, most of the definitions fall under three main perspectives, a public office perspective, market-centred perspectives and public interest perspectives (Pavarala, 1996). In this study, I adopt Khan's (1996) definition of corruption based on the public office perspective, which states that corruption is a 'behaviour that deviates from the formal rules of conduct governing the action of someone in a position of public authority because of private motives such as wealth, power, or status.' This definition shows that corruption is:

- The abuse of public roles or resources for private benefit;
- Inappropriate exchanges of money or favours for undue influence or power;
- Violations of public interest or norms of behaviour for special advantages or self-serving purposes (Rose-Ackerman, 1999; Werlin, 1994).

A catalogue of corrupt acts such as bribery, extortion, influence peddling, nepotism, fraud, speed money and embezzlement (Rose-Ackerman, 1999; Werlin, 1994) are used to represent corruption in different forms. Two main categories of corruption in institutions responsible for environmental management have emerged. These are:

- Petty corruption practised by public servants who may be grossly underpaid, and depend on small rents and
- Grand corruption of high public officials who make decisions involving large public contracts (Stapenhurst and Langseth, 1997).

On their part, Caiden and Caiden (1994) have categorized corruption into:

- Individual corruption – referring to the individual who strays from a prevailing norm of official public behaviour.
- Systemic corruption (sometimes referred to as ingrained corruption) that occurs when corruption has become an integral part of the system. Here, corruption has become so regularized and institutionalised those few who live up to the old norms are actually penalised.

The causes of corruption in institutions that deal with pollution management in developing countries are numerous and complex, making it difficult to assess whether corruption causes other variables or is itself the consequence of certain characteristics that hinder the effective management of pollution issues (Lambsdroff, 1999). The following are three reasons that have emerged from my own observations as contributing to the flourishing of corruption in developing countries.

First, the prevalence of corruption in the pollution management institutions in developing countries is the result of the difficult task of insulating politics from the public service. Officials of these institutions can not resist the temptation of using political tendencies to undermine their official duties, all because administrators on one side are inevitably guided by politicians who, however altruistic they may be, are motivated by the need to seek special advantages for themselves and their supporters. Such advantages directly or indirectly divert public resources to private gains. On the other hand, administrators themselves are politicians, struggling for higher salaries and promotion (Werlin, 1994).

Secondly, reforms imposed on developing countries are disruptive in nature and have weak remedies for corruption. Although decentralization has been offered as the only viable prospect of curtailing corruption in the third world (Theobald, 1990), evidence has shown that this assertion is untrue in practice, since deregulation has weakened the capacity of the state to control corruption while privatisation has created a host of opportunities for personal accumulation through corruption (Zeftel, 1998). Devolution and deconcentration have reduced corruption to some extent in the delivery system inherent in traditional centralised system in developing countries where central government lacks adequate local information necessary to monitor performance of bureaucrats entrusted with local service delivery (Bardhan and Mookherjee, 2000).

Thirdly, the inadequate remuneration given to officials in environmental management institutions adds to the problem. For example in 2004 the minimum daily wage in Ghana was 1.199 USD (MFEP, 2003). The result is a number of behaviour patterns which I can refer to as 'survival strategies' that have evolved among public servants. A typical example is environmental professionals in public institutions awarding contracts to friends and relatives for a price or in fact carrying out

the contracts themselves in order to earn some extra income. According to Osei-Hwedie and Osei-Hwedie (1999), public servants are becoming more corrupt and tolerating corrupt behaviour because of expectations that rise due to comparison with the quick money made in the capitalist market sector.

Corruption is threatening good governance especially in developing countries because of its potential to 'redirect' aid, subvert policy reforms and undermine market institutions (Hope, 2000; Stapenhurst and Langseth, 1997). Corruption also distorts all forms of development and performance partly because of its institutional spillover effects and it also affects professionalism in the public services of developing countries and leads to frustration on the part of the few honest public servants to the extent that they emigrate. Political stability in developing countries is affected by corruption resulting in violence and frequent regime changes, which undermine political development and the process of national development (Klitgaard, 1997; Szeftel, 1998). The result is that corruption has compounded cynicism and weakened faith in developing countries' new democratic governments that are rocked by scandals and incidence of corruption.

A number of efforts such as improving institutional performance and policing, greater transparency and accountability, more effective oversight and punishment and the building of a political culture intolerant of corruption have been made to control corruption in public services in developing countries. The results have been disappointing (Szeftel, 1998; Rose-Ackerman, 1999).

The future of pollution management institutions in developing countries depends on the acknowledgement that corruption is a crime of calculation, not passion. It is true that there are saints and honest public officials who resist all temptations. Combating corruption requires 'cultural engineering' and the establishment of a 'national integrity system' through careful regulation of monopolies, clarifying official discretion, enhancing transparency, increasing the probability of being caught and being given serious penalties which must make corruption a high-risk and low-return undertaking (Szeftel, 1998; Rose-Ackerman, 1999). In the context of the present study, it is specifically worth noting, moreover, that decentralisation especially functional devolution which involves participation of communities, co-management and integrated management could create more counter-pressure against corruption, because it enhances transparency and more involvement of the corruption victims (Bardhan and Mookherjee, 2000).

2.3.7 Organisational learning

I discuss organisational learning in here because of its connection to creating an enabling context for the identification of solutions to environmental problems.

A variety of theoretical perspectives on organisational learning have emerged since the 1960s (Shrivastava, 1983). Argyris and Schon (1996) define it as a process of individual and collective inquiry which constructs and modifies organisational theories-in-use. Daft and Weick (1984) maintain that although 'organizations do not have mechanisms separate from individuals to set goals, process information, or perceive the environment,' the organizational interpretation process is more than the sum of what occurs individually. Fiol and Lyles (1985) agree that although 'individual learning is important to organizations, organisational learning is not simply the sum of each member's learning' and suggest that both behavioural and cognitive changes by an organization constitute learning. Levitt and March (1988), in their analysis of organisational learning, place greater emphasis on routinised behaviour than on organizational inquiry and interpretation and describe organisational learning as routine-based, history-dependent, and target-oriented. Routines, broadly defined, include the rules, practices, procedures, conventions and strategies through which organizations operate.

In considering the different views of organisational learning highlighted above, several important points of agreement emerge among the different perspectives. There is considerable agreement among the above-mentioned theorists that organisational learning involves multilevel learning (individual, group, organization), that it requires inquiry, that it results in shared understandings, and that it implies behavioural and/or cognitive change. On the other hand, there are also some differences. For example, Argyris and Schon (1996) view organisational learning as the sharing of assumptions developed through individual and collective inquiry, whereas Levitt and March (1988) emphasized organisational learning as adaptation to changes in the environment by adjusting strategies and structures including procedures and routines. Although there is considerable debate about whether organisational learning is adaptive behaviour or whether lessons learned are embodied in shared cognitive maps that guide behaviour, I am of the opinion that there is a difference between learning involving behavioural and cognitive change.

Multilevel learning

There is a reasonable degree of consensus that a theory of organisational learning needs to consider the individual, group, and organisational levels (Crossan et al., 1999). Specifically, different theorists (e.g. Argyris and Schon, 1996; Daft and Weick, 1984; also see Huber, 1991) state that, although insight and innovative ideas occur to individuals, not to organizations, sharing individual ideas, insights, and innovations is a key component of organizational learning. Moreover, 'although individuals are the agents through whom the learning takes place, the process of learning is influenced by a much broader set of social, political, and structural variables. It involves sharing of knowledge, beliefs, or assumptions among individuals' (Shrivastava, 1983).

Learning is distinctly organisational when it relies on the combined experiences, perspectives, and capabilities of a variety of personnel in an organization. Thus, 'complex organizations are more than *ad hoc* communities or collections of individuals' (Crossan et al., 1999); relationships among individuals are structured and shared understandings are developed which may then become institutionalized as formal or informal organisational routines. In such situations, there is opportunity for exchange of information and experiences which could help in the identification of options for solutions. Thus, experiences from different levels of the organisation are shared and what will work best for the organisation to deal with environmental problems is explored, with lessons learnt from other levels.

Habits of inquiry and shared understanding

A second area of general agreement involves inquiry as a necessary but insufficient condition for organisational learning. In terms of collective inquiry, assumption sharing and feedback become central features of how some theorists define organisational learning (e.g. Argyris and Schon, 1996; Daft and Weick, 1984). Whether inquiry is formal or informal, there is a cyclical process of questioning, data collection, reflection, and action. This process may lead to generating alternative solutions to problems, reflecting on previously unquestioned assumptions, experimenting, scanning the environment for salient information, or other activities that enable organization members to restructure their organisational knowledge base.

An example of collective inquiry in managing an environmental problem in an industry might be the creation of quality circles where representatives from management, line workers and engineers meet to discuss ways to improve product quality. Or, inquiry could proceed more informally when, for example, a manager of an industry might institute a new environmental policy and then modify the policy as on-going feedback is received from other staff of the industry.

Organisational learning involves shared understandings that integrate lessons about the relationship between actions and outcomes that underlie organisational practices (Argyris and Schon, 1978). Shared understandings are generated through various learning processes such as 'interpretation' (Daft and Weick, 1984) or 'imitation' (Levitt and March, 1988). Whether shared understandings are described in terms of theories of action or routines, they often appear as tacit rather than clearly articulated assumptions. All organizations have shared understandings that guide behaviour and decision making whether they are actively learning or instead, are relying on lessons from the past. The critical practice for organisational learning is to uncover these shared understandings and to articulate and examine the assumptions embodied within them. Because shared understandings are often tacit, conversation and increasingly precise language are necessary to

make them explicit (Crossan et al., 1999) so that options for solutions that are hidden in these understanding are brought out.

Behavioural/cognitive change

Organisational learning, involving as it does behavioural and cognitive change, has the tendency to create an enabling context for the discovery of options for solutions. This is because for instance, with double-loop learning, individuals engage in a process of scrutinizing goals in relation to the environment and from people's personal and social environments through critical questioning such as 'That objective isn't realistic because…' or 'Instead of always doing this, we could be…' This has the potential of generating options that actors might have not considered before.

Here, some illustrations of single- versus double-loop learning in organisations involved in environmental management that can be imagined. Organisations that have recently acquired computers and Internet access might be interested in exploring ways of managing their environmental problems. With single-loop learning, personnel in the organisation might locate information from the computers in place of using written materials. The behaviour has changed but the underlying way of managing the environmental problem has remained the same. With double-loop learning, personnel could decide to rethink the use of computers, perhaps using them to re-examine and alter the way they manage environmental problems. An example is acquiring new skills in problem definition and analysis to solve environmental problems.

Organisational learning demands cognitive changes as well as behavioural changes in order to support sustained renewal. This process however requires a disposition and norm of continuous learning as well as conditions that allow flows of learning among individuals, groups, and the organization as a whole.Learning flourishes best in organizations that practice democratic principles of liberty, pluralism, and regard for the worth of individuals.

Linking organizational learning to pollution management organizations would help clarify how each organization influences matters of importance and identifies where significant gaps exist in the whole pollution management strategy. Here, I see a logical interrelation between the different organizations in two main ways: as a forward process from situation assessment to situation improvement and as a backward process to evaluate and monitor results. This implies that information in one organization is related to the information in the other. Within each organization, many different activities influence the process, and for that matter, determine the output. The number and scope of these activities vary between the different classes of actors and the scale of the pollution management task. In each

organization the following elements of pollution management are proposed (figure 2.6):

- *Context of pollution management* – This presents the governance structure of the organization, and the traditions in the organizations. These attributes influence the past, present and future management of pollution by the organization.
- *Pollution management previous* – This represent previews of decision-making arrangements, control mechanisms, and tools that were used to manage pollution problems. The result of these elements which is the outcome of measures and the pattern of interaction serve as input elements for pollution management in the present.
- *Pollution management present* – This represent present decision-making arrangements, control mechanisms, and tools used to manage pollution problems. The result of these elements which is the outcome of measures and the pattern of interaction serve as input elements for pollution management in the present. Feedback from the evaluation and monitoring of the object of pollution management is used to design a new strategy for the future.
- *Pollution management in future* – This represents the proposed decision-making arrangements, control mechanisms, and tools used to manage pollution problems in the future based on insights gained from present pollution management actions.
- *Object of pollution management* – Elements of pollution, comprises attributes, and the nature of the technology, which require management, the normative, social and cultural characteristics of the actors responsible for pollution problems and the way evaluation and monitoring activities that caused pollution are undertaken. The present pollution management has a direct influence on the object of pollution.
- *Context of the object of pollution management* – These include the actors and stakeholders in the context that cause and/or are affected the by pollution. These are communities, environmental organizations, enterprises, non-governmental organizations and the government institutions.

Finally, three dilemmas of organisational learning are worth noting. First, the cost of practicing democratic principles that reflect the value of individuals, participation in decision making, freedom of thought and inquiry, and a tradition of vigorous criticism and healthy human relationships may be high, especially for organisations that rely much on routine production processes. Secondly, the importance of multilevel learning and governance models may be underestimated. And thirdly, where norms of isolation and self-reliance prevail, people have little reason to change if they have not experienced or cannot envision the difference that learning can have at every level.

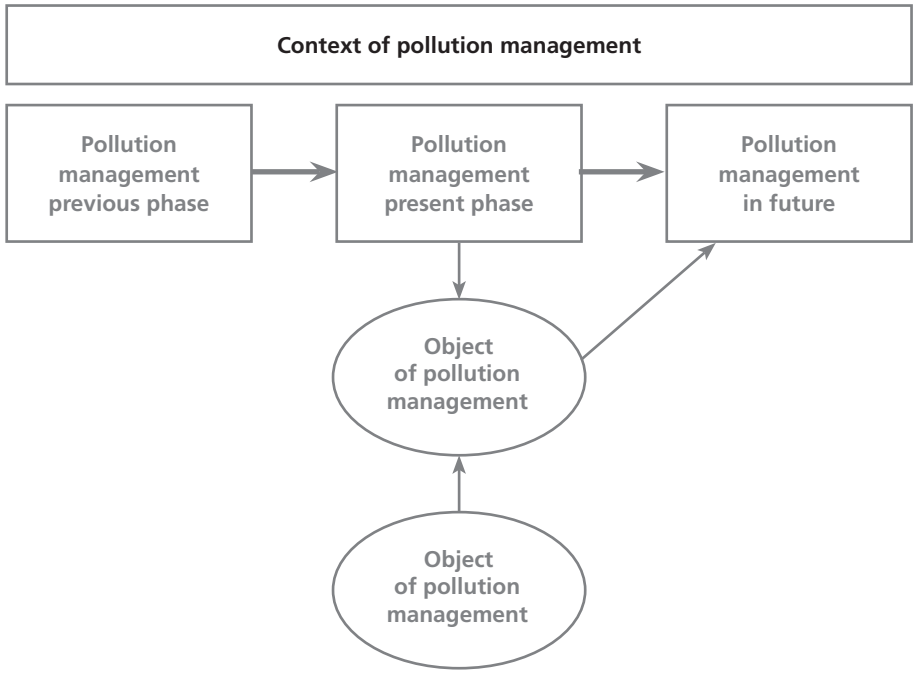


Figure 2.6 ■ Proposed different elements of pollution management

2.4 Sustainable development

Pollution is perceived as a serious problem in both developed and developing countries. An initial reactive approach to pollution problems has not achieved the desired results in finding solutions. Most recently, mankind's attitude towards the environment has evolved to encompass a proactive response in an attempt to find appropriate solutions. This has led to the evolution of new concepts, including 'sustainable development' as a basis for overcoming the environmental problems. In this section, I examine the concept of sustainable development and its use as a conceptual pillar in the development of the OPiC framework.

2.4.1 Historical and conceptual precursors

In order to understand the Sustainable Development concept, one needs to consider the historical process that culminated in the concept. Exactly when that historical process began is debatable as reflected by the varied opinions that exist within the Sustainable Development literature. For instance, Mitcham (1995) believes that the philosophical and historical background against which the ideals of Sustainable Development emerged were basic ideas about the character of historical change as cyclical or a progressive process. Mitcham grounds his argument

in the belief that the concept has links with the idea of movement away from an imperfect past towards a perfect future. Most current discussions on the concept of sustainable development take the report, 'Our Common Future', published by WCED, as a starting point. This report, a comprehensive one produced through a global partnership, constituted a major turning point in the concept's development. As with any conceptual process, some significant conceptual precursors led to the WCED's definition of sustainable development. In the present study, three historical and conceptual precursors identified are *(i)* religious and traditional beliefs, *(ii)* the theory of limits and economics and *(iii)* appropriate technology.

The values of religion and tradition have taught us to perceive and act on the resources of nature in terms of particular human interest, beliefs and social structure. Through religious and traditional beliefs and values, we have framed nature in human terms in order to satisfy human needs, abilities and power relations. At the same time, religion and tradition have also presented nature to humanity through various spiritual teachings (Gottleib, 1996). This is by reminding us of our relationship with ecological resources. Most of these teachings especially Christianity are based on the notion that it is man's right to 'master the earth'. These are an essential source for the environmental problems caused by societies on earth. Other environmentally related passages in the religious text have made Christianity more environmentally minded than it may seem at first glance (Kinsley, 1996; De Groot, 1992), and churches nowadays preach forms of stewardship rather than mastership.

Besides the dominant religions, there are numerous indigenous and traditional beliefs that have been used as the basis for dealing with environmental issues. For instance, for most human history, our species lived in ways that were environmentally sustainable. A typical example is the Nile valley cultures that developed and depended on an intricate system using natural resources in a sustainable way (Gowdy, 1997). Traditional beliefs differ from one culture to the other. However, the core element that runs through many of them is the importance of living in harmony with nature through constant communication with nature in a holistic form.

The theory of limits is based on the work of Thomas Malthus (1798) in which he noted that the limit to population growth is caused by resource scarcity. It was around this time that the sustainable use of resources was first mentioned in the field of economics (Goodland, 1995). Malthus in his work observed that vices and misery that befall societies are not due to evil human institutions, but rather to the fecundity of the human race, and population when unchecked will increase geometrically while subsistence increases arithmetically (Blanchfeild, 1975). This theory expressed in terms of 'environmental limits thinking' put limits on the supply of goods, ecological resources and the resultant diminishing returns to labour in ecological resource exploitation (Pearce and Turner, 1990).

The concept of appropriate technology evolved in the wake of global pollution, resource exhaustion, corporate concentration, and the diminution of individual liberties. The main notion of appropriate technology that natural resources were being exhausted gave an impetus to the rise of concerns that also looked at environment from the social, economic and ecological aspects of resources (McClaughry, 1989). This approach added a new dimension to the thinking about appropriate scales of organisation and at present, appropriate technology is promoted as the way to help develop the less developed communities (DuBose, 1995) while taking care of the environment. The present idea on low inputs and organic agriculture may also be seen as part of this movement. In this light, the concept of appropriate technology defined as technology that takes heed of the skills, levels of population, availability of natural resources, and pressing social needs defined by the people themselves is the immediate precursor to the concept of sustainable development.

2.4.2 Recent evolution of the concept

Without underestimating the significance of any of the preceding concepts, it is my belief that the concept of sustainable development emerged largely from the forces generated by the 'limits-to-growth' debate of the early 1970s. The limits-to-growth debate was ignited by the findings of the Club of Rome Report (Meadows et al., 1972). The fundamental argument of the Club of Rome in their report called 'Limits to Growth' is that technological development and societal increase simply cannot continue as they have for the last 200 or 300 years. The simple and obvious point of 'Limits of Growth' is that exponential growth, a characteristic of modernity, cannot continue forever. This report involved an in-depth study of the environmental and resource limits to growth and the potential role of technological change in removing such limits. The result it generated indicated the rapid depletion of resources and the fast approaching limits to the growth in resource use. The condemnation of growth-oriented policies resulted in a range of socially and politically unpalatable questions in relation to economic growth. To avoid these questions and their obvious ramifications, there was a change in the course of the limits-to-growth debate by embracing the concept of sustainable development. Yet, because of the influence of dominant institutions, the sustainable development debate proceeded in a manner that deliberately avoided critical issues concerning the desirability of economic growth and environmental management. Consequently, dominant institutions were unable to legitimate and justify the status quo.

The shift from emphasising on what *should not be done* to stressing on what *should and can be done* is constituted by the shift from a discussion of 'limits to growth' to 'sustainable development'. This led to the concept of sustainable development being the focus of the 1972 UN conference on Human Environment in Stockholm. It was at this conference that environmental management and environmental as-

sessment were recognized as management tools (DuBose et al., 1995). It was also recognised that environment and development could not for long remain in a state of conflict and that environmental and development ideas needed to be considered concurrently. This shift in the framework of the discussion was decidedly initiated was by two other reports. According to Tryzna (1995), the first breakthrough in conceptual insight is the International Union for the Conservation of Nature (IUCN), which working closely with the World Wildlife Fund for Nature and the United Nations Environmental Programme, formulated the World Conservation Strategy, which was launched internationally in 1980. This was a major attempt to integrate the environment and development concerns into an umbrella concept of conservations. Although the term 'sustainable development' did not appear in the text, the strategy's subtitle, 'Living Resource Conservation for Sustainable Development' certainly highlighted the concept of sustainable development (Khosla, 1995).

WCED picked up the theme a few years later. The report of WCED (also known as the Brundtland Commission), 'Our Common Future', built on the tactics of the World Conservation strategy, reemphasised the shift in terms of discussion from limits to sustainability. This shift resulted in two extremely polarised positions. On one side were the environmentalists, who argued for the limits to growth or no-more growth to meet the threat of pollution, protect natural resources, and respect the rights of future generations. On the other side were the economists, who argued for the need for development and more growth especially for developing countries, to alleviate poverty in the present and make it possible for nations to play their role in international affairs. The Brundtland report's solution to bridge the gap between these conflicting interests was to propose neither simply a limit nor simply development but sustainable development. The conceptual definition of the Brundtland Commission contains two concepts: Firstly, the concept of 'needs' in particular, the essential needs of the world's poor, to which overriding priority should be given, and secondly, the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs.

Not surprisingly, the Brundtland Commission's definition of sustainable development was interpreted in so many ways, receiving a very wide acceptance. According to Holmber (1994), 'by 1994 there were more than 80 different definitions and interpretations fundamentally sharing the core concept of the WCED's definition'. Another major development around this time was the 'Earth Summit' in Rio which coincided with the UN Conference on Environment and Development (UNCED) held in June 1992. The outcome of the UNCED conference is the production of major international documents such as the Rio Declaration 21 and international conventions on desertification, biodiversity, and climate change, which led to the identification of participation as a tool for sustainable develop-

ment in every corner of the world and which has drawn a lot of critique. However, considering the institutional foundation of WCED and the global realities in the mid 1980s, the definition of sustainable development, provided by WECD contained much practical wisdom and has been highly instrumental in developing the new global thinking that is emerging today.

2.4.3 Defining the concept

In the context of the present research, I categorise the definitions of sustainable development into *(i)* institutional, *(ii)* disciplinary and *(iii)* ideological conceptualisations. This categorisation is done in order to identify the source of pollution, the core approaches used to solve pollution problems, the proposed platform and key tools for the solution. A summary is given in table 2.4.

Institutional conceptualisations

The definitions given by WCED, the International Institute of Environment and Development (IIED) and the World Business Council for Sustainable Development (WBCSD) are taken to be the representative of the institutional version. A comparison of these definitions shows that they all share needs satisfaction, with variations in the interpretation depending on the context. The differences in interpretation are related to the ways in which the institutions identify the core of the solution, solution platform, and the tools required to actualise the solution.

The definition of sustainable development given by the Brundtland Commission in the previous section serves as the core element for almost all the institutional definitions. The Brundtland Commission report contained the key definition of sustainable development, as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987).

The definition of sustainable development developed by the International Institute for Environment and Development is based on the identification of three systems as basic to any process of development: the ecological system, the economic system, and the social system. As noted by Holmberg (1994) 'human society applies a set of goals to each system.' The objective of sustainable development will then be to maximise goal achievement across these three at the same time. The typical feature of this definition is that it is based on increasing empowerment of people to take charge of their own development, combined with clear knowledge of environmental constraints.

The other institutional version is the definition presented by the WBCSD. In this definition, the concept of sustainable development recognises that economic growth and environmental protection are linked, and that the quality of present

and future life rests on meeting basic human needs without destroying the environment upon which all life depends (Schmidheiny, 1992). The WCED version asserts that economic growth in all parts of the world is essential to improving the life of people. This version also asserts that the requirement of clean, equitable economic growth remains the single greatest difficulty within the scope of sustainable development for business and industry. The way to achieve such growth is through the development of strategies to maximise value added while minimising resource and energy use through the implementation of the principle of eco-efficiency and new technologies.

Disciplinary conceptualisations

The disciplinary conceptualisation of sustainable development, which involves economist, ecologist and social ecology as shown in Table 2.4, reflects the response of the scientific community to the challenge of the environmental crisis of the twentieth century. At the centre is what Jacob (1994) refers to as the neo-classical approach to environmental problems: that is to 'turn the environment into a commodity that can be analysed in monetary terms like other resources'. The neoclassical economists are of the opinion that the environment is undervalued, and because it can often be used free of charge, it tends to be misused and overused. If the environment were given its proper value in economic decision-making terms, it would be protected much more highly (Redclift and Benton, 1994). The proposed solution of the neoclassical economists is composed mainly of two stages. The first stage is to determine the price of the environmental resources by constructing supply and demand curves based on the application of different valuation techniques. This enables the economist to identify the appropriate level of environmental protection for society to adopt (Jacob, 1994). The second stage is to turn these imputed prices into real-market prices, either by changing the prices of the existing market activities by taxing environmental damage, by creating markets for environmental goods by issuing permits, or subsidizing environmental improvements. The solution to pollution problems that are caused in this way is through the internalisation of externalities through the use of market-based tools.

The ecological conceptualisation of sustainable development as noted by Clarke (1993) is based on the following two main premises:

- the assumption that nature is a self-organising system that changes, responds and evolves over time.
- the assumption that human beings depend on nature for their needs through interaction with the elements of nature.

Based on the above premises, two domains of ecological sustainability are identified. 'Shallow ecology' meaning the treatment of environmental problems without tackling the underlying causes and without confronting the philosophical assumptions that underlie our current economic and political thinking. On the

other hand, the 'deep ecology' aims to tackle the underlying causes of environmental problems. This is because, in the end, environmental reforms of social and economic systems are not a viable solution to offset the increasing pollution problems (Braidotti et al., 1994). The source of pollution problems used by this conceptualisation is that human beings have domination over nature, hence, human beings have the right to pollute nature. The source of solution to such problems is human beings having respect for nature. This can be achieved by taking a bio-centric approach to pollution problems.

Social ecology on the other hand is based on the conviction that nearly all of our present ecological problems originate in deep-seated social problems and cannot be understood, let alone solved, without a careful understanding of our existing society and the irrationalities that dominate it. Thus, economic, ethnic, cultural, and gender conflicts, among many others, lie at the core of the most serious ecological dislocations we face today. The social ecological conceptualisation identifies domination of people over nature as the main source of environmental problems (Jacob, 1994; Bookchin, 2003). It is imperative to define different social hierarchies to deal with specific and different environmental pollution and charge vertical and horizontal hierarchies with clearly assigned responsibilities. This would help solve environmental crises that arise as result of the co-evolution of humanity and nature.

Table 2.4 ■ Comparative analysis of the different conceptualisation of sustainable development

Conceptualisation	Source of Environmental Crisis	Source of Possible Solution	Tools Areas
Institutional ■ WCED ■ IIED ■ WBCSB	 Political development Rural development Business development	 Sustainable growth Environmental care Eco-efficiency	 Governments Community Business
Disciplinary ■ Environmental economics ■ Ecology ■ Social Ecology	 Under valuation of ecological resources Human domination over nature Domination of people and nature	 Internalisation of externalities Respect for nature Co-evolution of humanity and nature	 The market Place Bio-centric thinking Re-definition of social hierarchy
Ideological ■ Eco-feminism ■ Eco-socialism ■ Eco-theology	 Male centred Capitalism Christian arrogance	 Women centred Socialism Spiritual revival	 Women associations Unions (trade) Churches

Overall, the disciplinary versions exhibit conceptual shortcomings that are reflected in their solution strategies. Moreover, there is a danger that 'the prevailing conflicts of views about the environmental crisis, which arise from being locked by the reductionist way of thinking, may harden into inflexible and polarised oppositions (Redclift and Benton, 1994). According to these authors, this can be attributed to the fact that every discipline approaches the other in a reductionist

way, seeking to impose its views and procedures on the decision making process. In this respect, there is the need for a new way of scientific thinking based on radical revision of the existing approaches, with the objective of transcending the pervasive 'dualism' that dominates modern thinking.

Ideological conceptualisations

Table 2.4 mentions the environmental versions of liberation theology, radical feminism, and marxism. Some academics consider eco-feminism as the conceptual juncture, where the four main features of the liberation theory – the oppression of gender, race, class and nature finally come together (Plumwood, 1993). The French feminist writer Francoise d'Eaubonne who identified overpopulation and the destruction of natural resources as the two immediate threats to human survival, introduced the concept of eco-feminism in the 1970s (Braidotti et al., 1994). In her view, the 'male system' is the main source of destruction and threat and the only way out would be for women to destroy the male system. Eco-feminism today is a significant stream within the feminist movement, which contains a range of theoretical positions based on the assumption that there is a correlation and interconnection between the domination of nature and the domination of women. The idea behind eco-feminism is to expose, challenge, and change dominant power structures, whether within gender or economic systems. The basis for this is the merging of the potentials of ecology and feminism to create a new force for social and cultural change.

The next ideological concept is the eco-socialism. This ideology arose due to the modern environmentalism, which triggered a new debate between socialists and environmentalists. Eco-socialism is based on the assumption that sustainable, ecological sound capitalism is a contradiction and can never be realised. It asserts that the ecological problems we are facing are the result of the inherent crisis within the capitalist system and that it can be overcome only through ecologically oriented socialist development. As noted by Pepper (1993), 'eco-socialism is anthropocentric and does not consider individual humans as pollutants; neither are they 'guilty' of greed, aggression, over-competitiveness or other savageries.' If human beings behave in any of these ways, the cause is the prevailing socio-economic systems. According to the concept, we should not dominate or exploit nature in the sense of trying to transcend natural limits and laws, but we should collectively plan and control our relationship with nature. This can be done by re-appropriating collective control over our relationship with nature, through a common ownership of the means of production. Individual ownership is not rejected *per se* so long as it cannot be separated from nature. If they are separable, however, they must be replaced by common development where technology is adapted to nature and not destructive of it, and at the same time strengthen the competency and controlling power of the owners (Pepper, 1993).

The next is eco-theology. The rise of modern environmentalism opens a new door of criticism towards traditional religions. Christian religious traditions and beliefs have been singled out by environmental groups to be one of the causes of environmental problems because of their teaching of man's domination over nature and his duty to make the world a better place to live in. It is against this background that eco-theology started to emerge. Using as its basis the views of St Francis, who is considered a patron saint of ecology, eco-theology tends to reinterpret old traditions to help us face the current environmental crisis (Dickson, 2000). The concept tries to explore the religious beliefs and traditions about treating things the way we want to be treated. Eco-theology is based on the notion that mankind has ignored the wealth of ecological resources in the religious tradition. What is needed is an environmental theology to dig up the appropriate religious texts and interpretations which can throw light on the present environmental crisis. According to Haught (1996), the main source of our respect and love for man and nature is our relationship with God, and the solution to environmental crisis lies in a renewed commitment to humanity, to the virtue of detachment and to the central religious posture of gratitude by which we accept the world as God's gift and treat it accordingly. The source of solutions is through revival and the using of churches and religious organisation as tools to effect change in human beings. For eco-theology, 'sustainable development' primarily relates to the spiritual development of individual humans.

Taking a clue from discussion above, the sources of environmental crisis in developing countries are reflected in the institutional and disciplinary conceptualisation. The potential socurces of possible solutions and areas were the OPiC framework is used to deal with the environmental crisis include the following:

- Production processes employed should adopt eco-efficiency approaches and new technologies that will add value to products and minimise resource and energy use. Communities should adopt approaches that care for the environment in undertaking development activities.
- Promoting the sense of environmental care among communities in especially rural areas is a possible source of solution to environmental problems caused by rural development.
- The empowerment of women in environmental management is a major source of possible solutions to environmental problems caused male dominated male actions. The formation of women associations to deal with the environmental problem under consideration is a potential tool to address this problem.
- Use a bio-centric approach to tackle pollution problems caused by human activities that do not have respect for nature. That is, making human being respect nature and treating it with care.
- Actors should link economic growth with environmental protection so that the quality of present and future life is balanced. With the requirement of clean, equitable economic growth being the single greatest difficulty within the scope

of sustainable development for business and industry, growth is through the development of strategies to maximise value added while minimising resource and energy use. Promote this through the implementation of the principles of eco-efficiency and new technologies.

- Define different social hierarchies to deal with specific and different environmental pollution and vertical and horizontal hierarchies clearly with responsibilities assigned. This would help solve environmental crises that arise as result of the co-evolution of humanity and nature.

2.4.4 Constant stock of capital as a condition for sustainable development

The essence of WCED's widely accepted definition of sustainable development is that the conventional economic development imperative of maximizing economic production must be reoriented toward minimizing suffering today and in the future. This depends, on one hand, on reducing ecological destruction – mainly through reducing the claim on resources that the human economy draws from nature, and on the other hand, improving people's quality of life. In other words, SD is living within the productive capacity of nature (Pearce et al., 1988) In line with this, ecological economists have proposed the concept of 'natural capital' (Costanza and Daly, 1992). Natural capital used in this context, even though lacking a universally accepted definition, includes those components and relationships of the ecosphere that are essential for the continuous self-production of the natural system. Variation in opinion about the concept has led to the emergence of two main sustainability measures: strong sustainability measures and weak sustainability measures (Pearce et al., 1989).

A strong sustainability measure is based on the principle of keeping intact the quantities of natural and human-made capital separately. The need to keep these two capital assets intact is due to the belief that both assets are perfect or near perfect complements and, as such, the productivity of one is dependent upon the availability of the other (except services provided by the natural capital). This assumption implies that any augmentation of the quantity of human-made capital is unable to offset a depletion of natural capital sufficiently to maintain a constant stream of consumption over time. The only way to have a sustained constant consumption is through improvement in the efficiency with which human-made capital converts natural capital into final goods and services. However, there are thermodynamic limits on the capacity of human-made capital to overcome the diminution of natural capital stocks. Hence, strong sustainability requires that any adverse residual impact on the environment needs to be zero, especially those with a cumulative impact.

Weak sustainability on the other hand, is the measure based on keeping intact the combination of natural capital and human-made capital rather than maintaining each variety of assets individually. This measure works on the belief that both categories of assets are perfect or near perfect substitutes. As such, it is assumed that the depletion of natural capital stock will not undermine the capacity to maintain a constant income over time so long as the stock of human-made capital is augmented sufficiently to compensate natural capital. That is, single stocks may decrease and even be exhausted, so long as the aggregate condition is being satisfied all the time. This condition may vary in situations when the measure is a non-declining utility over time. In such a case, it is a very weak sustainability measure (Pezzey, 1989). A very weak sustainability measure is based on the capacity of a combined stock of capital irrespective of its makeup to sustain a given level of utility.

Some scholars use strong sustainability as the criterion for judging whether humanity lives within nature's productive capacity. In this case the ecological bottom-line of sustainability is only met if each generation inherits an adequate stock of essential natural capital assets, independent of the human-made capital stock. In addition, natural capital must not be less than the stock of the assets inherited by the previous generation. Pearce and Alkinson (1993) have remarked, and justifiably so, that the debate finally hinges around the question of substitutability or complementarity of human-made capital for natural capital, which is examined in the section below.

2.4.5 Complementarity and substitutability of natural capital

Complementarity and substitutability of natural capital is based on the functions of the natural environment where ecological and other environmental processes are examined (e.g. De Groot, 1992). As noted earlier, the sink function, the source function, habitat and life support function are the main functions of the natural environment. Given that these functions of natural capital are necessary to sustain human-made capital, the question of substitutability may be rephrased as the question of how much natural capital is needed to maintain intact the stock of human-made capital required to achieve sustainability. This question relates to the first and second law of thermodynamics.

The law of conservation of matter and energy, which is the first law of thermodynamics, ensures that matter-energy embodied in resources exacted from natural capital, which is then transferred into human-made capital, can never be lower than the matter and energy embodied in the human-made capital produced. This suggests that matter and energy created through the production process is a breach of the first law. The second law, the entropy law, states that matter and energy is less available for future production following its transformation into human capital. In addition, the entropy law does not give room for 100% recycling

of matter and precludes any recycling of energy. The deductions from the first and second laws of thermodynamics above in relation to the production of production of human–made capital are:

- The ratio of matter-energy embodied in human-made capital to that in natural capital must be less than the value of one if sustainability can be achieved.
- The production and maintenance of any given human-made capital requires the input of a minimum, irreducible quantity of natural capital. How much minimum requirement is at any point in time depends entirely on human technology embodied in the human-made capital, however.

Thus, as human technology improves, a given quantity of human-made capital produced from a small natural resource capital may become larger. However, a point is reached where it is not possible according to the law of thermodynamics to reduce waste production and increase human-made capital. At this point, the production and maintenance of an optimal stock of human-made capital requires the continued input of irreducible amount of natural capital. This is a critical point in the substitutability versus complementarity issue.

Based on the above assertion, it is my contention that, at bottom, natural and human-made capital are complementary and not substitutes. To strengthen my case, I may point out the following:

- Substitutability between natural and human-made capital might well be an illusion created when the capacity to produce a given quantity of human-made capital from a lessened input of natural capital results, not from substitutability per se, but from a reduction in natural capital wasted in the conversion to newly produced human-made capital, which is more of implicit substitutability (Lawn, 1999). In fact, this does not constitute substitutability because human-made capital does not 'take the place' of natural capital.
- Human-made capital and natural capital are fundamentally different elements of the production process. Natural capital constitutes the material cost of production and human-made capital. The natural capital transforming agent constitutes the efficient cost of production. Hence, efficient cost of production without material cost of production processes nothing. Therefore, natural capital is the' true' input of the production process (Lawn, 1998).
- Human-made capital is itself the output of the production process requiring input of resources exacted from natural capital. Consequently, to produce more of the perceived substitute requires more of what is being substituted, which is the defining condition for complementarity not substitutability (Daly, 1996). Human-made capital is based on processing natural capital which has many functions for which substitutability is simply not conceivable. For example, finding a substitute for the depleted ozone layer.
- If the substitutability of human-made capital for natural capital is possible, why has mankind devoted time, effort, and energy to accumulating the former

when its perceived substitutes already exist? It is because they are complementary and production is limited by the lack of human-made capital.
- Finally, while some human-made capital is used for natural capital functions, it can never fully replicate the sink and source function of natural capital.

How do the above ideas of substitutability mean for pollution management, environmental management and OPiC in practice? Say, we have a society of 100 people with 100 acres of arable land and 10,000 acres of forest. People need, say, shoes. Hence they start a shoe workshop. This takes up one acre of forest plus trees cutting for energy for the workshop. Thus, they converted natural capital to human capital; natural capital has become less. Is this unsustainable? The OPiC framework proposes that the activity must be evaluated through an 'equity filter'. This implies that development proposals have to prove that they are not burdening future generations, and the ideas developed above may help to get this 'equity filter' right.

In this context, the OPiC framework adopts the following main precepts to keep intact, the functions of the natural capital in order to achieve sustainability.
- Maintain the ecosphere's source function intact and sustain the rate of natural capital entering the production process by first ensuring that there is deliberate use of renewable natural capital to substitute for the depletion of non-renewable natural capital. In this way all the capital used is less than the regenerative capacity of the renewable natural capital. Second, ensure that if the total stock of natural capital is greater than the natural regenerative capacity of the renewable natural capital, part of the usable non-renewable capital is used at a rate equal to the regeneration of a suitable renewable natural capital substitute.
- Maintain the sink function of the ecosphere by ensuring that the quantity and qualitative nature of human-made capital in the form of waste does not exceed the waste assimilative capacity of the ecosphere. This requires substituting unsustainable human-made capital with more sustainable human-made capital.
- Humankind should preserve and /or restore the ecosphere's rich biodiversity in order to limit any irreversible damage it might inflict on the ecosphere instrumental function. Both extraction of resources and insertion of resources to the ecosphere must be limited to a rate that avoids humankind's need to exploit the ecosystem.
- Values and principles for natural capital that can be substituted and those that cannot should be defined. Strong sustainability approaches should be used for environmental functions provided by natural capital that are not or most likely not substitutable whilst weaker sustainability approaches should be applied for natural capital that require major human management inputs. In using a strong sustainability, one applies non-negotiable well-defined norms, values and standards, while for weak sustainability, market-based tools and economic tools are applied.

2.4.6 Aspects of an environmentally sound planning process

Planning can be characterised by substance and process. Up till now, I focused on the substance side of (environmentally sound) planning. The present section is on the process side. Specifically, I discuss context analysis and macro-level analysis, and draw conclusions for their use in design, implementation, monitoring and evaluation of solution to pollution problem presented in Chapter 6.

Context analysis

The aim of context analysis is to reach a thorough understanding of the actors and driving forces connected to an environmental problem and its solutions. This analysis may involve key actors to generate trust, commitment and ownership of the problem. Context analysis is required to design concrete solutions and define concrete agreements with actors. Key characteristics of context analysis are presented in table 2.5. The arrow in the table shows that context analysis feeds into macro-level analysis.

A context analysis starts out from the problematic human action that has been identified in a problem analysis and then works its way 'outward' into the context step by step, asking each time what actors, social mechanisms and social system characteristics may be behind the phenomena found. Based on Vayda's (1983) principle of 'progressive contextualisation', the Action-in-Context component of the Problem-in-Context framework is specifically designed for context analysis (De Groot, 1992). A detailed description of how contextual analysis is taken up in the OPiC framework is presented in section 4.7. Though this approach works quite well to identify concrete target groups and policy options for solutions, a limitation is that it does not give much systematic insight in the larger systems and long-term processes the actors are embedded in. The macro-level analysis aims to fill this gap.

Table 2.5 ■ The main characteristics of context analysis and macro-level analysis

Contextual analysis →	Macro-level analysis
■ Local issues are considered and driving forces and stakeholders at micro and meso levels. ■ The analysis starts out from a local problem and establishes links with the broader context. ■ Analysis of specific events, cases, failures and successes are carried out in detail. ■ Concrete potential target groups and policy options are identified.	■ External factors, sectors, actors and macro level driving forces are analysed. ■ The analysis starts from a broader context focusing on key factors and establishing linkages with the local problem. ■ The analysis is aimed at acquiring a broad insight of issues and trends. ■ Analysis considers relatively large areas and a long period of time to determine historical patterns of change, resulting in a vision or prediction of the future.

Macro-level analysis

Local situations cannot be fully understood without insight in their macro context. Fed by information from the context analysis, macro-level analysis focuses on the systemic and longer-term processes that the local situation is embedded in, so as to help in making more realistic predictions and reduce the amount of 'trial and error' in the design of solutions. Macro-level analysis may start from a broader context and may select themes that appear to link strongly to the local situation (Table 2.5). Identifying such themes requires both social-scientific theoretical insight and some knowledge on the local situation. For Ghana and probably many other areas too, typical issues for macro-level analysis may be, for instance:

- Spatial distribution of land use patterns of and their changes over time;
- The dynamics and interaction of population and the environment, e.g. the presence of technical and institutional innovations that respond to increasing scarcity;
- Trends in conflict intensity created by or potentially influencing the environment;
- Attitudes of local communities towards nature, government and markets;
- Trends of globalisation and local counter-assertion.

2.5 Conclusion: building blocks for the OPiC framework

The objective of this study is to develop an Opportunity-and-Problem-in-Context framework (OPiC) to support pollution management in developing countries. Based on the review presented in the previous sections, the following building blocks for the framework are proposed.

The approach of the scientific community to environmental challenges started within the disciplinary domains. Disciplinary science based on reductionist views will remain to be the best source of gaining in-depth knowledge about single elements of the broad framework, such as on pollutant dispersal and toxicity and environmental regulation. But when it comes to complex pollution issues, the limitations of the reductionist view come into view. The move from the disciplinary to interdisciplinary approach has been dictated by the inherent limitations of the disciplinary approach in dealing with systems of organised complexity. The limitations of the disciplinary approach again dictate the need to also take up elements from to the transdisciplinary approach in dealing with environmental challenges.

Building blocks from the offspring of the scientific approaches

To deal with both simple and complex environmental issues, interdisciplinary and transdisciplinary approaches are the best fit. Pollution is of many kinds and can be managed by adopting an interdisciplinary causal chain approach or transdisci-

plinary system approach. Coalescing these two, I propose the following building blocks for the OPiC framework:

- The combination of CSPH+PR classification of functions of the environment and participatory rural appraisal methods (from the multidisciplinary approach), progressive contextualisation (from the causal chain approach) and adaptive management, integrated management and material flow analysis (from the system approach) in the OPiC framework is aimed at overcoming the epistemological shortcomings of the traditional frameworks for pollution management.
- The CSPH+PR classification can be used to analyse and explain the intrinsic capacity an ecosystem needs for self-renewal, taking into account the social needs and human goals and the different of the environment. The insight gain from the analysis is used in the development and operationalisation of the problem identification component of the OPiC framework. The CSPH+PR classification also serves as the backbone for the identification of policy options based on the Problem-in-Context framework in section 5.1
- Participatory rural appraisal methods can be used in the OPiC framework to identify problems faced by actors (community and individuals); willingness of actors to promote their role in environmental management; the perception of actors about rules, regulations and attitudes, to harness local and traditional knowledge systems for environmental management, and for crafting appropriate policies to stimulate environmentally responsible behavior by actors. Depending on the situation and the task at hand, a combination of methods such as secondary sources, visual models, income and expenditure matrix, semi-structured interviews, workshops and direct observation should be used. This building block is captured in section 5.4 where 'basis in people' and 'basis in learning' are presented as key components of an enabling context for the discovery of opportunities and also a major component in the design, implementation, evaluation and monitoring component of the OPiC framework (see section 6.3).

Causal chain related building blocks

The most important building block based on the causal chain approach is the progressive contextualisation. This involves the adoption of procedure that focuses on significant human activities on the environment and placing them within progressively wider context. It is crucial to study specific activities performed by specific people in specific locations at specific times, then trace the causes and effects of these activities outwards, including the factors impinging on them, without defining boundaries. By adopting progressive contextualisation, micro and macro forces at play, the options available to actors, the different decision-making arrangements possible, the underlying factors affecting the options and motivations of actors will generate insight for the development and selection of solutions to environmental problems.

System-related building blocks

In the OPiC framework, the systems are taken as any organised physical entity with a specific functional purpose and manifestation, which are characterised by uncertain and undistinguishable information embedded in them. System theory is the core foundation on which a learning organization should be built since processes and structure of systems, whether biophysical, economic, social and institutional, are linked and interconnected. With pollution problems being complex and the social systems that are responsible for solving them also show some characteristics of complex systems and are difficult to describe and explain, an adaptive management approach is suitable to deal with the complex systems at any scale and level. The adaptive management approach is therefore one of the design principles for the development of solutions in the OPiC framework (see section 6.2). Another area in the OPiC framework where adaptive management should be used is environmental assessment and management. This involves the integration of ecological and participatory research approaches and adaptive management in this sense refers to a structured process of 'learning by doing'.

Material flow analysis is the basis for the use of life cycle assessment in section 4.4 and the identification of opportunities in section 5.2. The main building blocks from material flow analysis for the development of the OPiC framework are the prevention of primary resource claims through a reduction of the demand for additional products by an improved use of information and existing hardware and the increase of resource use efficiency on a life cycle wide basis. This includes the reuse, remanufacturing and recycling of products and a shift towards renewable resources. The OPiC framework takes material flow management as a pillar as it has the potential to balance the pressures on the different actors and is also able to combine upstream and downstream incentives.

Building blocks from governance

The decentralization of pollution management functions is ideally part of a broader political process of decentralisation. The most important underlying condition for successful decentralization is serious commitment. This means that central governments must be willing to give up responsibilities and local governments must be prepared to take over such duties. However, for this political compromise to be reached, it is necessary that a sufficient level of mobilisation by civil society be put in place at the local level, so that the true benefits from decentralization can materialise.

Not all pollution problems should be managed in a decentralised fashion. Even when national governments decentralise responsibilities, they often must retain important policy and supervisory functions. Thus, the devolution of authority in pollution management to the lowest possible level connected to the physical scale of the pollution problem is necessary while the central governments retain rights

to instruct the lower-level governments when needed. This will contribute to justifying and accepting higher-level national issues such as national equity.

Co-management approaches (where the state and community negotiate to agree on shared responsibility for a range of pollution management functions) and integrated environmental management (where all interested actors are involved to agree on a common vision, strategy and roles and responsibilities) should be used in synergy to manage pollution problems. The way this should be done is presented in section 6.2.

A number of efforts have been made to combat corruption but none has been effective. Corruption in environmental related institutions in developing countries is a problem with governance and has to be acknowledged. In the OPiC framework, it is proposed that corruption could be reduced by enhancing transparency, increasing the probability of being caught and given serious penalties.

Multilevel learning, habits of inquiry, shared understanding and Behavioural/Cognitive Change are the key tenets of organisational learning that could serve as the enabling context for identification of options for solutions to environmental problems. These tenets are applied in section 5.4 and of the OPiC framework.

Building blocks from the sustainable development concept

It should always be borne in mind that environmental problems are partially created by ideological conceptualisations which may be a male centred approach to development, capatalism and Christian arrogance. Adopting a feminist approach, embracing green socialism and promoting spiritual revival are therefore always options that may support solutions.

It should always be borne in mind that it is not possible to maintain a preferred state of the environment without degrading it in an attempt to develop some human preferences, for different environmental conditions act as constraints on the quantity and quality of capital stock long before ecological integrity becomes an issue. Hence, any use of renewable and non-renewable capital, no matter how well substituted, may create changes in the ecosystem structure, function, and/or composition regardless of how well the natural capital is harvested or waste emitted.

The use of weak and strong sustainability in assessing the sustainability of human activities is not fixed because of the common condition that each type of stock has maintained at each point in time. The debate finally hinges around the question of substitutability or complementarity of human-made capital for natural capital. It would appear that, at bottom, natural and human-made capital are complementary and not substitutes because (i) human made and natural capital are different elements of the production process, (ii) human-made capital does 'take the

place' of natural capital when (iii) human-made capital is the output of production process which requires input from natural capital (iv) production of natural capital is limited by the lack of human made capital.

Against this background, the OPiC framework uses a two-tiered evaluation system in selecting policy tools and options for pollution management strategy. The two-tier process has equity placed above the efficiency objective, followed by the adaptability objective. The equity principle protects the basic needs of the present poor people, future generations, nature and other entities without a voice on the market.

Context analysis and macro-analysis are two main methodological approaches for an environmentally sound planning process. Contextual analysis has the great advantage of concrete connection with the problem and solutions at hand, and macro-analysis gives insight in the wider-scale structures and processes. Jointly, they lay the basis for the design of robust solutions that address the root causes of problems.

3 Context of application

In the preceding chapter, contextual analysis and macro-analysis were identified as two approaches that should be part of the OPiC framework in order to avoid disconnected and hence ineffective solutions. In this chapter, I focus on a number of substantive elements likely to be encountered in contextual and macro-analysis of pollution in developing countries and Ghana in particular.

I have taken Ghana and Tema as the 'template' to design OPiC, because these are the places I know inside out. Also, I take the Ghana/Tema situation as typical for countries or regions of low income and not-so-strong countries and regions. This implies OPiC is designed for developing countries in Sub-Sahara Africa even though some developing countries in Asia such as could find some of the information in OPiC relevant

Section 3.1 ■ *Constraints in developing countries*

This section presents constraints in developing countries for environmental management. On the negative side, corruption, institutional and physical infrastructure constraints, human resource constraints, financial resources constraints, socio-cultural resources constraints and mismatches between sectors are discussed as the main causes of actors' behaviour in developing countries.

Section 3.2 ■ *Background of Ghana and Tema*

This section presents the socio-economic background of Ghana and the current development strategies adopted. The section also presents an overview of the pollution problems in Ghana, discussing the development in pollution management in Ghana, institutions involved in pollution management, the National Environmental Policy and pollution management tools used in Ghana. In this section, I also present a general description of Tema, an industrial port city of Ghana from which lessons are learnt for the development of the OPiC framework.

Section 3.3 ■ *Conclusion for the OPiC framework*

In this section, based on insight gained from the previous sections and my experience working in developing countries, I present ways through which OPiC can respond to constraints in developing countries and outline the conditions necessary for the use of OPiC in developing countries.

3.1 Constraints in developing countries

The focus of this section is on constraints in developing countries that help analyse and explain pollution problems and also hinder sustainable pollution management. The emphasis given to the constraints vary widely from one document to another, depending on the pre-analytic vision embraced by the authors. They include: (i) mismatch between sectors, (ii) socio-cultural barriers, (iii) financial resources, (vi) institutional infrastructure, (v) physical infrastructure and (vi) human resources.

3.1.1 Mismatch between sectors

One of the shortcomings of pollution management tools in developing countries is the limited attention given to understanding and strengthening sectoral complementarities that are critical to pollution management. Looking at problem identification and opportunity discovery tools reviewed in Chapters 4 and 5, one can see that each of them places different emphasis on the private sector, civil society and the public sector, regarding their role in helping solve pollution management problems. In this section, I discuss these three sectors.

The management of pollution problems in developing countries has long been the sole responsibility of the public sector. More attention nowadays is given to involvement of market parties and civil society. This shift has been initiated by the Rio summit in 1992 (Hens and Boon, 1999) and has been reinforced by the process of globalisation which has lead governments of developing countries to rethink their development strategies by paying more attention to 'market forces'.

The reality is that in developing countries market parties and civil society are hardly involved yet, however. In general, national pollution management strategies in developing countries are based on promoting strictly regulatory state engagement in pollution management, in a way the undermines rather than stimulates involvement from the other sectors.

One main effect of this mismatch between sectors is evident in the use of tools for pollution management. In most cases, pollution management goals are not well tailored to the characteristics of the pollution problem at hand. Factors such as the nature of the pollutants (whether acutely toxic, bio-accumulative, and carcinogenic, dose-response dispersed sources) are hardly taken into account but maybe even more importantly, they are not tailored to economic situation of polluters such as competitiveness, budget constraints, availability of economic substitutes/alternative and demand.

In conclusion, any framework for pollution management in developing countries should facilitate and make explicit when and how the private sector and civil society could be involved.

3.1.2 Socio-cultural resource constraints and opportunities

Implicitly or explicitly, policies in developing countries are driven by the concept of 'development' which is widely interpreted as a movement from archaic to the new, or from traditional to modern ways of life. In such a socio-cultural context, indigenous institutions are described as informal, archaic institutions associated with underdevelopment (Ayittey, 1991). However, indigenous institutions such as kinship, family and clan lineage, land tenure systems, chieftaincy and traditional courts have a great potential for the management of pollution in developing countries.

Since different cultures have their own potentials to manage environmental problems, the use of pollution problem analysis and explanations tools reviewed in Chapter 4 which have their roots in industrialised countries are not automatically appropriate in the development context but need to be tailored along cultural and political systems. From the assessment of indigenous institutions in Ghana, Appiah-Opoku and Mulamoottil (1997) conclude that the use of a pollution management tools like EIA can be effective if socio-cultural factors that are relevant to the pollution management process are considered. A typical example is the incorporation of indigenous institutions and their knowledge into pollution management strategies at the grassroots level in the Ashanti region of Ghana which has reduce the previously total dependence on outside ideas, technology and experts in managing local pollution problems (Appiah-Opoku and Mulamoottil, 1997).

Another constraint is that state organisations in developing countries are often caught in a very bureaucratic policy culture and even less inclined to accept public participation than their industrialized counterparts. Even though traditional leaders in developing countries may be quite able to help organise public participation, they are only rarely given the opportunity to do so in pollution management.

Ecological knowledge and values of local people can help in understanding the complex nature of the environment. As noted by Appiah-Opoku and Mulamootill (1997), for instance, 'the religious norms, ecological knowledge, and practices of the Ashanti tribe in Ghana may provide an effective response to specific challenges posed by the local environment'. The philosophy of the Ashanti people is aimed at the perpetuation of all objects, both animate and inanimate. That is the Ashanti people always undertake activities that cause the features of the environment to survive for a long time. The Ashanti people also have a sanctioned aspect of social actions enshrined in indigenous beliefs, norms and taboos, coupled with a land tenure system that makes it wise to involve indigenous institutions in en-

vironmental management. The exclusion of suchlike themes and energies from environmental management is a missed opportunity.

3.1.3 Financial resource constraints

Because of political instability in many developing countries, it is difficult to create the institutional setting necessary for effective environmental management. Strategic planning for pollution management requires along-term planning horizons and a long-term commitment of development finances. These conditions are rarely met in areas prone to political turmoil and civil unrest.

Even in relatively stable countries such as Ghana, however, resources allocated to environmental institutions and agencies tend to be minimal. Most governments of developing countries face difficult financial conditions and are under pressure to manage their debt, cut down public spending and focus on the economics of nation building and economic growth as the main source of state legitimacy. These pressures tend favour crude capitalism and to shorten the time horizon about any decision concerning pollution management, making it hard for governments to invest in the environmental area. For example in Ghana, only 0.07% of the government expected expenditure is allocated to the environment (Ministry of Finance, 2001) as compared, for instance, to the Netherlands where environmental expenditure in 2000 was about 1.9% of the total government expenditure (RIVM, 2001). The lack of funding for the environment in developing countries is often aggravated by corruption resulting in inefficient spending of the few funds available.

I argue that the financial problems facing developing countries are not caused by a lack of thrift or opportunities but by a lack of faith in these countries' own economies as investment sites, and the consequent propensity to expatriate capital to developed countries. One should stress here that funds held by developing countries in developed countries amount to several billions of US dollars, creating capital flight from developing countries. For instance, the capital flight from the severely indebted, low-income countries in Sub-Saharan Africa is equivalent to about half the external resources used for development (Amoako and Ali, 1998).

Unlike developed countries, where pollution abatement receives substantial revenue allocation not only from government but also from private corporations for pollution management abatement, in developing countries pollution abatement is seen to be the responsibility of solely the government. Private companies do not help with the provision of funds. There is no effective formal internalization of pollution in developing countries and no voluntary assistance from private companies. One example of the latter is from Denmark where Novo Nordisk, a phar-

maceutical company, has assisted the Danish Environmental Protection Agency by providing infrastructure and research grants for pollution management.

Foreign aid sometimes helps out to soften the financial shortages of pollution management in developing countries, but there is no structural basis for the provision of such funds. It would be much better if capital flight could be stopped and market parties would better co-finance.

3.1.4 Institutional constraints

The last decennia witnessed the establishment of many agencies and other organisations by governments of developing countries to handle pollution problems. With the establishment of these institutions, there have been some constraints associated with the use of pollution management tools. Some of such constraints stems from centralisation of activities in institutions, the fragmentation of environmental responsibility among institutions and the lack of co-ordination between the institutional units responsible for different sectors, and the difficulties of integrating environmental planning into the policies and programmes of the sectors. These two constraints constitute the major gap in the implementation of pollution management tools in developing countries. For instance, in Ghana the two main institutions responsible for pollution problems are the Ministry of Environment and Science and the Environmental Protection Agency. Other institutions involved include, however, the Council for Scientific and Industrial Research, the ministries of mines, energy, works, housing, trade, industry, local government and rural development. The involvement of so many institutions in pollution management puts heavy burdens of co-ordination, integration and control on the system.

Another issue is that institutions responsible for pollution problems do not act in an integrated manner right from the planning stage, resulting in that pollution problems in most cases not given the necessary strategic attention at policy and programme level but only late and focused on individual project activities. One major cause is that more often than not, data about the risk of pollution are not available when key decisions are being taken.

Another constraint worth noting is the inefficiency of institutions in developing countries. This is in most cases related to their disoriented objectives, which are mainly wavering between serving the political system in power and serving the public. This is due to the highly politicised basis of civil service in developing countries that has its roots in the colonial era. As result of these disoriented objectives, institutions in developing countries have often become instruments for consolidating power rather than promoting and providing services for pollution management strategies. The dominance of political factors combined with a lack

of balance between bureaucratic and political elements in institutions has turned many simple pollution management procedures into highly complex ones. For example, in Ghana, any local-level management of pollution problems (e.g. solid waste or the pollution of water bodies) has to be approved at the regional and national levels before it can be implemented.

In response to the institutional constraints prevailing in developing countries, 'capacity building' has become a major buzzword in the donor countries. Many of these capacity-building programmes focus on increasing the number of professionals in the environmental field. As may have become clear from the previous sections, this runs the risk of addressing only a fraction of the constraints. Building bureaucratic capacity is obviously good but it does not build bureaucratic will, political capacity, political will or the strengths and motivations of local institutions and the private sector.

3.1.5 Physical infrastructure and data constraints

Due to the poor state of physical and communication networks in many developing countries, transaction costs in all economic and government sectors are high. For pollution management in particular, physical infrastructures that is critical to developing countries in the following decade is information and communication technology. Most of the tools to be reviewed in chapters 4 and 5 require that a lot of data be processed before any decision can be made. However, all good intentions in developing countries to use some of these tools may be thwarted by the poor quality of, and unavailability of reliable information. This is because in developing countries, pollution problems and associated issues are often not given the necessary attention and also not measured and documented well. In addition, new emerging issues and parameters that are required to develop concrete pollution management strategies are not measured at all due to the absence of the necessary monitoring or data collection systems.

In most developing countries, these issues have only recently become a priority, and measures are now being taken to set up environmental databases to improve effective methods and also set up dedicated institutions for collecting and processing environmental information. For example in Ghana, the Environmental Information System for the Environmental Protection Agency is currently being developed through an Environmental Information Network project funded jointly by the International Institute for Communication and Development (IICD), and the government of Netherlands.

3.1.6 Human resource constraints

Human capital plays a decisive role in the process of pollution management. Most developing countries suffer from low levels of investments in human capital and to make things worse, public education has been the sector that has suffered major setbacks. Pollution management tools however, tend to become ever more sophisticated; additional skills and human resources are required, which are often beyond the technological and managerial capabilities of many developing countries and frequently beyond their budget. The result of this is that in most cases, foreign experts are called on to draw up pollution management strategies. These strategies, as a result, tend to rely on these sophisticated and expensive tools, thus perpetuating the dependence on foreign expertise. The two major causes of human resource constraints are human resource depletion and lack of education.

Human resource depletion

In developing countries such as Ghana, most of the knowledgeable pollution experts often travel abroad for well-paid jobs while the few skilled people left who are involved in the environmental institutions tend to live and work in the capital cities and infrequently visit the field. In addition, those who have foreign education often do not return after completion of their studies. For instance, in a 1995 World Bank study, it was noted that some 23,000 qualified academic professionals migrate from Africa each year in search of better work conditions (Fadyomi, 1996). This has necessitated their replacement by more expensive expatriates, who in Africa alone numbered 30,000 in 1993. The World Bank estimates that 100,000 expatriates from the industrialized countries are employed in Africa at a cost of US$ 4 billion per year, amounting to nearly 35% of official development assistance to the continent. As Gosh (1996) noted, 'skilled labour migration from developing countries may actually lead to the postponement of structural changes needed to generate and sustain a process of dynamic broad based development.'

This form of resource loss has not received much attention from the international community. Recently, there have been some international efforts from developing countries aimed at luring back nationals from abroad. One of such endeavours was to encourage Ghanaians living abroad to come home through a 'homecoming 'summit organised in Accra, Ghana in July 2000. The aim of the 'summit' is to identify opportunities in the country for professional service. Actions such as these do not address the structural causes of brain drain from the developing countries, however, which, are:

- Lack of research facilities and professionally inspiring working environment;
- Low payment, lack of incentives, political interference;
- Mismatch between education, job opportunities and national socio-economic realities;

- Reliance on foreign and international expertise and bias against local expertise and knowledge.

Another major challenge that has been a problem in developing countries from a human resource perspective is the alarming spread of the HIV/AIDS. According to a report released by the World Bank (1999), in 1982, one country in Sub Saharan Africa had had a prevalence rate of 2%. By 1998, 21 countries in Sub Saharan Africa had prevalence rates above 6%. It is not only the sheer size of the population affected by AIDS that becomes of grave of concern for developing countries. Its attack on the most productive segment of the society aged between 18 to 50 years makes it particularly detrimental to developing countries.

As an example of human resource depletion, a survey carried out from June to December 2002, revealed that the Council for Scientific and Industrial Research, the Government's brain house, lost 80 scientists to private companies.

Education and training

The educational system in most developing countries is lagging behind in terms of producing graduates in the field of environmental science, engineering and technology. There has been very little progress and even retrogression in educational systems in recent times (Stien, 1998). For instance, it was only in 1998 that the Kwame Nkrumah University of Science and Technology in Ghana started a master programme in the field of environmental engineering and also the University of Ghana started a master's programme in the field of Environmental Science. Furthermore, there is also a problem of quality and the reliability of the information collected by people who are not qualified to handle that type of information. A typical example of this is a chemist acting as an environmental engineer.

Besides the academic level, the competence of a country's workers and technicians at the middle level is as crucial, as it is problematic. For example, secondary school education in most sub-Saharan African countries does not comprise much of vocational and technical education. As a result, high school graduates who constitute the bulk of the unemployed do not have any productive skills. For instance, in Ethiopia, the total number of secondary level manpower generated in 1994 was 154,305, out of which only 10,932 were absorbed by the job market (Solomon and Goitom, 1998).

Due to the lack of locally based experts, most pollution management tools used in developing countries are not properly executed. For instance, findings from companies interviewed in Tema, Ghana showed that tools, methods and strategies used to deal with pollution problems are presented in a form that is not sufficiently useful to tackle the pollution problem at hand. This is evident in problems of various kinds such as inadequate or non-existing non-technical reports, too much data with

too little analysis, unnecessary complex interpretations, and insufficiently clear and precise recommendations and proposals for decision-making.

3.2 Backgrounds of Ghana and Tema

Throughout the text of this study, examples are given from Ghana, and the applicability of the tools and framework is illustrated for Ghanaian circumstances, especially the case of Tema. Moreover, the experts interviewed the context of this study (see section 1.3) come from Ghana mainly. It serves, therefore, to give more details on Ghana and Tema. That is the subject of the present section.

3.2.1 Background of Ghana

The present section starts with the socio-economic background of Ghana followed by a review of the development strategy. I end the section with a review of pollution problems in Ghana, developments in pollution management and an analysis of the National Environmental Policy of Ghana.

Socio-economic background

Ghana is located in the central-southern area of the West African sub-region along the Gulf of Guinea. Ghana shares boundaries with La Cote d'Ivoire to the West, Burkina Faso to the North and Togo to the East (see figure 3.1). The Greenwich meridian cuts through the country from North to South. The country lies between latitudes 4° 30' to 11° N and longitudes 1° 10' E to 3° 15' W with a coastline of 550 kilometres. Ghana covers an area of 23.9 million hectares, spanning two major ecological zones. The high forest is confined to the South western part of the country, while savannah woodlands cover the North and coastal areas. The country has natural vegetation ranging from dense rain forest in the South, tailing off to savannah and grassland in the North. The climate is tropical with high mean annual precipitation in large parts of the country, except in the extreme North where the savannah climate with quite dry conditions prevails. Rainfall ranges from 900 mm in the coastal savannah to 2100 mm in the forest belt. The highest precipitation occurs in the extreme southwest, reaching 3000 mm per year. The rainfall pattern in the Southern part of Ghana is bimodal with a major peak in June/July and a minor one in September. The driest period comes between October and February (Hens and Boon, 1998).

Ghana's population as at 2000 was about 18.5 million. The current level of Ghana's population is a result of persistent high birth rates and declining mortality rates. Currently, the birth rate is estimated at 45 births per 1000 people while the death rate stands at 13 deaths per 1000 people. The fast growing population has resulted in a high ratio of dependants to the working population. Children under 15 years

of age account for almost half (47 %) of the total population (Ghana Statistical Service, 2000).

Ghana had been under a quasi-military regime since 1982. However, in 1992 there was a transition to a multi-party democratic governance. This shift in governance saw the intensification of true multi-party democracy that has been consolidated by the change of government in 2000. Overall, the last decade has witnessed the emergence of democratic institutions, such as a free and liberalized press and organs for addressing serious frauds and lapses in human rights and administrative justice, all of which are necessary for the institutionalization of good governance. The political party that is currently in power is the National Patriotic Party (NPP).

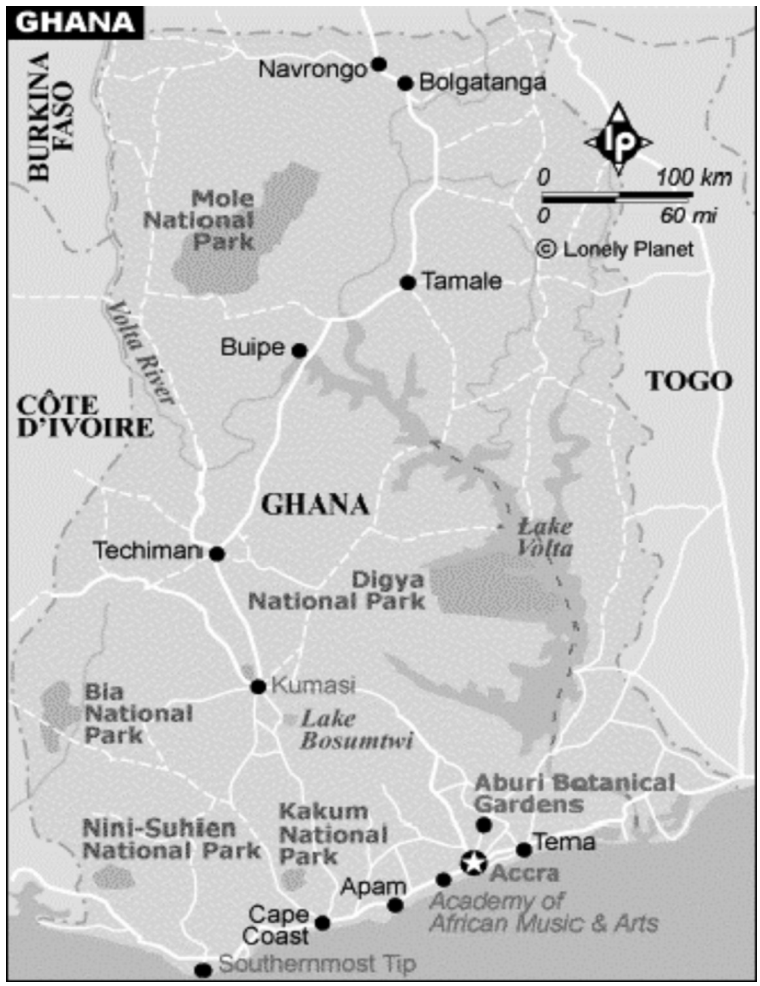


Figure 3.1 ■ Map of Ghana showing the location of Tema

The country is endowed with mineral resources, particularly gold, bauxite, diamond, manganese, limestone and iron ore. In addition, Ghana has abundant resources in forestry, agricultural crops and fisheries. The country also has a relatively well-developed energy system based on hydroelectric and thermal power with a fairly sophisticated and extensive industrial infrastructure. Water is abundant in Ghana, although seasonal shortages are quite common. Water shortages are primarily due to poor management and the inadequate use of available technologies.

The Ghanaian economy is highly dependent on agriculture, which accounts for around 35.9% of GDP; the service sector accounting for 29.9% whiles the industrial sector contributes 24.9% to GDP. An estimated 85% of the population earns their livelihood directly or indirectly from agricultural production (UNDP and ISSER, 2001.) An Accelerated Agricultural Growth Strategy (AAGS) has been formulated which is designed to increase the pace of the sector's growth from the current rate of 3-4 % to 5-6 %(MoF, 2002). Industrial establishments in Ghana are overwhelmingly concentrated around the coast and the government is fostering attempts to boost the manufacture of consumer goods in the northern part of the country.

Development strategy

Ghana entered a spiral of long-term economic decline in the 1960s due to low investment, low and falling efficiency of resource use and declining exports. Between 1960 and 1982, real per capita income fell at an average annual rate of nearly 2 percent while annual inflation rose from 6.2 percent to 123 percent. In response, the Economic Recovery Programme was initiated to reverse the country's downward economic trend. A process of sustained growth with focus on economic liberalization and stabilization, social development, long-term growth, poverty reduction, gender balance and regional integration was started. In subsequent years, real GDP growth averaged 4 percent annually while inflation dropped to 20 percent during 1992-94. However, the performance of the economy slipped in 1992, when large fiscal imbalances resulted in heightened inflation and currency depreciation (MT and I, 1992).

A development strategy document that has guided the socio-economic development of Ghana is Vision-2020. This document was in reaction to the need to ensure long-term growth to avoid the drastic drop in living conditions by addressing poverty in an integrated manner and improving the management of the economy to place the nation on a path of sustainable growth. Following the Vision, the economy was characterized by:

- a policy framework oriented towards the private sector;
- the state divesting controlled enterprises and restructuring public sector administration;
- largely agrarian setups with low manufacturing value-addition;

- low savings and investment;
- dependence on two commodities for foreign exchange earnings;
- high debt, both external and domestic;
- low private sector response to economic frameworks and incentives.

Currently, the government has replaced the Vision 2020 documents with the Ghana Poverty Reduction Strategy Programme (GPRS) as the official policy framework for poverty reduction. The replacement is based on the notion that the Vision 2020 document did not have specific costs targets and all stakeholders were not considered, making its implementation difficult. The GPRS document represents comprehensive policies to support growth and poverty reduction based on the notion that the economy of Ghana should be managed effectively, to enable wealth creation and, improved governance and to reduce regional income inequalities.

The Government has also decided to take advantage of the Enhanced Highly Indebted Poor Countries (HIPC) initiative so that its debt service payment to bilateral donors would be suspended. In light of this the government, has started the implementation of some policies, which will serve as triggers so that the full benefits of the Enhanced HIPC will be realized. Improved macroeconomic stability and the substantial external assistance associated with the HIPC Initiative has provided the Government with a window of opportunity for implementing the reform agenda that it developed during the preparation of the Ghana Poverty Reduction Strategy (GPRS). Ghana is also among 35 Sub-Saharan African Countries selected to benefit from the African Growth and Opportunity Act (AGOA) passed by the US Congress in 2000. This means the US market is now open to Ghanaian businesses to export, duty free and quota free, a wide range of products to the US.

In general, the following trends and factors characterize the Ghanaian case:

- The pain and memory of past economic downturns and the transition to multi-party democratic governance;
- The resultant economic liberalization and market-based stance of economic policy which has yielded a fragile stabilization as the economy is still prone to destabilization by external economic factors;
- Increasing population, unemployment, demands on social services and a fall in living standards;
- Relative peace and stability;
- Poor natural resource management resulting in loss of forest cover and general environmental degradation.

Pollution problems in Ghana

The present pollution issues and problems in Ghana are closely related to the economic and industrialisation programmes pursued in the country since the attainment of independence in 1957. After independence, a number of industries were set up in various parts of the country to develop natural resources. In the process of exploiting these natural and agricultural resources in the industrialisation programmes, adequate care was not taken to guard against the depletion of the resources (GEPA, 1991). As a result, a host of environmental problems comprising of various forms of air, water and soil pollutions were experienced. Major producers of pollution in the country were the mining, mineral exploitation and processing, textile, food processing, petroleum refining and handling industries (GEPA, 1991). Table 3.1 depicts the major types of pollution in Ghana and their sources.

Most of the industrial establishments in Ghana are located around the Accra and Tema metropolis, which covers less than 1 percent of the total inland area of the country. The concentration of industries has given rise to noise, smoke, and carbon monoxide emissions, municipal and industrial wastes.

The operation of mining and manufacturing industries has given rise to various types of pollution. Atmospheric pollution associated with industrial activities in Ghana results mainly from combustion processes of industrial machinery and vehicular fleet. The atmospheric pollutants tend to be in the form of dust, odours and gases which contain varying amounts of oxides of sulphur, nitrogen, carbon and hydrocarbon (GEPA, 1994). The main industrial water pollution sources are from the food processing industries, the textile industries and the mining industry. Minor sources of industrial pollution include industries manufacturing soap and detergents, wood, cement, rubber, plastics and steel. Most of the wastewater from industrial establishments is discharged in to the environment untreated. Industries in the country also produce various types of solid waste. Typical among these are, for example, the food processing industries that generate organic solid waste, building and construction industries which generate metal scraps, dust particles and asbestos tailings, the textile and the garment industries that generate wax, cotton fluff, feints of cuts and floor wastes. The paper and printing industries generate paper cuttings and trimming and exposed photographic films. The metal and metallurgical industries generate ferrous, non-ferrous and miscellaneous wastes (GEPA, 1994). This has resulted in the severe degradation of the environment at sites such as Chemu lagoon in Tema.

Table 3.1 ■ Types of pollutants and their sources in Ghana

Type of Industrial Pollution /Pollutants	Source
Air Pollution	
Dust	Mining, manufacturing, wood processing industry
Heavy metal (As, Me, Cy, Fe)	Mining industry
Fluoride,	Steel industry
Smoke	Exhaust and stack emission of industries
Asbestos	Cement-asbestos product plants
Antimony oxides	Aluminium production
Sulphur oxides	Oil refinery, gold mining, aluminium production
Nitrogen Oxides	Oil refinery, gold mining, steel production
Oxides of carbon	Combustion furnaces in general, aluminium production
Hydrogen fluorides	
Hydrocarbons	Oil refinery, aluminium production
Water Pollution	
Colour	Textile
Turbidity	Paint Works, mining
Alkalinity	Manufacturing industries
Biological Oxygen Demand	Textile industry, soap and laundry industry
Chemical Oxygen Demand	Breweries, textiles, food processing,
Acidity	Oil refinery Paint Works.
Discarded petroleum products	Automobile assembly plants, paint works
High Temperature	Oil refinery, textile, food, ferrous and ferrous industry
Pesticides	Farming and chemical industries
Noise	
Domestic noise	Household
Industrial noise	Mining and manufacturing industries
Vehicular noise	Transport industry

Currently no comprehensive data exist on the list of polluting companies and the nature and amount of pollution these companies cause. However, Boateng (2003) identifies Nestle Ghana Limited, Unilever, Volta Aluminium Company Limited, Nexan Cable Metal, GHACEM, PZ industries Limited, Ghana Oil Refinery, Cocoa Processing Company Limited, Ghana Textile products limited, Ferro Fabbrick Company and Aluworks as the major polluting companies in Tema.

Developments in pollution management in Ghana

In 1974, the Government of Ghana established the Environmental Protection Council (EPC), which became the first governing body in Sub-Saharan Africa to focus on issues of environmental management. The EPC was primarily an advisory and research organization expected to co-ordinate activities of other bodies concerned with environmental matters. It had no power to enforce measures for improving the environment but rather served as a meeting point for bodies that actually exercised power with regard to the various sectors of the environment. The EPC facilitated the co-ordination of environmental programmes and activities in the country (EPC, 1991). However, long before the establishment of the EPC, many legal enactments existed in the country in addition to various official bodies, which actually exercised executing powers with regard to environmental

care and protection. These powers were however widely scattered among the bodies involved in pollution management and not one of them could be said to have enjoyed exclusive control of the whole of the environment or even of significant portions of it (Hens and Boon, 1998).

After the establishment of the EPC in 1973, there was the need to introduce a systematic procedure for evaluating the environmental effects of development projects (Abrokwa-Ampadu and Ampadu-Agyei 1987). In light of this, Ghana's Investment Code was legalized to regulate investment in four key sectors of the economy, namely, manufacturing, construction, agriculture, and tourism, The Investment Code requires investors to show sufficient evidence that their proposed project(s) would not have any deleterious effects on the environment. Another significant development with implications for environmental management was the National Environmental Action Plan of 1991 (EPC, 1991). However, it was after the Rio Earth Summit in 1992 that Ghana realized that its economic prosperity actually depends on the maintenance of a high quality of the environment. In 1993, the National Environmental Action Plan (NEAP) was approved for implementation and a National Environmental Policy (NEP) was defined.

In 1994, the EPC was re-structured and re-named the Environmental Protection Agency. The mission of the GEPA is to co-manage, protect and enhance the country's environment and to contribute to the solution of global environmental problems. GEPA is the main stakeholder in environment related activities in the country and it is tasked with the collection, analysis and dissemination of environment related information. GEPA is also involved in training and education programmes aimed at a better understanding of the environment and processes that affect it.

Institutions involved in pollution management

The main post-Rio institutions established to facilitate the formulation and implementation of policies related to pollution management are the National Planning and Development Commission, the Ministry of Environment and Science (MES), the Environmental Protection Agency (EPA) and the District Assemblies (DAs). The link between these institutions is presented in figure 3.2. The involvement of so many agencies in the implementation of the country's policies and programmes on pollution clearly calls for effective co-ordination, monitoring, evaluation and control (EPA, 1994).

The National Development Planning Commission (NDPC) was set up under the National Development Planning Law of 1989 to formulate and advise the government on comprehensive national development strategies and to ensure that planning and development strategies and programmes are effectively carried out. Within its mandate, the NDPC has a significant role to play in the monitoring,

evaluation and control of national development programmes, including environmental policy and actions (EPC, 1991).

In 1993, the Government established a Ministry of Environment, Science and Technology (MEST) now MES, to co-coordinate the implementation of Agenda 21. MES therefore set up a National Committee for the Implementation of Agenda 21 (NACIA 21), which also co-operates with other relevant Ministries and Government Departments. MES is responsible for the policy formulation, planning, programming and monitoring actions by agencies and departments under it. The ministry of Environment and Science co-operates with the Ministry of Food and Agriculture, the Ministry of Works and Housing and the Ministry of Local Government and Rural Development, Clearly, an effective implementation of the policy and programmes requires a good degree of co-ordination amongst these institutions (EPA, 1994).

The Ghana Environmental Protection Agency (GEPA) is given a full mandate and responsibilities for regulating the environment and ensuring the implementation of Government policies relating thereto (EPA, 1996). The GEPA has ten regional offices across the country. GEPA key objectives are to:

- Ensure that the implementation of environmental policy and planning are integrated and consistent with the country's desire for effective, long-term maintenance of environmental quality;
- Provide technical assistance to the District Assemblies to enable them meet their responsibilities for managing the local environment;
- Work in partnership with stakeholders; to guide development with the aim of preventing, reducing and as far as possible eliminating pollution and nuisances; initiating and pursuing formal and non-formal environmental education programmes;
- Collect, collate and disseminate information and promote as well as support research programmes needed to ensure sound environmental management and use of natural resources;
- Apply the legal processes in a fair, equitable and efficient manner to ensure responsible environmental behaviour in the country and continuously improving the EPA's performance to meet changing environmental trends and community aspirations (EPA, 1996).

The GEPA is scientifically supported by a wide array of national institutions. GEPA also co-operates with government agencies, the DAs and other bodies and institutions through inter-sectoral networks in seeking solutions to environmental problems in areas in which the partners have responsibility. The reason is that prior to the establishment of GEPA, these institutions were in existence with mandates in certain aspirates of the environment. Some of the institutions the GEPA co-operates with are the Forestry Department, the National Standard Board, Cen-

tre for Scientific and Industrial Research, Ghana Standards Board and the Geological Survey Department which support the EPA through research activities.

The government's policy of decentralization of administration to the district assemblies (DAs) accords the district assemblies a central role in the implementation of the NEAP (EPC, 1991). The role of the DAs in environmental management in the country has been defined as: 'District Assemblies will be the organ through which national policies and programmes on the environment will be translated into action at the local and district levels. Their members and action programmes will serve as vehicles for creating awareness at the grassroots level of the complex interaction between development and environment in order to ensure improved quality of life for the broad mass of the people' (EPA, 1996). In order to achieve this, the DAs have set up District Environmental Management Committees (DEMCs) to monitor and co-ordinate environmental protection and improvement activities at the district level. Community Environmental Committees (CECs) have also been established as the organs through which the environmental programmes of the District Assemblies are carried out.

Some pollution management activities are fully carried outside GEPA. There are other institutions such as the Council for Scientific and Industrial Research and Ghana Standards Boards which are involved in pollution management. There is currently no co-ordination between these institutions and departments. The only networking that exists is an inter-sectoral committee made up of industrial environmental pollution stakeholders, the police and Attorney-General's department, to handle various cases of industrial environmental pollution.

There are a number of international and local NGOs assisting Ghana in a variety of ways to implement its environmental policy, programmes and projects. Typical examples of international NGOs working in Ghana include the World Bank, the United Nations Programme for Development, World Vision International, Concern Universal, Action Aid and Friends of the Earth.

A key principle that runs through all the institutions involved in pollution management is participation of individual and communities in decisions-making that has been identified as a key sustainable environmental management. Thus, the government recognizes community management as one of the best approaches to environmental conservation, as stipulated in the national environmental action plan. In practice it remains, as said earlier in this chapter, that only very little of this comes off the ground in reality.

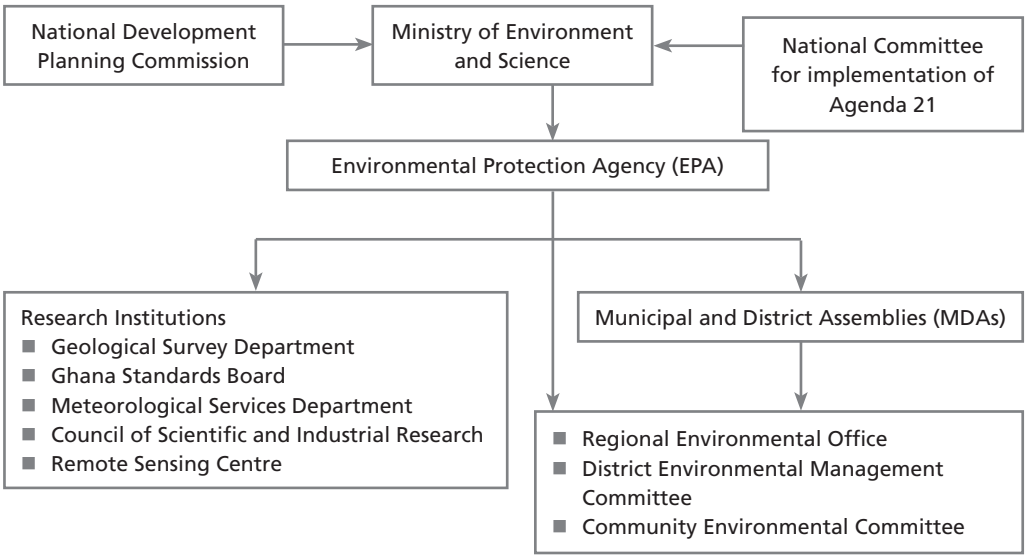


Figure 3.2 ■ Institutions involved in environmental management in Ghana.

3.2.2 National Environmental Policy of Ghana

Ghana has a National Environmental Policy (NEP), which is enshrined in a National Environmental Action Plan (NEAP). The aim of the National Environmental Policy is to improve the surrounding, living conditions and the quality of life of the citizenry of Ghana. The policy also seeks to ensure reconciliation between the country's economic development and natural resource capital and also to make the environment the key element of Ghana's economic and social development (Biney, 2000).

The specific objectives of Ghana's National Environmental Policy are to:

- Maintain ecosystems and ecological processes essential for the functioning of the biosphere;
- Ensure sound management of natural resources and the environment;
- Adequately protect humans, animals and plants, their biological communities and habitats against harmful impacts and destructive practices and preserve biological diversity;
- Guiding development in accordance with quality requirements to prevent, reduce, and as far as possible, eliminate pollution and nuisances;
- Integrate environmental considerations in sectoral structural and socio-economic planning at the national, regional, district and grassroots levels;
- Seek common solutions to environmental problems in West Africa, Africa and the world at large (EPA, 1996).

The government of Ghana has adopted the following principles for the effective implementation of the NEP:

- Optimum sustainable yield in the use of resources and ecosystems;
- Use of most cost-effective means and incentives to achieve environmental objectives;
- Delegation of decision-making and action to the most appropriate level of government;
- Polluter pays for the cost of preventing and eliminating pollution and nuisances caused by him;
- Public participation in environmental decision-making and international co-operation.

The policy also contains statements about dissemination of environment related information for educational purposes to increase the awareness among the public in environmentally related issues. Also, the need for research activities in environmentally related fields is recognized. The policy covers the management of environmental resources, the prevention and control of pollution, actions to be undertaken in specific areas, the development of appropriate scientific and legal instruments for environmental control, environmental education, a monitoring programme and international co-operation (EPA, 1996).

The environmental policy of Ghana emphasizes the importance of community participation in environmental management programmes. In fact, it is based on implementation modalities at the local level. Currently, the municipal and district assembles have developed local action plans while a few are still going through such developments. Furthermore, community participation and the environment are one of the cross-sectoral policy components of the environmental policy of Ghana. Nevertheless, the environmental policy of Ghana does not have an explicit reference to local resource and environmental management approaches that are based on indigenous and traditional practices, as the principal mechanism of management activities at the local level. The government has to realise that efficient environmental management will require more than merely formal participation.

The government of Ghana has also indicated its commitment to using the preventive approach to environmental protection efforts in the country. As a signatory to a number of international conventions and protocols related to environmental protection, the government of Ghana is making efforts to bring these conventions, protocols and agreements into the domestic legal realm required for maximum effect. The policy tools that are used by the government of Ghana to ensure the implementation of the principles in the environmental policy statement are depicted in Table 3.2. In practice, environmental policy is oriented most towards adoption of regulations, bypassing more preventive approaches.

Table 3.2 ■ Industry-related Environmental Policies and Regulations Guidelines. Source: Ghana's Environmental Action Plan Vol. 1, 1991

Policy Tools
■ Environmental education and research-improving the scientific base of environmental policy, among other things, through appropriate research programmes. ■ Environmental Assessment – The assessment of potential impact of certain public and private projects on the environment and the integration of the environment into national practice. ■ Environmental Standards – Establishment and implementation of appropriate standards and guidelines so as to ensure an acceptable level of public health and environmental protection. ■ Environmental regulations – Harmonization of appropriate legal instruments. Thus, prepare and adopt regulations for environmental pollution control ■ Environmental communication – Improve access to information on the environment. ■ Adopt incentive system for resource use in all industries

The environmental policy statement of Ghana was prepared in 1992 and has since not been updated despite the fact that it contains some key policy elements. The environmental policy as it is, contains policy elements that imply the importance of mainstreaming socio-ecological aspects in development programmes. Two cross-sectoral policy components with a mainstreaming effect in the environmental policy of Ghana are identified. One deals with the importance of incorporating environmental cost and benefits in development planning process and the other deals with carrying out Environmental Impact Assessment (EIA) of projects.

The environmental policy of Ghana also contains sectoral policies, which give directions that may ensure the promotion of sustainable industrial development in the country. For instance, the environmental action plan of Ghana provides policy directions for the control of hazardous materials and pollution from industrial waste. This sectoral policy emphasizes the importance of pollution prevention and waste minimization as the primary approach to pollution management.

The government of Ghana has adopted an environmental desk approach to mainstream the environment into government policy. Thus, an environmental desk is established at the Ministries, Departments and Agencies to: assist them address environmental concerns, ensure the coordination of sector activities to guarantee sustainable development and ensure the integration of national environmental policies in sector policies and programmes. Presently, the government has set up thirty environmental desks in various ministries and departments as a way to provide access to environmental information and also provide the public with information about initiatives taken by the various ministries and departments in relation to pollution management (MoF, 2003).

3.2.3 National environmental capacity of Ghana

As said, Ghanaian government institutions are understaffed in quality terms. The GEPA institutional structure is similar to western agencies, making it not difficult

for it to recognize the potentials of traditional institutions in pollution management. Equipment for measuring pollution parameters at GEPA are inadequate and the few that they have are not in good condition. For instance, this study has revealed that GEPA has only one noise and air measuring equipment. Human resources at GEPA even though multidisciplinary lack expertise in risk assessment and it is made up of only 120 professionals (1.7% with PhD, 55.8% with Masters degree and 42.5% with Bachelor's degree). This human resource is inadequate looking at the task GEPA has to undertake.

The government of Ghana has taken practical steps to develop a national capacity in the field of cleaner production. For example, a national capacity building programme on cleaner production is being carried out and based on the outcome; plans for the establishment of a National Centre for Cleaner Production in the country are being finalized. The centre will be hosted by GEPA and will be part of the international cleaner production centres programme, jointly coordinated by the United Nations Industrial Development Organization (UNIDO) and United Nations Environmental Programme (UNEP). The focus of this project is on building technical capacity for industries to implement pollution prevention and waste minimization projects (UNIDO, 1999).

Despite the fact that private sector responses to pollution problems is below the pass mark, there has been some improvements in the last few years. Private companies are now developing environment management plans; carrying out environmental educational programmes in their companies and also contributing financially to environmental education and research programmes in the country to some degree. NGOs and civil society are also involved in environmental education and awareness creation. For example, in 2002, there were 69 functional NGOs working in the environmental sector and registered with GEPA.

In the background, some capacity problems are being addressed little by little. The use of computers is currently being introduced into basic and secondary schools in the country, for instance. Employees of environmentally related institutions are being trained on how to use computers. Computers are also used for audio-visual learning purposes at the African Virtual University on the University of Ghana campus, and at the Distance Learning Centre at the Ghana Institute of Management and Public Administration, Accra. The government has also established a national ICT centre to co-ordinate ICT activities and at the same time taken steps to connect all schools in the country and research institutions involved in pollution management in the country.

Another example is that the National Science and Technology Policy (NS and T) of Ghana contains a number of strategic provisions that imply the importance of promoting sectoral synergy. For instance the NS and T identifies the formulation and

implementation of plans, programmes and projects to accelerate the country's development and to giving due attention to environmental protection. The provisions in the National Science and Technology Policy rightly emphasize the importance of identification, improvement and promotion of environmentally friendly technologies. However, they do not have concrete mechanisms in place yet.

3.2.4 A description of Tema

General background

Tema is the port city of Ghana and is located 25km east of Accra. Tema lies on the Greenwich meridian (Hens and Boon, 1998). Tema is the capital of the Tema municipal Assembly and is divided into twenty-five communities with distinct landmarks. According to the 2000 population census, the population of Tema is 506,400. Details of the population are presented in table 3.3. Generally, Tema is densely populated with a population density between 500-1000 persons per square kilometre. This is because of increased industrialisation and migration of people coming to work in Tema, coupled with persistent high birth rates and declining mortality rates. The population growth rate is estimated at 4% per annum: rural migration of labour force for urban employment is a major cause of growth.

Table 3.3 ■ Population of Tema (2000 Population Census (Ghana Statistical Service 2002)

Total Population	Male	Female	Sex ratio
506,000	251,000	254,000	98.7

The monthly and annual figures for the main elements of climate of Tema area has been given in the Reconnaissance Survey Report (Ametekpor, 1994). The area falls within the coastal Savannah Ecological Zone of Ghana. The main features of the climate are that the annual rainfall is low, totalling just about 739mmm; the rainfall pattern is bimodal with the main wet season occurring from mid-March/April to mid-July followed by the minor wet season from early September to Mid-November. About 75% of the total rainfall falls during the major wet season. Average annual temperature is around 27°. Generally the temperature increases from 26° below at 09:00 hours to 28-32° at 15:00 hours during most of the year. Temperatures are highest during the main dry season (February to March) and lowest during the short dry season (August). Relative humidity at 15:00 hours averages 75-80% during the greater part of the year but may drop below 65% during the dry months of December to March. Humidity rises to almost 100% at night. Evaporation rates in Tema are that annual losses from open water surfaces may be as high as 1650 to 1830 mm per annum.

Tema has a general undulating landscape. The higher grounds carry savannah short and medium grasses with scattered medium trees and isolated thick clumps.

The highest point is less than 300 feet above sea level and the average elevation is about 200 feet. Slopes are generally of 2%-5%.

The main geological formation underlying Tema is the basement complex group comprising acid and basic igneous and metamorphic rocks which have been affected by weathering. The geology of Tema is underlain by Dahomeyan (Precambrian) schist and gneiss with minor areas underlain by intrusive granite and pyroxenite, basic gneisses and quartzite schist. Continental tertiary deposits cover most parts of the area. Recent alluvium occupies the valleys of the major streams that drain into the Chemu lagoon that is located in the middle of Tema. Marine sands are deposited along the coastal areas. Along the margin of the Chemu lagoon occur marshes, sedges, herbs and pockets of low mangrove thickets. Streams which flow into Chemu lagoon are not perennial. They flow only during the rainy seasons and dry out in the dry seasons, especially during the main dry season, December to February.

Tema is traditionally ruled by the Ga chief of the city but it is presently under the jurisdiction of the Tema Development Cooperation. The main occupation of traditional people of Tema is fishing. Fishing is however closed from October/November to the end of the March/April. The opening of the fishing season takes place after the celebration of annual Kpledjoo festival of the Tema people in early April.

Due to the development of commercial activities in Tema and the port, the majority of the residents are from other parts of the country and the world. Some live and work in Tema, while others commute daily to Accra to work.

Pollution problems in Tema

Water bodies within and around the city of Tema have been suffering from serious pollution because the city intensively expanded during recent decades. Major causes of pollution are domestic and industrial wastewaters that are discharged into the Chemu lagoon directly or via sewer outlets.

The main industrial production activities in Tema and result in pollution include the petroleum refinery, food cannery, textile manufacturing, paints and dyes manufacturing, paper products, cocoa processing, aluminium processing and steels works. All these production activities use large amounts of raw material and energy in their production process. It is estimated that 70% of the (non-firewood) energy produced in Ghana is used by the industries in Tema and transportation of inputs to the industries results in the emissions of CO_2 and SO_2 (EPA, 1998).

The industries do not have a system in place where waste could be sorted and reused in the production process or used by other industries. Of the industries, 30% discharge the effluents directly into the lagoon without treatment, even though by

law, they are required to treat their effluents to meet acceptable standards before discharge. Only 20% of the industries have constructed a wastewater treatment plant to treat liquid waste before discharge into the lagoon (EPA, 1998).

Small and medium size industries lack knowledge about pollution issues related to their firm. Three quarters of the small and medium size firms interviewed in Tema do not know any specific issue relating to pollution or even how to manage it. Half of them generally do not want to know about pollution management tools because they do not have adequate personnel who can apply the tools. All small and medium scale enterprises interviewed affirm that they discharge their wastewater without treatment directly into the sewer which ends up in the Chemu Lagoon.

Large firms interviewed claim they have knowledge about the pollution issues related to their activities but do not have qualified personnel and separate department that will help them deal with pollution issues related to their firms' activities. Firms with environmental management plans do not implement the plans due to the lack of well-established management systems that address external and internal pollution problems. For example, only three large firms interviewed have wastewater treatment plants that are operational.

Tema has a well developed drainage system compared to other cities in the country. However, the community sewerage treatment plant constructed is not currently used because of technical and social problems. This has made parts of Tema especially where low to medium income level people live, confronted with visible domestic wastewater being discharged into the environment and solid waste disposed off at open places. For example, it is reported that communities in Tema are responsible for 65% of the BOD in the Chemu Lagoon (EPA, 1998).

The Tema Municipal Assembly has the mandate to help manage pollution in the municipality and also to influence the activities of industries (PNDC Law 207). However, the current attitude of authorities in the municipality does not result in enough pressure on actors causing pollution in Tema to shift towards finding solutions to environmental problems. This is reflected in the non-compliance of the following provisions laid down by the Environmental Action Plan of Ghana:

- The Water Company of Ghana has been given the power under section 14 to make regulations among other things to prevent pollution of water. As far as can be ascertained, this provision has not been used.
- Municipal Assemblies are responsible for the development, improvement and management of the environment in their municipality. They are also responsible for monitoring the impact of projects on health and environment, as well as the enforcement of legislations and making of bye-laws. This responsibility has not been exercised by the Tema assembly.

Non-compliance with the above provisions is due to the lack of an environmental management committee and the focus on economic issues. Although the Tema Municipality is responsible for the economic and non-economic welfare of the population in the city, interviews held with authorities show that they see environment and economic issues as two different and separate fields without linkages, and with economic issues clearly prioritized. As a result, current bottlenecks such as **llack of proper institutional structures and lack of environmental personnel**, in-adequate logistics, unclear reporting structures, cross-cutting of roles and responsibilities are not being addressed. There is also a lack of finance to develop and implement a strategy towards pollution management, a lack of pressure on the municipality by the media and NGOs and a lack of public participation.

The Ghana Environmental Protection Agency office in Tema is the authority is mandated to perform monitoring, inspections and ensuring law enforcement in close co-operation with other law enforcement agencies. However, the lack of appropriate coordination among external institutions and internal organisational departments, inadequate finance, equipment and personnel to undertake pollution management assignments, lack of concrete and strategic plans and strategies for pollution management, among other things, has made the office to fail in its task.

In recent years, religious groups, professional associations and community-based groups have become concerned with the promotion of pollution management practices in the Tema, and are able to gain easy access to people at the grassroot level to engage community members in development activities. The groups play a valuable role by sensitising the local population to pollution issues and engaging in pollution management projects and programmes.

3.3 Conclusion for the OPiC framework

In section 3.1, constraints that hamper the effective management of environmental problems in developing countries were identified. Based on the conceptual analysis and review of tools that have been done in the preceding chapters, as well as the situation in Ghana presented in sections 3.2 and the insight gained from my experience working in developing countries, I here present my conclusions on some key characteristics that the OPiC framework should possess in order to respond to the constraints

Maybe most basically, OPiC should facilitate *locally based application*, as independent as possible from foreign expertise and funding. This appears to boil down to the following two points:

- The structure of OPiC should not only adequately express the structure of environmental problems, their explanation and their solution, but do so in a way

that lies close to basic human reasoning. OPiC should read like a 'story' that mimics as much as possible of what 'everyone' would tell – or at least understand – of how a problem is structured, how it come about and what might be done about it. That way, OPiC will be as open as possible to participation of local (community, private or NGO) actors in problem analysis and the use and adaptation of local institutions for problem solving.

- OPiC should express the structure of environmental problem situations in a conceptually compelling manner, so as to be able to work independent from data quality. Poor data quality, if coupled with good political will to acknowledge and solve the problem, could then still result in solutions that may be acceptable to all. In case of higher data quality (evenly or partially), solutions could move from the socially acceptable to the scientifically optimal, without disrupting the basic structure of the underlying analysis.

A basic rule of conflict resolution is that actors should be invited to focus on what they really need, rather than on their personal or organisational positions. Analogously for OPiC, the framework's key concepts should focus on values, functions and whole-problem oversight rather than partial or sectoral issues.

- Such a 'principled analysis' should, for instance, use the functions-of-the-environment concept rather than compartments (water, air, ….) to describe how environmental change links up with societal impacts. It should also make explicit what role is played by values (political objectives, norms, standards etc.) in the analysis and solution of the problems at hand.
- Individuals and organisations may have multiple roles in problem situations. They may be standard-setting agencies, problem-causing actors, problem victims or creative agents of opportunity – or several of these at the same time. OPiC should help, conceptually, to keep these roles distinct and support analysis based on these realities rather than convoluted unclarity.

When part of a problem situation, actors often have a tendency to focus on their lack of capacities rather than on a possible lack of motivation. Lack of capacity, after all, elicits rewards (capacity building etc.), while lack of will does not.

- Developing countries have plenty of capacity constraints but do not necessarily lack in political will or creative power to find solutions through opportunities. By keeping values and opportunities in clear view, OPiC should facilitate developing country actors to focus on their responsibilities and strengths rather than their constraints.

The OPiC framework will bring about major improvement in pollution management in Ghana because it is flexible, adaptable, easy to implement and has economic efficiency, environmental effectiveness and equity as key components, compared to the current environmental management system and instruments which are geared towards end-of-pipe solutions. Current environmental manage-

ment approaches in Ghana require many quantitative data, but the causes of the problems, the actors behind problem and how they are related to the problem and the reasons the actors undertake their actions, as well as the functions and carrying capacity of the environment and the windows of opportunities to solve environmental problems remain largely un-analysed. OPiC seeks to address all these critical issues.

The core of this research is the adaptation extension of the PiC framework, e.g. with an opportunity component to effectively deal with pollution problems in developing countries. The choice of tools in chapter 4 and 5 which are used to develop the OPiC framework were motivated by their link to the PiC framework. The tools were chosen to broaden the different components of the PiC framework with each one used to analysis specific issues that they have a comparative advantage. Chapter 4 presents review of functions of the environment, cost Benefit Analysis, environmental Impact assessment and life cycle assessment as tools for use in the OPiC.

Environmental management instruments such as environmental performance indicators, environmental auditing and corporate environmental management are not included in the tools reviewed in chapter 4, largely because they do not appear to offer much flexible insight in problem analysis, compared to the other tools. Some of the instruments are core components in the design for solution for environmental management, however, and are therefore selectively reviewed in chapter 6.

4 Tools for problem analysis and explanation

In this chapter, I present tools for problem analysis and explanation for use in the OPiC framework with application potential in developing countries. A detailed analysis of the methodology of these tools is not provided in these sections since that is outside the cope of this study.

Section 4.1 ■ *Functions and values of the environment*

In this section, I discuss the various environmental functions in terms of economic and non-economic values for society. I also review the different types of economic techniques that could be used to value of the environment. The relevance of functions and values of the environment is then presented. The section ends with the illustration of functions and values of the environment in Tema, Ghana.

Section 4.2 ■ *Problem-in-Context Framework: Problem Analysis*

This section reviews the Problem-in-Context framework with special emphasis on the problem analysis component. Key concepts that are central to the development of the Problem-in-Context framework are discussed. The tool is central to the development of OPiC since it puts the interactions between people and environment, and between facts and values into focus.

Section 4.3 ■ *Partial Analysis I: Environmental Assessment Methods*

This section presents a review of environmental impact assessment and strategic environmental assessment as a methodological framework. Emphasis is given to the relevance of environmental impacts assessment in developing countries. At the end of the section, an illustration of how these methods are applied in Ghana is presented.

Section 4.4 ■ *Partial Analysis II: Life Cycle Assessment*

In this section, I review the life cycle assessment framework, a tool that could be used to support decisions regarding policies and development projects. It is an essential tool for environmentally sound design of products. Experiences from the application of LCA in developing countries are also reviewed and lessons learnt to improve its use in OPiC.

Section 4.5 ■ Partial Analysis III: Cost Benefit Analysis
Cost Benefit Analysis is one of the tools used in the assessment of the impact of proposed interventions. This section presents a discussion of the application of the tools in developing countries.

Section 4.6 ■ Problem-in-Context Framework: Problem Explanation
I review the Action-in-context component of the Problem-in-Context framework. The framework identifies actors behind activities that cause pollution, the reason why the actors carry out the activities and actors who influence these reasons. I present an illustration of pollution problem explanation in Tema, Ghana.

Section 4.7 ■ Synthesis: Backbone for pollution problem analysis and explanation
In the last section of the chapter, I present the summary backbone for pollution problem analysis and explanation in the OPiC framework.

4.1 Functions and values of the environment

Functions and values of the environment are reviewed here because it is one of the backbone of OPiC. This tool establishes the relationship between environmental functions and economic value of the environment, and OPiC seeks to extend and broaden the application of this tool in developing countries, using Ghana as a reference.

4.1.1 Environmental functions

As part of the overall image of relationships between society and the environment (Figure 4.1), environmental functions can be defined as the different ways in which the environment contributes to human life. Classifications of functions may therefore play a role in the systematic evaluation of impacts and effects of human activities on the environmental qualities and back to society. Such classification lends support for the analysis of environmental problem. Different classifications of environmental functions exist (see Dixon and Sherman, 1990). One comprehensive and practical example is the CPSH+PR classification presented in the work of De Groot (1992). The CPSH+PR classification is based on the concept of capacity and production features of human beings and the environment and how they are related.

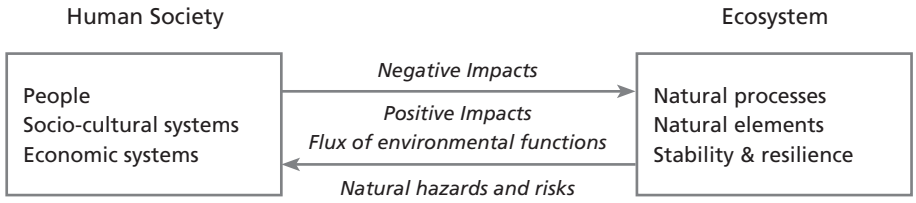


Figure 4.1 ■ Interrelation and interdependency between human society and the ecosystem (Adapted from (Kessler, 2003)

Two levels of functions of the environment are identified in the CPSH+PR classification (De Groot, 1992). Level one functions of the environment shows the direct services the environment may provide and they include:

- *Carrying functions* are characterised by the environment providing space and substrate for human activities.
- *Production functions* are in two main forms. Joint production functions are where human management and inputs play an important role besides the natural capacities to assimilate energy and reduce entropy. Natural production on the other hand is where the environment is 'in the lead' while human beings are only the harvesters.
- *Signification functions* are where the environment produces on its own and human beings are the beneficiaries in the cognitive and spiritual realms. Typical human benefits are those that result from science, cultural orientation and spiritual participation.
- *Habitat functions* are where the environment provides ecological home to non-human intrinsically valuable inhabitants of the earth. This function is the carrying and production functions the environment provides for plants, animals (non-human) and ecosystems.

Table 4.1 gives a more detailed overview.

Level two functions underlie the previous four. They represent the capacity of the environment to provide the direct functions and they include:

- *Processing functions* are characterised by the relationship in which human beings and nature benefit from the capacity of the environment to reduce harm and risk that result from human activities. Here the environment plays an active role in the processing, dilution and transformation of waste and pollutant as a result of human activities.
- *Regulation functions* refer to the capacity of the components of the environment to dampen and shield harmful influences from other components of the environment, such as harmful radiation or flood waves.

Table 4.1 ■ CPSH+PR classification, highlighting the sub classifications and presenting some examples (Adapted from de Groot, 1992)

Classification of functions	SUb classification of function	Examples
Carrying functions	Construction functions	Provide space and substrate for urban, rural and industrial infrastructure construction
	Transport functions	Provide space and substrate for water and land transport
	Waste disposal functions	Provide space and substrate for waste disposal
	Anthropocentric recreation functions	Provide space, substrate and backdrop for sports etc.
	Space and substrate reservoir	The availability of unfilled-in-space to respond to future needs and problems
Production functions	Agricultural production functions	Provide water, soil fertility, solar energy among others for arable farming
	Intensive animal husbandry functions	Provide water, nutrition etc. for bio-industry; dairy farming etc
	Joint production reservoir	Provide soil fertility, genes for future use in crop and animal production
	Other joint production functions	Provide nutrients for agroforestry, aquaculture, etc.
	Natural forestry	Provide water, soil fertility, solar energy for timber and firewood
	Natural fisheries	Provide nutrient and water for game and commercial fish
	Extensive animal rearing	Provide pasture for cattle and wildlife on ranches
	Other ('minor') natural products	Provide nutrient and water for medicinal plants, forest fruits, flowers, bushmeat etc.
	Drinking water	Provide safe and plentiful drinking water sources
	Abiotic production	Provide solar energy, wind energy, water flow energy
	Natural production reservoir	Provide stock of minerals, fossil fuels, peat and species and genes for future use
Signification functions	Signal function	Provide spatial and temporal early warning indicators of human actions
	Scientific signification function	Provide geological, historical, climate etc. records for research and education
	Cultural orientation function	Provide seas, forest, deltas through which cultures develop their specific characters
	Relationship function	Inviting and facilitating direct and indirect relationships between people and nature
	Participation function	Inviting and facilitating direct and indirect participation in nature's beauty and process
	Contemplation function	Provide direct/indirect places and occasions of special aesthetical, sacramental and solitude value
	Signification reservoir function	Provide undiscovered possibilities to enrich the knowledge and experience of the world
Habitat functions	Conditions provision function	Provide space, energy and food for the development of species and ecosystems
	Habitat reservoir function	Provide space, patterns and mechanism for the biological evolution to continue

Processing functions	Abiotic processing function	Undertake dilution, photolysis, sorption of waste and toxicants in the environment
	Biotic processing function	Undertake mineralization of organic waste in the environment
Regulation functions	Shield function	Provide protection against too high levels of radiations and natural disasters like flood and hurricanes
	Dampening function	Able to dampen processes (soil erosion, river flow etc) that are too fast or fluctuating in the environment

4.1.2 Economic value estimation

Environmental functions are economic goods if they correspond to human needs and desires. This section is concerned with how monetary value could be placed on goods and impacts arising from changes which may affect the functions of the environment quality or the available stock of natural resources. The point of departure for the economic evaluation of the functions of the environment is based on the assumption that natural resources somehow impact on the well-being of individuals in society. As noted by Edward-Jones et al. (2000), money measures can act, albeit imperfectly, as measures of the extent to which the utilities of individuals are affected.

Valuation techniques seek to compensate for the lack of market value for many environmental goods, by indicating demand for such goods through implicit prices. Common to the use of valuation techniques are the following assumptions (Edward-Jones et al., 2000):

- The total value of a change in environmental goods is the sum of the values of its effect on individuals who make up society.
- Different kind of impacts should be able to be compared and some quantity of money can always act as substitute for some quantity of environmental goods.
- Environmental goods of equal valve can be substituted for each other with no loss of welfare.

Below are the broad categories of methods and tools that can be used in economic value estimation of the environment.

Total Economic Value

Total economic value (TEV) is the concept under which all impacts on human welfare are summed up. The impacts may be classified according to the functions overview, but economists often distinguish between the following three main types of values:

- *Use values* are associated with the benefits that come as a result of the direct contact with natural resources. This can either be through consumption of natural resources in the form of marketed goods and services or for non-con-

sumptive use such as water retention and treatment. These values can direct and marketable, direct and non-marketable and indirect.
- *Option values* are associated with benefits or values placed on environmental goods by those who want to secure the use of the good in the future.
- *Non-use values* refer to benefits derived from environmental good which do not have direct contact with people. Here, direct or indirect use of the environmental good is not required to derive the benefits but rather from the knowledge that such good exists.

In the following sections section, I present different economic valuation techniques available for environmental valuation of the components of TEV. These techniques have been classified in many ways. The approach used here is adapted from the classification proposed by Edward-Jones et al. (2000). It distinguishes between two broad groups: actual behaviour-based techniques and potential behaviour-based techniques.

Valuation techniques based on actual behaviour

These techniques are made up of conventional market approaches and constructed market approaches.

Production function, opportunity cost and dose-response techniques

The production function technique considers the background environment of the environmental good as the factor of production of that good in addition to human related production factors (Edward-Jones et al., 2000). This implies that the technique replies on the conditions prevailing in the context since a change in the environmental quality results in a change in productivity and production costs, which in turn lead to changes in the value and output of good.

Effective implementation of the production function techniques relies on the accurate estimation of the physical effects of the action under consideration on the output of specific marketable goods, and the development of a proper pricing mechanism for these goods. However, major problems could exist when one tries to specify the physical effect on a production process where there are constant interactions between a number of forces, particularly in trying to isolate the effects on production that influences a subset of these forces (Edward-Jones et al., 2000).

The main challenge facing the use of this approach is tendency for the pricing of the output of the production process to not represent the 'true' market price thereby giving a wrong estimation of the associated benefits. This could be due to the improper adjustment of market prices to reflect monetary values of impacts in the future and correct market prices, if necessary, so that they represent measures of true scarcity of the goods.

The opportunity cost technique which is a direct corollary of the production function technique, uses market prices to estimate the value derived from using a resources in a particular way either by preserving the values of the resource or examining the values of alternative uses (Edward-Jones et al., 2000). What is specific about the approach is that unpriced goods and services are estimated by measuring the benefit forgone by not using the same resource for some other use.

For instance, the cost of using a lagoon for waste dumping rather than preserving it for production of fish would be measured by the forgone income from not selling fish from the lagoon. In project execution, the technique can be used to value the viability of the project and its alternative option rather than the benefits of the environment of the context in its natural state. The option with the least benefit shows that its execution does not justify the irreversible loss of the environmental and natural resources given the cost of opportunity available to provide the same product or service.

The opportunity cost approach is a useful technique for the determination of benefits of non- consumptive use of environment good such as preservation, protection of habitats, cultural sites or historical sites and aesthetics. The focus here is, the technique measures what to be given up for the sake of preservation and thereby take the opportunity cost as the minimum value for the preserved resource and if preservation will continue.

The dose-response technique is a further variation on the production function technique, primarily used to estimate pollution effects on human health and the wellbeing of the environment. The technique involves the establishment of a relationship between pollution and its effect. The result of this relationship is a dose-response function where the response is directly related to the cause of pollution. A coefficient of the relationship is established and a demand curve is used to assess the economic values of effects (Edward-Jones et al., 2000). In using this technique, benefits and cost estimated should be considered as lower limits values because it only accounts for direct cost and values but discards other indirect values and cost (suffering and immunisation). This makes the use of this technique best suited for situations where direct cause-effect relationships can be established and related expenses are clearly identifiable.

Defensive or preventive expenditure

This technique is based on the notion that individuals and communities often spend money to mitigate or eliminate damages caused by adverse environmental impacts. Under the defensive expenditure approach, the value of expenses incurred to mitigate or eliminate damages caused by adverse environmental impacts is considered as the minimum estimates of the benefits of environmental improvement.

As noted by Edward-Jones et al. (2000), the advantage of this technique is that the costs of mitigation are generally easy to estimate compared to the direct cost of the environmental damage. This can be achieved by directly observing the expenditures made by individuals and communities or ask individuals and communities what they are might be willing to pay such mitigation and whether they can provide best estimates of what expenditures individuals would have to incur to protect them adequately against adverse impacts.

The use of this technique is clearly related to the ability to pay of the population since if individuals are not able to afford to pay expenditures, the expected benefits will not be realised. One advantage of this technique is it ability to express secondary benefits in addition to the mitigation of losses in environmental quality (Dixon et al., 1998).

Hedonic Pricing method

The hedonic pricing method seeks to isolate the contribution that environmental quality makes to the total market value of an economic good (Edward-Jones et al., 2000; Russell, 2001). The underlying principle is that the total value of any good is a function of the set of characteristics of that good, such as its environmental setting. Hedonic pricing has mainly been focused on property prices to see how they vary with environmental attributes. Data is collected on all factors that influence the value of the property and statistical techniques used to isolate the variations in the prices of the property that comes about as a result of changes in environmental factors while values for all other characteristics remain constant.

The price differential between two properties that results from difference in environmental quality characteristics reveals individual valuation of the importance of environmental quality in decision making which is likely to vary between individuals according to their personal preferences. This implies individuals with different social factors, income levels, age and so on have different values. A total value for a change in environmental quality can be derived by summing all the values of all the individuals associated with the property under consideration (Russell, 2001).

Edward-Jones et al. (2000) mention lack of information and data, a lot of variables and huge amount of date required to carry out analysis hedonic pricing and the reliability of the available data as the key limitations to the application of the technique. In addition, the technique does not assess non-use values.

Travel Cost Method

This method is based on the expenditure incurred by individuals in order to reach recreational sites and the expenditures as a means of measuring willingness to pay for recreational activities. The cost involves the sum of the cost of travelling,

opportunity cost of time and fees paid to have access to the site which gives an estimation of the demand in terms market price for the opportunity or services provided by the site under investigation (Edward-Jones et al., 2000; Litman, 2001).

The travel cost method is considered to be one of the most effective approaches in valuing recreation services (Bockstael et al., 1991). Navrud and Mungatana (1994) have pointed out that this method has been used to define the demand for and value of wildlife in Lake Nakuru National Park in Kenya. It can only measure values of recreational sites, however, and it is not clear how time spend in the recreation can be valued, how alternative sites affect the values that derive from a particular site, what component of the overall cost should be allocated to one particular site out of several sites visited and what are the motivations for individuals to visit one or more sites.

Valuation techniques based on potential behaviour

Contingent valuation

The contingent valuation method (CVM) is used to estimate economic values for all kinds of ecosystem and environmental services. The method has great flexibility, allowing the valuation of both use and non-use values, and a wider variety of non-market goods and services than it is possible with any other non-market valuation technique (Georgoiu, 1997; Pearce, et al., 2001; Alam, 2005). The most appealing aspect of the contingent valuation method is that it allows estimating total value rather than components of that total value (Frykblom, 1997).

CVM involves directly asking people to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service or the willingness to accept compensation for a damaged environment or to accept a condition of being deprived of the improved environment (Edward-Jones et al., 2000). This can circumvent the absence of markets for environmental goods by presenting consumers with markets in which they have the opportunity to pay for the goods in question.

CVM is based on the fact that benefits of non-market goods are likely to be implicitly treated as zero unless their market value is somehow estimated. This is because people do not reveal their willingness to pay for them through their purchases or by their behaviour (Pearce, et al., 2001). The result of this is a debate over the reliability of CVM and the overall suitability of the passive use of values in policy analysis. This debate has resulted in many theoretical and empirical issues being raised in relation to rethinking of issues concerning the benefit of environmental goods, and how people respond to questions about market situations.

Common to the application of CVM through the above techniques are (i) an introductory section which helps to set the general context for the discussion to be made; (ii) a detailed description of the goods to be offered to the respondent and the institutional setting within which the goods will be provided; (iii) the manner in which the goods will be paid for and the method by which the survey elicits the respondent's preferences with respect to the goods; (iv) debriefing questions about why respondents answered certain questions the way they did and the collection of a set of respondent characteristics including attitude and demographic information (Frykblom, 1997).

The use of CVM has brought to light biases which could lead to different estimated of value of an environmental good or service depending on the particular approach used to undertake the CVM survey. The following principal problems of bias associated with the use of CVM are identified in Edward-Jones et al. (2000):

- The uncertainty surrounding the design of survey tools, e.g. whether to use willingness to pay or willingness to accept questions.
- Respondents could deliberately misrepresent their true will willingness to pay or willingness to accept in order to manipulate the results of the study.
- Respondents may also decline to pay for goods such as amenities because they anticipate enjoying them without pay which could lead to undervaluation of the good.
- Information provided to respondents about the environmental good may influence the willingness to pay bid.
- The type of payment method through which the bid given by respondent are collected may vary and be evaluated differently due to political undertones.
- The way willingness to pay or willingness to accept questionnaires are formulated and administered could influence the final value obtained.

Added to this list could be the problematic aspects of economics in general, e.g. the assumption that aggregates of individual responses are equal to total value, hence include system aspects and the long term.

Taking clue from the above problems, CVM requires competent survey analysts to achieve defensible estimates, even though it difficult to analyse and describe. This has raised questions among academics over whether it adequately measures people's willingness to pay for environmental quality. People have preference in making choices with market goods, so their purchasing decisions in markets are likely to reflect their true willingness to pay. However CVM is based on the assumption that people understand the goods in question and will reveal their preferences in the contingent market just as they would in a real market (Whittington, 1998, 2002). This may not be the case in some situations since most people may be unfamiliar with placing market values on environmental goods and services and may not have an adequate basis for stating their true value.

Choice experiment

The choice experiment is a technique to evaluation that seeks to discover, similar to hedonic pricing, the contribution of different characteristics of a good towards its overall value (Hanley, 1998). The choice experiment is carried out through the evaluation of hypothetical scenarios in which different combinations of a good composed of a number of valuable characteristics are compared (Edward-Jones et al., 2000). The characteristics of the composite good are then ranked depending to the score assigned to different scenarios. Individuals are presented with several short descriptions of a composite good with each description treated as a complete package and different from other packages with respect to the characteristic of the good.

Typical environmental characteristics considered in choice experiments include, for instance, landscape diversity, accessibility, number of species and total area. The number of characteristics that can be investigated within scenarios is limited by the ability of respondents to cope with the experiment. Edward-Jones et al. (2000) suggest seven to eight characteristics to be investigated in one scenario. Individuals usually make pairwise comparisons between scenarios, and accept or reject a scenario based on the basis of their personal preferences (Luken et al., 1992).

Replacement cost, shadow projects and substitute cost

The replacement cost method estimates the value of environmental damage taking into account the amount that has (or would) to be spent to restore the environment to its undamaged state. In pollution contexts, replacement cost refers to the potential clean-up cost. Edward-Jones et al. (2000) note that restoration of damaged habitats to their pristine state has been the subject of criticism with regard to the use of replacement costs. Changing the site of an environmental good to avoid environmental impacts is also a form of replacement cost from the perspective of the individual who incur a cost in order to effect the changes (Winpenny, 1991)

The shadow project approach is similar to replacement cost. It involves the calculation of the cost of a project that provides an equal alternative environmental good or service to replace an environmental loss. The cost of the shadow project is used as an estimate of the value of the original environmental good. Edward-Jones et al. (2000) identify assets reconstruction (providing alternative habitat site for a threatened habitat), asset transplantation (moving habitat to a different site); and asset restoration (enhancing a degraded habitat) as the possible alternatives for recreating environment goods.

The substitute cost approach values a particular environmental services or good according the cost of available substitutes. If the available substitutes provide identical service, the value of the environmental good is the saved cost of using the substitute. The effectiveness of this approach depends on that the substitute can indeed provide the same function of the environmental good and service substituted for, that the substitute is actually the least cost alternative and that willingness to pay evidence indicates that individual demand for the substitute good and service would be the same as for the original good and service (Edward-Jones et al., 2000).

4.1.3 Relevance of environmental functions and values in developing countries

Based on the review presented in sections 4.1.1 and 4.1.2 on the concepts of functions and valuation of the environment, the key question that this section addresses is what the value of these concepts may be in developing countries.

Comprehensive listings of ecological functions list such as CPSH+PR appear to be quite valuable for work in developing countries, because they are cheaply accessible and not computerised. They also provide a cross-sectoral approach to solving pollution problems, connecting all involved government and non-government agents. According to De Groot (1992), their use is especially feasible to support a systematic problem analysis in complex cases, e.g. regional environmental analysis. Kessler (2003) on the other hand, uses the functions concept as an obligatory first step to in his participatory planning approach for developing countries (SEAN), *inter alia* to identify stakeholders. Moreover, ecological functions can also be used to establish TEV, giving substantive flesh and blood to the abstract economic categories of 'options value' and so on.

All the valuation techniques outlined in the preceding section can be used in developing countries, but the one of special relevance appears to be the contingent valuation methods. CVM can be applied to virtually any issue and does not rely on pre-existing economic data. As said, CVM methods such as Willingness-to-Pay are not without serious pitfalls and require high-level expertise, but it would appear much better that environmental agencies acquire this single expertise than try to spread over all valuation methods. Living with the limitation of willingness to pay seems more desirable than fragmented, low-level knowledge on the whole array of methods.

The assessment of the TEV of environmental goods or services or environmental change could therefore take the following basic form:

- The good or service could first be analyzed in terms of (change in) ecological functions performance

- These then could be further analysed in terms of the economic TEV categories (use values etc.)
- These then could be translated into CVM survey terms, which should include an insight in the aspects not covered in the CVM terms (e.g. non-use values, system values, long-term values or distributional aspects).
- Non-CVM routes should be selected to cover these latter aspects. These routes could entail one of the other economic methods but not necessarily so; they could, for instance, amount to politically based safeguarding of these values (as in 'two-tiered value theory', see sections 4.5 and 6.3).

4.2 Problem-in-Context: problem analysis

This structure is reviewed because it is central to the Problem-in-Context framework and also the development of OPiC since it focuses on the interaction between people and the environment, in terms of and both facts and values, the opposition of which constitutes the environmental problem.

4.2.1 Problem-in-Context problem analysis summarised

The Problem-in-Context (PiC) framework aims at establishing a linkage between the social, moral and ecological reality of environmental problems (De Groot, 1992, 1998). PiC is based on the understanding that there is an environmental problem when there is a negative discrepancy between the norms or standards of desirable qualities and actual qualities of the environment. Human beings set standards and norms and they vary between people and in time. This means a particular situation can be perceived as being a problem by one group but not so by another. For instance, a water body can be perceived as polluted by some people if there is a negative discrepancy between their water quality standards or norms and the desirable qualities. On the other hand, another group of people will not consider the water body polluted because there is no discrepancy between their standards or norms and the desired quality.

De Groot (1992) defines final variables as the variables that normally need no further normative justification. This implies that once impacts are assessed in terms of these variables, it does not need to be further explained if these impacts are bad or good. These final variables are often used as inputs for problem analysis. The following are the final variable for the environmental effect and norms for present and future generations proposed by De Groot (1992) as a basis for general problem analysis:

- Effects and norms on human health;
- Effects and norms on economic and cultural well-being;

- Effects and norms on ecological well being (i.e. well-being of nature);
- Effects and norms on harmony and intensity of people-nature relations.

The final variables are the basis on which observed impacts on the quality of environmental function, and desired norms and standards for quality of the environmental functions.

In the PiC framework, negative discrepancies are presented on three different levels between which, following Kessler (2003), I interject a fourth, functions level:

- *Level 1 discrepancy*: Are the impacts on the final variables acceptable? This check is assessed against the norms that are agreed upon by society to support human and natural well being. If there is no negative discrepancy between the results of a particular human activity and the established final variable norm, there would be no environmental problem, only a series of environmental facts. On the other hand, if the impact on final values exceeds the norms of final values, then, there is a problem. This level can be used as the starting point from which other norms in the lower levels can be derived. For instance,
- *Level 2 discrepancy*: Are the impacts on environmental functions within acceptable limits? At this level desired norms and standards for the performance of environmental functions (for humans and nature) are set and accepted by actors. The standards in most cases are based on the agreed desired norms of the final values (level 1). These norms may be informal but also have the form of regulations.
- *Level 3 discrepancy:* Are the environmental effects acceptable? This level of discrepancy involves the acceptable changes of the environment. In most cases, the acceptable changes are traded off in other to undertake development projects. Concrete proposed and actual effects and outputs are assessed against the acceptable changes of the environment. These norms should normally be derived from the overlying (level 2) norms concerning environmental functions performance. If the concrete effects and outputs are assessed to above the acceptable level, then there is a negative discrepancy, defining an environmental problem.
- *Level 4 discrepancy:* Do human activities exceed environmental capacity? Here, the carrying capacity of the environment which is the maximum allowable intensity of human activity on the environment is assessed and used as a benchmark to assess human activities. Determining factor of the carrying capacity of the environment could be for instance, levels of available nutrients, water in the soil which determines the growth of the ecosystem. These factors are derived from level 3 norms but also depend on ecological structures and process in the environment.

For the overall structure, see Figure 4.2.

De Groot (1992) defines carrying capacity as 'the allowable intensity of an activity (either adding things such as pollutants or taking away things such as nutrients) derived from norms in terms of human well-being and values of nature, and co-determined by human inputs and natural properties of the environment.' This definition calls for norms of desirable qualities of human well-being and environmental functions, based on the interrelation between the defined desired norms. Carrying capacity is normally applied to define limits in the use of natural resources to avoid environmental problems. An example of carrying capacity of a lake in terms of pollution is the amount of pollutants that the lake can handle such that its diverse biological species composition is maintained.

The concept of 'environmental utilization space' ('eco-space') originated in the Netherlands, and is defined as the provision of products and services by the environment, depending upon the interaction in the ecosystem, without impact upon the capacity of the ecosystem to provide such goods and services, or causing irreversible changes (NAR, 1993). With that, the concept is basically equivalent to carrying capacity. Eco-space is based on the notion that society must act in accordance with the potential room for use of the environment and there is no question of trade off with social goals. The concept is derived from resource economics (Klaassen and Opschoor, 1991) and requires information on the absorption capacity of the environment. This presupposes that there are well-defined limits to the scale of reserves of natural resources within which properties and functions of the environment can be used.

Environmental problems can be described on any of the four levels, as presented in Figure 4.2, in which the flashy arrows denote the potential problematic discrepancy between the two sides ('facts versus values', 'is versus ought', 'empirical and normative') of the environmental problem.

PiC is a guide to the process of defining and analysing environmental problems for the identification of appropriate solutions. The analytical process employed in dealing with environmental problems is based on the causal chains. If systems are encountered along the research, it is taken up as part of an ongoing causal chain. For instance, a lagoon such as Chemu in Tema can be regarded as a system that responds to human activities which then results in a change in environmental functions performance (fisheries, pollution processing, habitat etc),which then impacts on final variables such as human health, economic welfare and biodiversity.

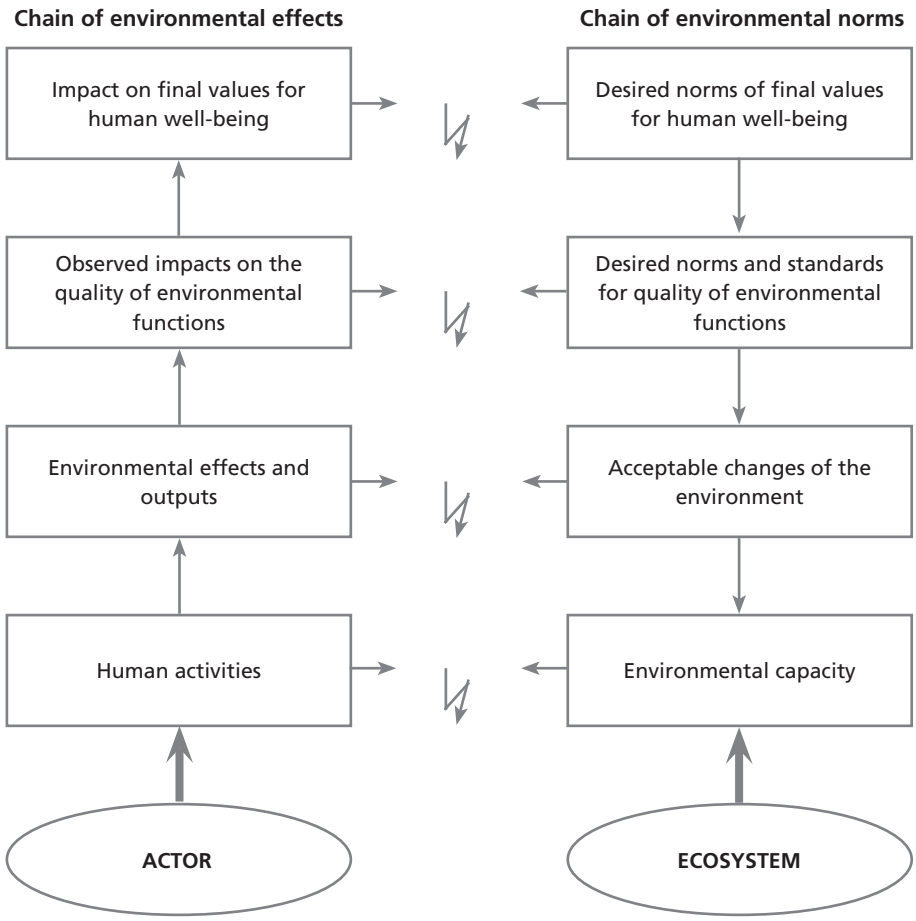


Figure 4.2 ■ Structure of the problem analysis in the Problem-in-Context framework (adapted from De Groot, 1992). The vertical arrows denote causal chains, on the empirical and normative sides of the environmental situation. The flashy arrows indicate discrepancies (positive or negative) between these two sides. Negative discrepancies define an environmental problem.

A problem may be identified at any level in figure 4.2 and a full analysis then comprises the establishment of the facts and norms at all four levels. The key process is often the derivation of norms in terms of human activities ('environmental capacity') because these constitute the objectives of the later design of the solution to the pollution problem.

4.2.2 Relevance of PiC-based problem analysis in developing countries

It may be noted that the PiC structure links up well with the criteria developed in the preceding chapter. For instance,

- PiC is conceptually clear and close to daily life reasoning, hence it can be used well to give structure to participation of all levels of people (local political, experts) in the problem analysis.
- By taking up a fully fledged normative side in the analysis, PiC-based work allows all actors to not only discuss facts but values as well. This deepens the possibilities of participation and the potential ownership of the analysis by all actors.
- Because of this comprehensive character, PiC embraces approaches like environmental impact assessment and life cycle assessment and economic evaluation. Hence it can give structure and context to such tools. For example EIA is a legal instrument in most developing countries to deal with impacts on the environment that will result from development projects while willingness to pay is used to assess how people value the environment and are prepared to pay for its restoration. The full illustration is in sections 4.3, 4.4 and 4.5.
- PiC can be used for qualitative reconnaissance up to fully quantitative levels of problem analysis. This makes it a useful in dissecting pollution problems at all levels of human interaction with the environment to determine the desired levels for human, ecological, economic and social welfare as well as the activities and impacts.

In all this, finally, it must be born in mind that, as De Groot (1998) mentions, PiC is strictly problem-oriented. This is a strength but also a limitation; PiC offers no guidance for more opportunity-oriented, creative work. That is why the framework developed in this study focuses much more on the identification of opportunities than does PiC does – see for instance Chapter 5.

4.2.3 PIC problem analysis illustrated in Tema, Ghana

In figure 4.3, I use the Problem-in-Context framework to lay out the pollution problems in Tema. In the chains of environment effects, we have the main actors at the bottom undertaking activities and producing gray water, emissions, wastewater and solid waste. The levels of pollution from the actors determine their impact on water quality, soil, air and biodiversity.

The Chemu lagoon in Tema has a low self-renewal because of the high level of pollution. Thus the ecosystem of the lagoon would take a long time to get back to its original state. The industrial activities taking place in the environ of the Chemu lagoon has resulted in the reduction of the capacity of lagoon to absorb pollutants leading to the reduction of fish species in the lagoon and subsequently affected the livelihood of people who rely on the lagoon.

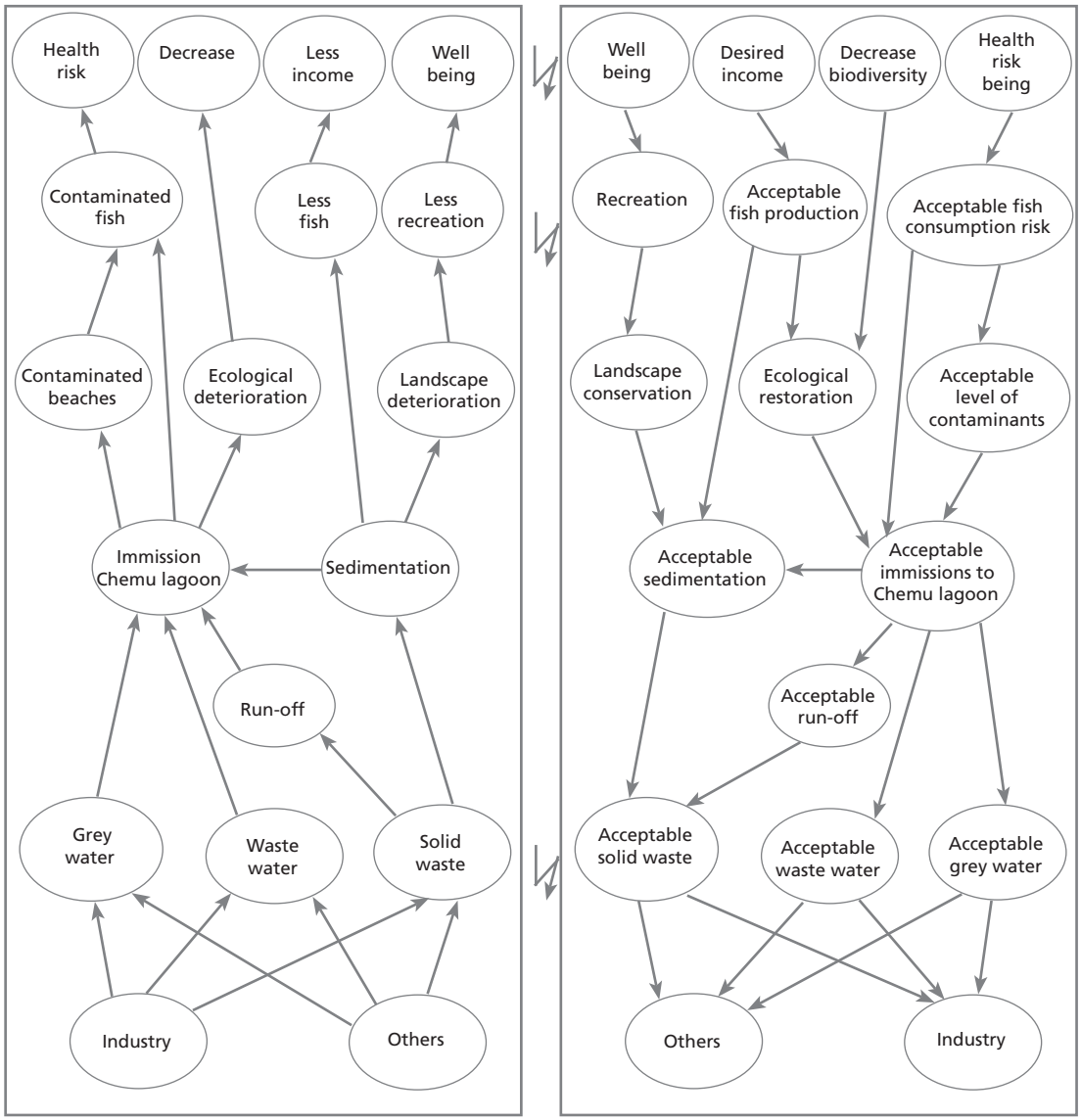


Figure 4.3 ■ Problem analysis of Tema city in Ghana with the Problem-in-Context framework.

4.3 Partial analysis I: Environmental Impact Assessment

In this section I discuss environmental impact assessment (EIA) of projects, and strategic environmental assessment (SEA) of policies, plans and programmes. The analysis through EIA and SEA are called 'partial' because they cover only a part of the full OPiC problem analysis (see Figure 4.14). Special attention is given to the

conceptual structure of EIA and the relevance and current use of the two methods in developing countries.

4.3.1 Environmental Impact Assessment (EIA)

EIA is a tool used to aid and improve decision-making processes with the main objective to determine the potential environmental, social and health effects of a proposed development project in a way that permits rational decision-making.

Currently, there are several definitions of EIA but none is universally accepted. In this research I adopt Sadler's (1996) definition, which states that EIA is 'a process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of proposed projects and physical activities prior to which major decisions and commitments are made'. EIA is characterized by a comparative evaluation of all reasonable alternatives of activities which will achieve the intended development objectives, through the integration of environmental, social, health and economic impacts in order to provide an environmentally sound decision about activities. Public participation is a very important element in carrying out EIA.

Although there are many regulations for the preparation of an EIA, the following are generally the main methodological phases (Modak and Biswas, 1999; Glasson et al., 1999; Edward-Jones et al., 2000; Morris and Therivel, 2003):

Project selection and impact significance – EIA is concerned primarily with significant environmental impact. Significant impacts of projects are identified and selected by analyzing and examining all possible impacts of the project with actors concerned. Three main classes of identification techniques are checklists, matrices and networks (Devuyst, 1998). A checklist is a one-dimensional way of thinking about the possible range of impacts as well as the interactions between the effects. Matrices on the other hand employ two-dimensional tables to relate development actions and environmental impacts to each other, in order to ascertain whether an impact is likely. The focus here is the direct relationship between the impact causing factor and the target environmental component. Networks aim to trace causal interactions in order to deal with complex (indirect multiple) impacts, which can arise from an initial impact. This is by linking causes and effects along the effect chain, working, as the Problem-in-Context framework (De Groot, 1998) puts it, from an activity's primary effect to its final impact on variables such as human health, well-being and biodiversity.

Impact measurement, prediction and assessment – There are different ways of measuring and predicting environmental impact and, no matter what model is adopted, characteristics such as spatial and time dimensions, reversibility and surprises

need to be considered. Issues such as social distribution of the environmental impact and the mixture of the effect are crucial at this phase. The prediction of impacts is based on professional judgment and the choice of environmental impact assessment techniques depends on the circumstances (Edward-Jones et al., 2000).

Alternative and mitigation measures – Here alternatives to the proposed project are considered in terms of no-action alternative, environmentally friendly alternatives and location alternatives with the view to finding the most appropriate alternative to the project. An important task here is the evaluation of the magnitude and significance of the impacts. It is through an appropriate choice of significant criteria that sustainable development objectives can be achieved (George, 1999). Use can be made of institutional, public and technical criteria with different interpretations depending on the situation (Canter, 1996; Edward-Jones et al., 2000; Morris and Therivel, 2003).

Environmental Impact Statement – The final statement is prepared to ensure that planning and decision-making processes are rationally based. Three main elements need to be present in all EIS (Lee and Colley, 1992; Edward-Jones et al., 2000; Morris and Therivel, 2003). First is the description of the development project and actual state of the environment. Second is a discussion of the environmental impacts of the project, presentation of possible alternatives to the project and analysis of the impacts of the alternatives, and third, possible impact mitigation measures and monitoring plans.

All projects have a planning process in which EIA can be integrated. Given its sensitivity to social, economic as well as environmental impacts of projects, EIA helps compensate for shortcomings in the project planning process and helps strengthen decision-making and communication mechanisms within projects, paving the way for introducing innovations. An EIA may reveal sound environmental, social, or economic reasons for shifting a project's direction. In view of the non-primacy often accorded the environment in the opinions and aspirations of project development actors, the EIA process may also function as a project control mechanism. However, one should not expect EIA to correct all the weaknesses of a flawed planning process.

A major drawback of EIA is its focus on individual projects and activities and not on the policy, plan and programme levels as well across projects, making the combined effect of a number of projects in a specific area not clear. Other shortcomings associated with EIA are its lack of transparency of the process and public participation. Whatever the problem is, EIA is applied at a late stage of project cycles, when a lot of preparatory work and decisions regarding pollution have in fact been finalized already, making it of little use in preventing pollution problems

at strategic decision levels. This has made EIA not able to address cumulative pollution impacts associated with a project and at the same time it usually fails to assess possible alternatives to the proposed project (Goodland and Tilman, 1995; Edward-Jones et al., 2000; Morris and Therivel, 2003).

4.3.2 Strategic Environmental Assessment (SEA)

Strategic environmental assessment emerged in the 1990s as a term for tools which aim to integrate environmental considerations into proposed policies, as opposed to EIA that focus on the project level. In the context of this study, I refer to policies as broad statements of intent that reflect and focus the political agenda of governments and initiate a decision cycle which are reflected in plans and programmes (Sadler and Verheem, 1996). It is believed that SEA provides context for the consideration of cumulative effects.

As Partidario (1999) states, the policy level is important for three reasons:

- The timing of decisions – particularly at policy and planning levels as a cascade of small incremental decisions that happen in the absence of a systematic impact assessment approach, in a way that subsequently influences environmental decisions.
- The nature of decisions – the less concrete and vaguer nature of policy and planning decisions are significant constraints to the operation of project-oriented tools like EIA.
- The level of information – it is realized that project level EIA requires the level of information and uncertainty that do not exist and could not be provided to the same extent at policy and planning levels.

Currently, there is no internationally agreed definition of SEA, but Sadler and Verheem (1996) are widely quoted. 'SEA is a systematic process for evaluating the environmental consequences of proposed policy, plans and programme initiatives to ensure the environmental consequences are fully included and appropriately addressed at the earliest appropriate stage of the decision making, on a par with economic and social considerations'.

SEA is often presented as an assessment tool that helps to focus on maintaining the broad ('source and sink') functions of natural systems (Sadler, 1999; Sadler and Verheem, 1996). However, this potential of SEA has not fully been realized because the way to make SEA simple, adaptable, and practical is not apparent. SEA is not yet clearly delineated and operative in strategic decision-making processes. There is broad consensus that there can be no single 'blueprint' approach to SEA and it should be tailored to suit conditions, institutional realities and political circumstances (Clayton and Sadler, 1998). Nevertheless, the following procedural steps are often used no matter the method chosen.

- Determine the need and type of SEA, by means of listing objectives and constraints of the planning process.
- Analyze the existing environmental context by identifying alternatives and impacts to be assessed from different sources and excluding irrelevant information
- Specify policy alternatives, identify impact, analyze impact, and identify mitigating measures through participation of stakeholders.
- Link other environmental assessments with SEA to monitor and evaluate impacts and mitigating measures.
- The above steps of SEA do not necessarily have to be a formal administrative procedure, aiming towards a report as a main product. Instead, SEA focuses on improving decision making, on the quality of the final policy, plan, or programme.

There are some critical constraints associated with the use of SEA. The major constraint is that, in order for SEA to be effective, SEA requires securing the political and institutional will so that decision makers can recognize it and policy makers acknowledge its legitimacy. Policy and decision makers must also appreciate the fact that SEA has a role to play in addressing environmental problems above project level. The problem, however, has been that, currently, actors tend to ignore SEA rather than risk sacrificing the incremental and political nature of their decision-making process to the relatively technocratic and rationalistic commitments imposed by the SEA procedures (Clark, 2000).

4.3.3 Use of Environmental Impact Assessment tools in developing countries

EIA used in developing countries is backed by national legislations and influenced strongly by development funding agencies. However, there is a variation in the way EIA is used. In sub-Saharan Africa, screening, scoping and assessment tend to be based on the funding agencies and international companies. For example, Nigeria's EIA has discretionary provisions relating to the projects of donor agencies and international companies for which EIA is required.

Based on my own experience and the work of Lee and Norman (2000), it is proposed that the following issues need to be addressed for the conceptual structure of EIA (not the quantification EIA which require larger databases to function) to fulfill its potential in developing countries:

- The use of EIA in developing countries should include assessment of the capacities of the designated responsible parties to implement the identified measures. It is also important that governments follow the approval of EIA with monitoring and take action EIA findings and recommendations.

- EIA could be used to correct great environmental deficiencies at the project level in developing countries. This is because comprehensive planning, regional and sectoral developing planning, regional conservation strategies and environmental profiles characterized with developing countries generate baseline information for EIA.
- The effective use of EIA in developing countries could be achieved with the parallel implementation of activities enacting legislations, awareness raising, improving data systems, counteracting corruption and providing opportunity for public participation adapted to the legal and institutional environment. I must stress that public involvement should be a key aspect of EIA in developing countries since EIA system contains formal provisions for public involvement in the EIA process.
- I believe the priority in the improvement of EIA use in developing countries is in training to increase human resource capacity to undertake and review EIA, institutional re-organisation and improved communication EIA results and recommendation to decision makers.

The concept of strategic environmental assessment has been given increased attention, evidenced by a constant stream of workshops dedicated to SEA. There is a keen desire amongst many developing countries to experiment with SEA. Pressure is also increasing in donor agencies to 'export' SEA to developing countries with the assumption that SEA is an appropriate approach, which may not be the case. Several ad-hoc SEA's have been carried out as part of a planning process mainly by development organizations. For example the Asia Development Bank has used SEA for the Greater Mekong while Ghana Environmental Protection Agency requires the preparation of SEA for large scale development activities. There is the need to take a close look at the relevance and potential utilization of SEA however, because currently, most EIA procedures in developing countries only consider traditional environmental aspects such as water, soil, air and noise and do not include socio-economic aspects.

The current educational programmes in impact assessment in developing countries are often restricted to information dissemination and communication practices (Didnck and Sinclair, 1997). This however, needs to be extended to involve education about impact assessment concepts and tools, in order to reduce the ad hoc character of their application (with different donors promoting their own individual methodologies), sending confusing signals to the developing countries concerned (Sadler, 1996).

4.3.4 Application of Environmental Impact Assessment method in Ghana

Ghana has an Environmental Assessment Regulation (1999) (Legislative Instrument 1652) which requires major development activities to be subject to environmental impact assessment. The Regulation lists a number of types of projects and activities subject to the EIA procedure, making no distinction between private and public projects. Figure 4.4 presents a summary of the Environmental Assessment Process in Ghana.

To carry out an undertaking, an application will be submitted to the EPA to register the proposed undertaking as part of meeting the environmental assessment regulation requirement. An initial assessment of the application is then carried to out taking into consideration the location, size and likely output of the undertaking, the technology intended to be used, concerns of the public and other factors relevant to the undertaking. The report on the undertaking should identify the environmental, health and safety impacts, environmental effects that can be avoided in the implementation of the undertaking, ways to address unavoidable environmental and health problems and alternatives to the establishment of the undertaking

After screening, the EPA will issue a screening report on the application to state whether the application is approved, objected to, requires the submission of a preliminary environmental report or the submission of an environmental impact statement. Projects that are expected to result in significant impacts will require the submission of an environment impact assessment report. The present EIA regulation in Ghana does not require a negotiation of the terms of reference for environmental impact statements. Environmental impact statements of the undertaking that will be submitted for environmental permits should include:

- a description of the undertaking and an analysis of the undertaking
- alternatives to the undertaking and reasons for the choice of site for the undertaking
- positive and negative impact of the proposed undertaking from the environmental, social, cultural and economic point of view and the potential impact on health
- consultation with the public, example to develop an environmental management and monitoring plan.

In addition to EIA, companies in Tema, cooperate organisations and companies use environmental management instruments to prevent and alleviate environmental problems. The instruments include corporate environmental management systems, environmental performance indicators, environmental reporting, environmental auditing and environmental management accounting. These in-

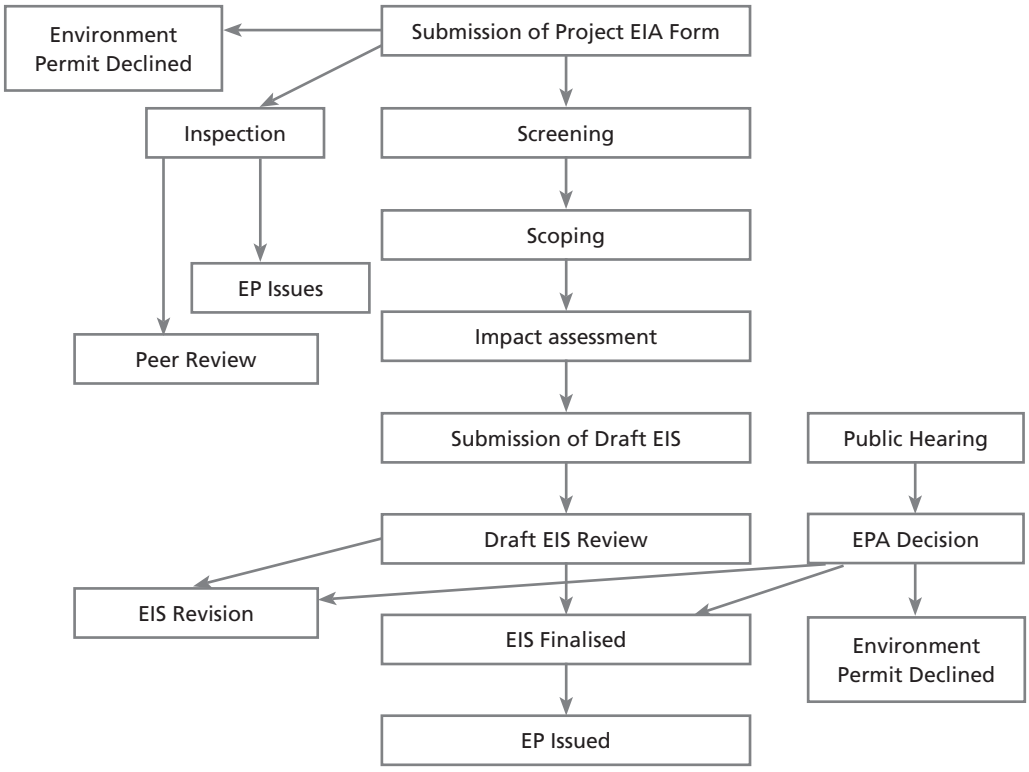


Figure 4.4 ■ Environmental Assessment Process in Ghana (Adopted from GEPA, 1992)

struments are applied at different levels of production and consumption, with the view to achieving policies, tasks and objectives of environmental management. Companies in Ghana with branches abroad have ISO 14001, 14015 and ISO 19011 certification, showing the companies' attitude towards the environment. For example more than 50% of the large scales industries operating in Ghana have ISO 14001, 14015 and ISO 19011 (2007, pers.comm.). In addition, companies install end-of-pipe equipment and machinery to pre-treat industrial effluent and filter the air before discharge into the environment. The adoption of these instruments, which used to be voluntary is now becoming mandatory. They are expensive and represent additional investment costs which companies and organisations in Ghana generally are not willing to make. This has resulted in low development and submission of environmental management plans by companies and organisations. For instance in 1997, in Ghana only 30% of the large to medium scale industries had submitted their environmental management plans, 40% were yet to do so while 30% were either not sure or unconcerned (Abakah, 1997).

4.4 Partial analysis II: Life Cycle Assessment

In this section, I present a summary of the key elements of LCA thinking and LCA methodology with a main focus on conceptual aspects. I look at the relevance of LCA thinking in developing countries and end the section with an illustration of how LCA may be applied to paper production in Tema, Ghana. Here, I am referring to the use of LCA thinking, not the full-fledged quantitative system. As with the preceding section, LCA is called 'partial problem analysis' because it represents one area out of the overall PiC-based problem analysis (e.g. Figure 4.14).

4.4.1 LCA Summarised

The concept of LCA is a relatively recent one, which emerged in response to increased environmental awareness on the part of the general public, industry and government. The immediate precursors of life cycle assessment as a decision-aiding tool were the global modelling studies and energy audits of the late 1960s and early 1970s (Nierynck, 1998). These precursors attempted to assess the resource cost and environmental implication of human decisions, especially consumption.

The recognition of incorporating environmental quality aspects in decision making and a shift in policy from pollution control to source reduction led to LCA being developed into a tool to identify the environmental consequences of products, including ways that enhance products' environmental benefits and also providing information on alternative products with less environmental consequences (Nierynck, 1998). LCA in its original form is a linear environmental assessment tool following, one by one, the stages of the life cycle of a product, service or activity.

I adopt the definition provided by Consoli et al. (1993) that 'LCA is an objective process to evaluate the environmental burden associated with a product, process or activity by identifying and quantifying energy and materials used and waste released to the environment and to implement opportunities to effect environmental improvements. The assessment includes the entire life cycle of the product, process, or activities, encompassing extraction and processing of raw materials, manufacturing, transportation and distribution, use/reuse/maintenance, recycling, and final disposal.'

As shown in figure, 4.5, a life cycle flow chart provides an outline of all major unit processes and their interrelationship that needs to be modelled in a life cycle assessment. Life cycle flow charts are important to help understand the product system. Life cycle flow charts can be done at different levels of complexity and sophistication as long as the charts are complete in terms of unit processes.

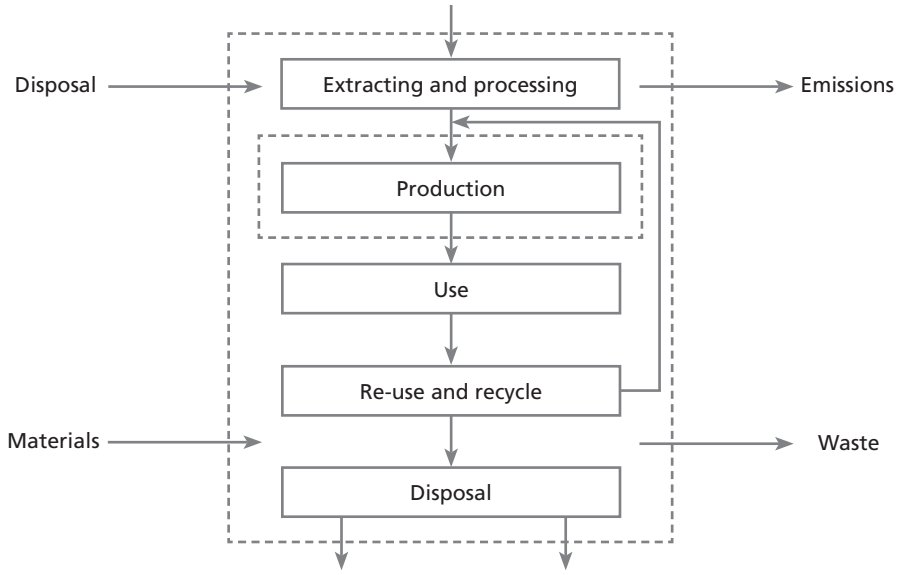


Figure 4.5 ■ A simplified flow chart showing stages in the life cycle of a product

Based on Udo de Haes (1990), three main principles of LCA are identified:

- *Comparisons of products* – Environmental impacts of products are compared either across product lines or within the product itself if modified. The unit of analysis and comparison are products, processes and activities that are functionally similar (the 'functional unit'); the main focus is the amount of product needed to perform a specific function.
- *Entire life cycle approach* -This principle takes into account the whole process involved in product production starting from the acquisition of the raw material, through the production of the components of the product. It also considers the use of the product and the processing and disposing of the waste and of the product.
- *Environmental interventions* – All interventions such as the extraction of primary resources, emission of harmful substances in the environment and aspects of land use are considered. The interventions are quantified so that products intended to perform the same function may be compared with their environmental performance. In addition, a qualitative assessment is used to determine the potential environmental interventions such as nature of emission, reuse of product, recycling of the product and the natural degradation that cannot be quantified.

A broad consensus on the overall structure of LCA appears to be emerging. Console et al. (1993) and SETAC (1993, 1997), have recommended the following four interrelated components that should be present in LCA (see figure 4.6):

- *Goal definition and scoping* – Three main issues are considered in this stage. The first is to define the objective and boundaries of the LCA study and the relevance of the study in terms of the actors involved and how the results of the study will be used. Second, the functional unit is defined in other to avoid unreasonable results (Heijungs and Guinee, 1995). The definition of the functional unit employed is then used to establish the basis for the selection of alternatives to be investigated. Data requirement, data quality, assumptions and limitations are also assessed.

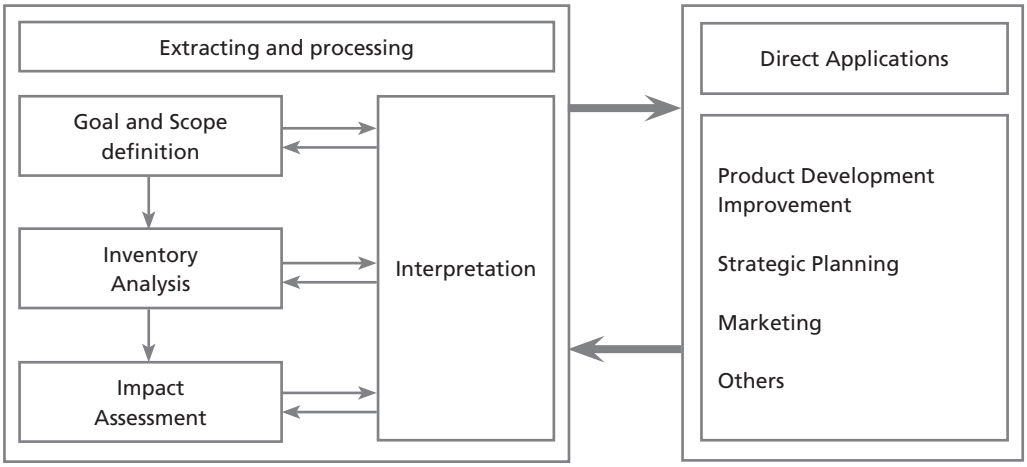


Figure 4.6 ■ Phases of the Life Cycle Assessment framework (adapted from Guinee, 2002)

- *Life-cycle inventory* – This phase involves the identification and quantification of energy and raw materials required for the whole life cycle, as well as the emission and waste generated during the life cycle (i.e. both input and output of the LCA process). Thus, inventory of all the environmental interventions of the LCA process, accurate description of the system to be analysed and proper understanding of the data and information collected and the interpretation are necessary.
- *Life-cycle assessment/analysis* – This phase involves the translation of the inventory results into environmental impacts, addressing both ecological and human considerations. A technical quantitative and/or qualitative process is used to characterise and assess the effects of the environmental loadings are identified in the inventory component. Depending on the LCA task at hand and the condition available to characterise and assess the impact on environment, loadings identified for instance, in terms of acidification potential, global warming potential or aggregated toxic potential. The analysis is done in relation to resource depletion, human health impacts, and ecological impacts.
- *Life-cycle improvement analysis* – This phase involves finding ways to reduce environmental impacts of the product under study through evaluation by

making improvements in line with sustainable development concepts (CSA, 1994) such as pollution prevention, reduction of energy and resource use and maximisation of the use of sustainable resource and energy through product development and process improvement. It also involves a systematic evaluation of the quantitative and qualitative needs and opportunities to reduce the environmental burden associated with energy and raw material use and environmental release throughout the life cycle of a product, for example, by redesigning it with less of more friendly component materials.

Risk elements of the LCA method

The reliability of life cycle assessment for decision making is affected by a number of risk elements and uncertainties inherent in the process. The presence of these risk elements and uncertainties in the LCA process are due to lack of knowledge about the true value of a quantity and the variability of the values. Based on the work of Bjorklund (2002), the following different types of uncertainty or risk elements appears in life cycle assessment may be identified:

- *Data inaccuracy*: There is data inaccuracy in the various units of the processes which concerns accurate measurements that are used to derive the numerical parameter values (Huijbregts, 2000). This is due to the fact that measures for values in life cycle assessment can be subjected to random error, which results from imperfection in the measuring instrument, the observation teahouse, and systemic errors. A typical example is inaccurate measurement of emission that could be associated with the inventory phase and the uncertainty associated with the determination of life times of toxic substances and their relative contribution to impacts.
- *Data gaps and un-representation*: Missing information on parameter values of unit processes could leave the life cycle assessment with data gaps. Such gaps do not give a correct presentation of the various units within the process. In most cases, the data gap is avoided by using unrepresentative data from similar processes but different geophysical and technical settings.
- *Use of models:* Oversimplification of aspects such as temporal and spatial characteristics that can be modelled in the assessment could result in some uncertainty in the underlying factors of the various aspects and their interconnection will not be included in the life cycle assessment (Huijbregts, 1998). This type of uncertainty is typical with the inventory and characterisation phases where one is faced with choosing static or dynamic and linear or non-linear models for the assessment.
- *Variability:* There is also the possibility for risk to arise in the process due to temporal variability and the variability between sources of the inventoried system and objects that determine the impact on the environment. Variability between performance level equivalent processes in the inventory phase and differences in environmental and human characteristics in the characterisation phase. Spatial variation will stem from fluctuation between different geo-

graphical sites in the environment. This takes place in the inventory phase in the form of regional variations in emission and in the characterisation phase as regional differences in environmental sensitivity. Temporal variations over time are relevant since processes and factor in the receiving environment vary naturally over short and long time scales.

- *Choices:* Making choices is one of the fundamental actions in any life cycle assessment. Because of the large amount of options available in making choices in LCA, there is often some degree of uncertainty surrounding what to choose. Uncertainty in choice is mainly association with for instance, functional units and system boundaries in the goal and scope phase, the allocation methods, weighting method and technology level in the inventory phase, leaving out know impacts in the choice of impact categories phase.
- *Lack of knowledge* of the behaviour of the system under consideration has a tendency of creating uncertainty in the assessment process. This affects all phases of LCA such as ignorance of about the relevant aspects of the system to be studies at the goal and scope phase, ignorance about the modelled process in the inventory phase, lack of knowledge about the impact categories, contribution to impact not know in the classification phase and characterisation factors not known in the characterisation phase. This situation results in the use of inappropriate weighting and estimation approaches which give a wrong picture of unit processes and flows in the LCA.

The above risk elements and uncertainties could be managed by using tools such standardisation, data quality indicators, data quality goals, critical reviews improving data availability and quality by ensuring good practice in data collection and use (Bjorklund, 2002). A major result of such effort is the LCA handbook of Institute for Environmental Science (CML), Leiden University. The usefulness of these standards for developing countries will be discussed in section 4.4.3.

4.4.2 Basic difference between LCA and EIA

Various authors have argued that there is an essential difference between environmental impact assessment and life cycle assessment (Udo de Haes and Huppes, 1994; Udo de Haes, 1996; Tukker, 2000). They may be summarized as follows:

- *Decision-making* – EIA is focused on formal political decision-making including public participation. LCA on the other hand is designed to support decision-making of producers and consumers.
- *Impact assessment* – EIA can follow the causal chain of human activities up to the final variables; EIA has no prescribed method. LCA on the other hand uses only short causal chains (emissions) that are cut short by immediately aggregating potential pollution (toxic potential, acidification potential, etc); this is done in a prescribed manner.

- *System boundaries* – EIA does not follow a cradle-to-grave approach (example including the energy cost of making cement for a road project); the assessment is time and location specific. However, LCA considers all elements of the life cycle but does so abstracting away from time and location specificity. A substance such as PVC, for instance, is set as having certain inputs (example oil) and output (example emissions) irrespective of where the PVC is manufactured.

In terms of the PiC problem analysis, EIA is relatively narrow but with long effect chains that run up to the final variables and LCA is broad but with short effect chains.

4.4.3 Use of Life Cycle Assessment in developing countries

The use of LCA thinking in developing countries has been rare and in the situation where they have been used, they faced high barriers. Some of these barriers are the lack of collaboration between government and companies in sharing data on LCA resources and the financial constraints on governments, universities and industries. The support and commitment from government in developing countries is crucial.

The fact that LCA is location-unspecific (see above) is a limitation of LCA. The impact of many types of emissions, after all, is dependent on local environmental circumstances such as soils, climate, population or vegetation. For application in developing countries, however, this limitation implies an opportunity, namely that basic data to support LCA will be applicable in any country. Thus there is a wide use for the development of an LCA network and methodology specific to developing countries. The creation of a multi-partnership infrastructure, which allows for the sharing of information and expertise about the development of LCA techniques, is required in order to allow for the input of many stakeholders into their development on a continuous basis. This work should focus especially on public database availability and the development of LCA thinking concepts, methods and models that require relatively low levels of computer and academic sophistication. Furthermore, attention should be paid to gather data related to products and processes that are in wide use in developing countries or may become so using the countries' indigenous materials and skills (Jensen, 1995; Van Weenen, 1997). As noted by El-Mosley (1997), 'the rediscovery of local raw materials means imagining, thinking, designing and carrying out research with the objective of developing new uses of local raw materials'. This provides developing countries with a strong stimulus for building or rebuilding their endogenous scientific and technological capabilities within a new vision of pollution management with principles and ideas from developed countries, on LCA thinking in particular.

The following are additional ways that LCA thinking could be operationalised in developing countries like Ghana, based on Welford et al., (1998), Heiskanen (2000a, 2000b, 2002) and Ometto et al. (2006):

- A key issue is to integrate life cycle thinking in environmental management and policies so that it becomes an integral element of actors' environmental management practices. This will add an important product-based line of thinking to traditionally process-oriented management, and also help prevent that environmental risks are merely being passed down or pushed up in the product's life cycle.
- Life cycle thinking can be used to construct problems and make actors aware of their responsibilities and capabilities for solutions along the product chain.
- At the strategic level, life cycle thinking may be stimulated through the adoption of reviews based on systematic, LCA-based checklists or matrices and requesting the environmental information from suppliers, based on these checklists and matrices.
- Organisations and actors should be helped to copy good practices of peers which have been able to improve both environmental and economic performance.
- Life cycle thinking could be integrated with environmental impact assessment through regulations that use the existing EIA obligations.

So doing, life cycle thinking may be institutionalised such that effective 'chain management' structures are created. Companies and organisations then adopt life cycle thinking to include all actors that are responsible for environmental damage along the production chain. This way, the analyses and actions may focus on where there is the greatest leverage and efficiency of reducing environmental impacts, and a wider accountability and transparency in product markets will be established.

4.4.4 Illustration of the application of LCA on waste paper in Tema

An illustration of the conceptual strength of LCA-thinking is demonstrated in figure 4.7. It looks at different impacts emanating from the generation, collection, processing and disposal of waste paper in Tema, Ghana. In this example, it is easy to add more detail, and it is also possible to draw a line separating inputs and impacts occurring within Tema and those outside of it. Then adding other products flowing to or from the Tema area, a good semi-quantitative grip on the area can be built up, in which qualitative and semi-qualitative knowledge on types of emissions, reusability, de-gradability, life span, waste flow may be integrated. It may also be noted that LCA lives up well to the criteria developed in the preceding chapter with respect to what OPiC should be. It appears, therefore, that the basic schedule of LCA thinking may be a good element to be incorporated in the OPiC framework.

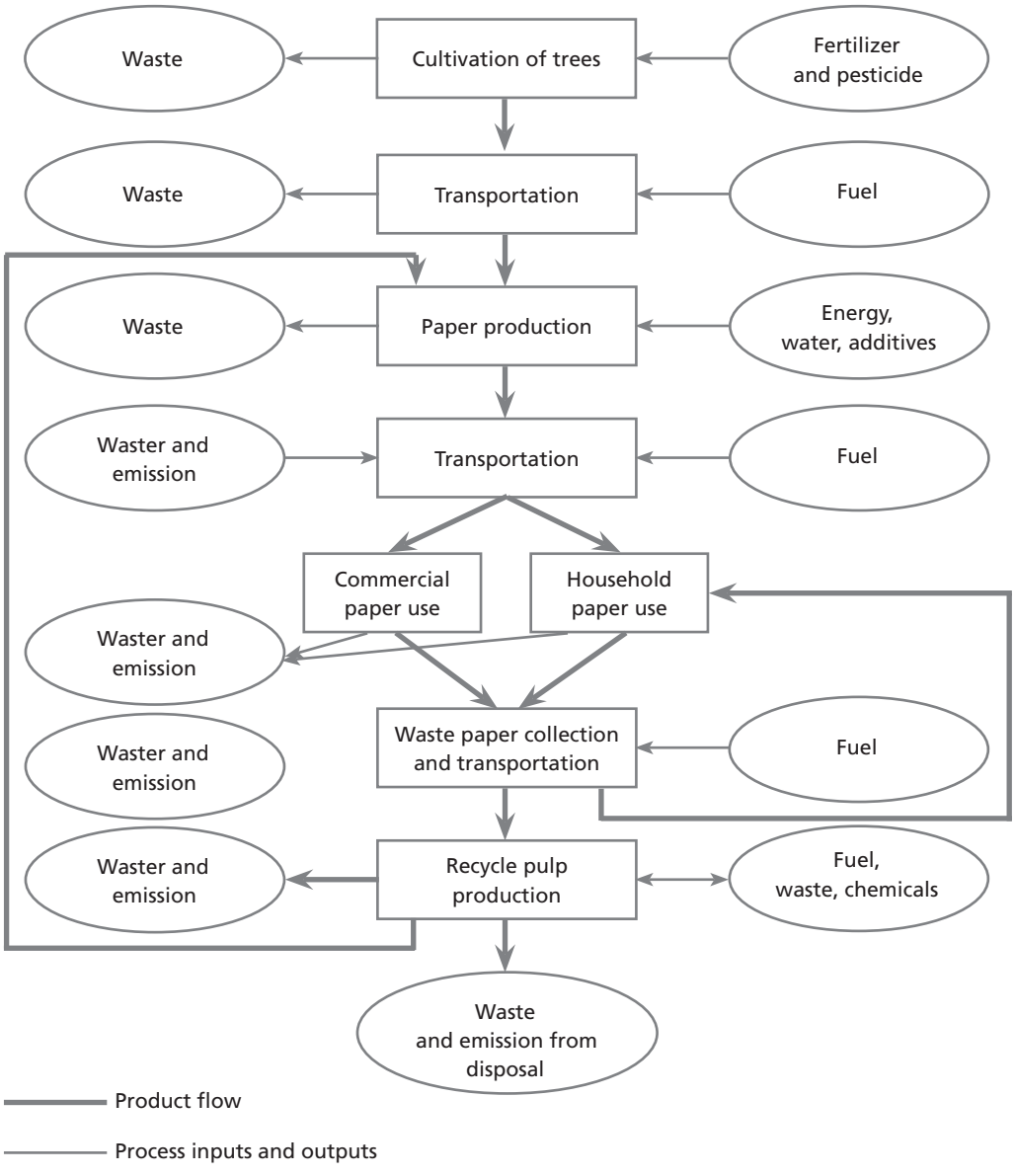


Figure 4.7 ■ A simplified LCA flow chart for paper and wastepaper use in Tema. Boxes indicate processes and circles are flows

4.5 Partial analysis III: Cost-Benefit Analysis

In this section, cost-benefit analysis (CBA) is reviewed as a tool for analyzing environmental problems. The idea is to present the key principles and how they are applied in developing countries. I do not mean to present a comprehensive and empirical encapsulation of CBA in this section. CBA is called a 'partial analysis' here because it focuses on the evaluative part of the full problem analysis (that is the upper part of the OPiC overview in figure 4.2)

4.5.1 Cost-Benefit Analysis summarised

In CBA, pollution problems are defined in terms of costs and benefits to individual human preferences and satisfaction. Cost includes those things necessary to implement and maintain a selected alternative, such as investment cost, opportunity cost and others. Benefits are the total change in direct and indirect welfare, positive and negative, brought about by a selected alternative. CBA is based on economic reasoning concerned primarily with efficient voluntary exchange. It is crucial to understand that economic assessment tools are focused only on this criterion to judge the merits of particular pollution management actions. This is then used to rate pollution management actions and the one with the least cost and high benefit is preferred.

The following are two ways of accounting in CBA:

- Financial accounting involves taking the real paid ('cash') prices of goods and services, irrespective of how these prices come about, hence including subsidies, taxes, market distortions etc, but excluding external effects.
- Economic accounting aims to take the true economic value of goods and services, hence excluding taxes and subsides, correcting for monopolistic pricing, etc.

There are system levels in CBA, which could be called decision-making levels. For example, decisions at farm, firm, district, national and global levels. CBA at these levels is guided roughly by the following rules:

- All transfers within the system are ignored.
- Values accruing within the system should be accounted for at the true value (i.e. economic values).
- Account for prices paid or received at the system boundaries financially.

The latter rule is exempted if the unit of decision-making has incurred moral or legal obligations to account economically. For example, if firms claim to be green firms, or nations sign treaties, then external environmental impacts should not be accounted for financially (i.e. cost = 0) but economically. System levels in cost benefit analysis are illustrated in figure 4.8.

Two characteristic system levels of CBA are the 'private' and 'social'. Private perspectives of CBA are used in assessing private projects in order to maximize private profitability. Transfers such as direct taxes and indirect taxes, which affect profitability, are recorded and the cost of external effects is not taken into account. Efficiency analysis is done by taking into account domestic market conditions. This is only relevant for separate firms, not for public decision-making regarding pollution management. Societal perspectives, on the other hand, can be to maximize real national income. In societal perspectives, transfers such taxes and subsidies are not taken into account but the external effects of activities are recorded and efficiency analysis is done with economic accounting and shadow market conditions (James, 1994).

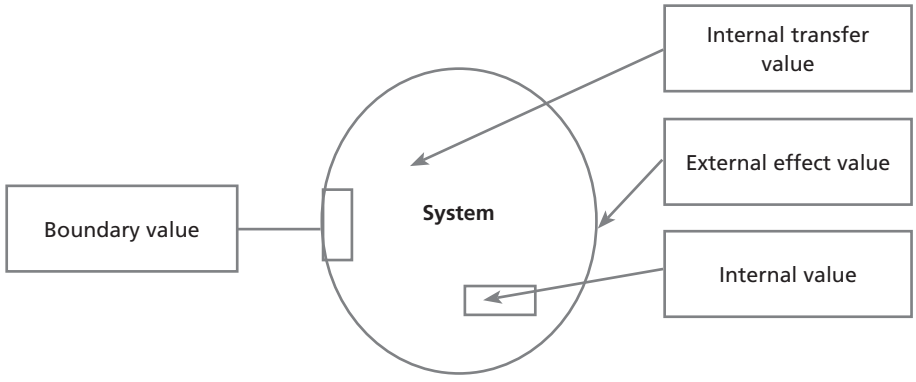


Figure 4.8 ■ System levels in Cost Benefit Analysis

Taking account of only the two levels of 'private' and 'social' is confusing in a way, because there are many levels in-between. For example, a village wanting to convince a private bank that a village-level action should be funded by the bank will have to prove that it can pay back the loan. These actions therefore require the use of financial accounting at the village system level. On the other hand, if the same village wants to convince a district government that its actions should be subsidized, it should present a CBA with economic accounting at the district level.

4.5.2 CBA methodology

In this section, I present an overview of the important elements of the CBA methodology. As shown in figure 4.9, there are six stages in the CBA methodology. These stages are: project definition, classification of impacts, conversions of impacts into monetary terms, discounting, project assessment under the net present value and sensitivity analysis. At the end of the section, I present a discussion on key shortfalls of the CBA methodology.

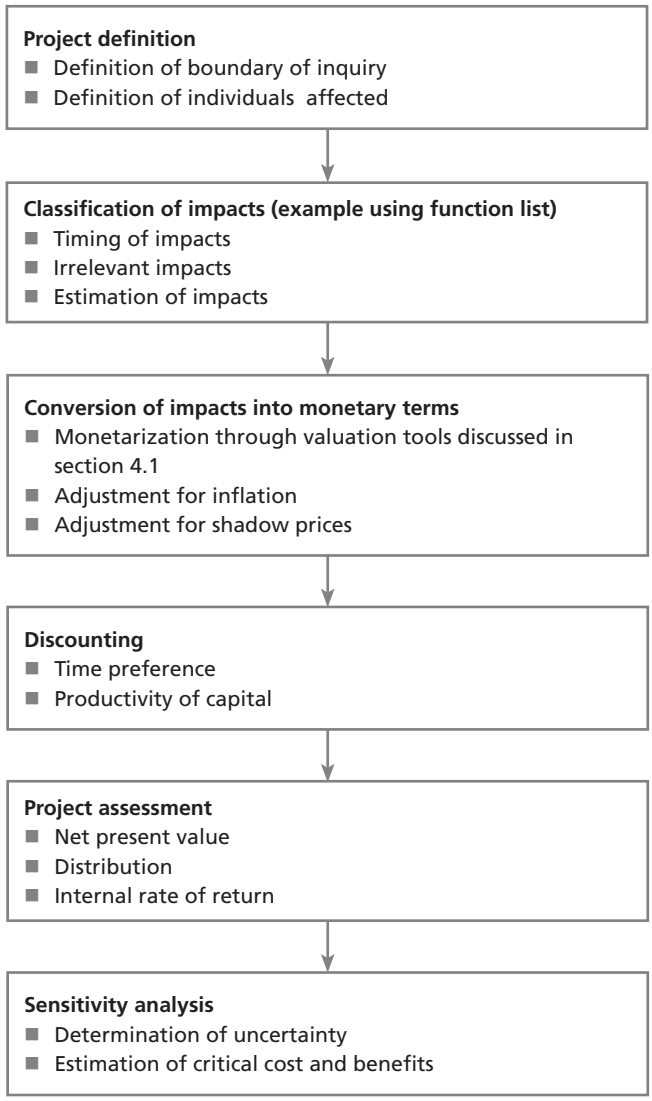


Figure 4.9 ■ An outline of Cost Benefit Analysis methodology

Project definition involves the determination of the implication of the project in terms of resource allocation and the establishment of the boundary of inquiry of the CBA. It also during this stage that individuals to be considered for the analysis are defined and the process takes into account both present and future generations.

Classification of impacts is where impacts in terms of resource use, effect on individuals and the environment arising from the project are identified (for example

using the functions of the environment as a link, see section 4.1). This is then followed by the quantification and tabulation of impacts. Determination of timing of impacts (which normally involve some element of estimation) is carried out since it is very important for the process of discounting. Since the degree of impact will vary in economic terms, irrelevant impacts are identified from impacts that affect the production or utility levels of environmental goods. The impacts are then estimated by isolating project related impacts from trends in background conditions ('with/without analysis') in order to have an accurate picture of the impacts resulting from the project (Hanley and Spash, 1993; Edward-Jones et al., 2000).

A conversion of impacts into monetary terms is then carried out because money is used as the value scale in CBA. Methods to be used are those discussed in Section 4.1. The conversion is done by estimating the monetary value of impacts arising in the future which might differ from the present value. This difference in value is due (*i*) to changes in the prices as a result of genuine shift in value in response to increasing scarcity and other factors and (*ii*) due to inflation. Market prices for goods are also corrected during the conversion process when necessary, so that they represent measures of true scarcity. The need for such price correction (shadow prices) could arise as result of imperfect competition in the market, effect of externalities and government intervention in the market (Edward-Jones et al., 2000). Choices here depend on the (financial or economic) accounting methods which have been discussed in the previous section.

Discounting – The fundamental supposition here is that the estimation of the value of a project, future cost and benefits count for less that the present cost and benefit. Discounting should be done separately from the process of adjusting inflation and should apply to values attributed to future consumption, not future welfare (Laylard and Glaister, 1994; Lumley, 2001). Discounting is done because of the time preference in the form of impatience and uncertainty when considering future goods and the opportunity for generating further benefits that come from having a good now rather than in the future, and because of the productivity of capital in the market due to opportunities in the economy to earn interest on capital when invested (Edward-Jones et al., 2000).

Project assessment is done by using monetary expressions such as Net Present Value (NPV), Internal Rate of Return (IRR) and Distributional Assessment (DA). NPV which is the keystone of CBA, requires that all monetary values be discounted so that benefits and cost arising from the project are all expressed in present value terms. The sum of the discounted benefits minus the sum of the discounted is equal to the NPV of the project. If the NPV is positive, the project represents an efficient shift in resource allocation and an increase of social welfare. IRR is used to discover what discount rate, when applied to the project, would yield a zero NPV for easy comparison of the project's net value with the opportunity cost of

the capital. Distributional weighting (sometimes referred to as social CBA) could be applied to the cost and benefit that have been calculated in order to address inequalities in the distribution of income. This is done my putting higher weight on the cost or benefit affecting lower income groups that those affecting higher income groups (Edward-Jones et al, 2000). This compensates to some extent the fact that the NPV of a project is positive even if the poor become poorer due to the project, as long as the rich become richer to a greater amount.

Sensitivity analysis is done to investigate uncertainties that result from the quantity and quality of physical inputs and output to and from the project, shadow prices for physical inputs and out puts, the value of changes in environmental quality, the appropriate discount rate and use of distributional weightings. During sensitivity analysis, the influence upon NPV of changing the fore mentioned uncertainties are calculated to allow for the estimation of certain critical cost and benefits not covered in the methodology.

Key problems with CBA methodology

It is worth noting that the CBA used to address pollution problems do not address equity issues although it covers all benefits and cost to society since, as said above, it does not say anything about the 'fairness' of distribution of consequences of human activities. A Net Present Value may be positive, for instance, in spite of poor sectors of society becoming even poorer. In fact, in a situation of a significant environmental effects, the poor often bear the cost and the rich enjoy the benefits (Angelsen and Sumaila, 1997; Brent, 1998). Or an ecosystem may be lost because the associated economic loss is counterbalanced by positive impacts on, say, industries. Future generations are a strong case in this respect. Because of the time discounting in CBA, cost accruing to future generations count for virtually zero against cost in the present. Saving cost in the present and rolling them off to future generations pays off heavily in CBA. Thus, CBA is an instrument that intrinsically works against sustainability.

Taking intra and intergenerational equity (Aguilar and Semanchin, 2001; Van der Straaten, 2001) into account is therefore essential for any morally balanced application of CBA. Intra and intergenerational equity is a public good, and markets usually fail to provide the optimal amount of it (Johannsson, 1993). If we define equity as the protection of the weak (e.g. the basic needs of the poor, the intrinsic values of nature or the care for future generations), it is clear that CBA, through its full focus on efficiency, ignores the equity criterion of policy making (De Groot, 1992, 1998; Van der Straaten, 2001). A balanced problem analysis or solution assessment should take care of both. This means intra and intergenerational equity should be addressed in order to decide on a project's feasibility. In 'two-tiered value theory' (De Groot, 1992), this is achieved not by forcing equity criteria into the CBA instrument but by separate political assessment of a project

feasibility in equity terms (sustainability; protection of basic needs; protection of nature) before the economic efficiency assessment though CBA. In OPiC, this idea will return in the form of an 'equity filter' taken up in the framework's evaluation structure (Section 6.3.2).

The following are some other critiques surrounding the use of CBA in dealing with environmental problems (Edward-Jones et al., 2000; Aguilar and Semanchin, 2001; Van der Straaten, 2001):

- The uncertainty with which physical cost and benefits associated with a project can be estimated may be prohibitive, especially in situations where complex ecosystems are affected by a development project.
- The methodology is applied to individual projects and not able to ensure sustainability of the impacts of a group of projects and developments.
- There is problem with the accuracy and acceptability of monetary estimated of impacts and the philosophical implications of these monetary estimates. This is presented in the discussion in section 4.1.2.
- The methodology gives room for institutional partiality since the CBA process can be easily manipulated to serve particular interests by varying the assumption used (system boundaries, project designs, shadow prices etc.) at different stages of the process.

4.5.3 Relevance of CBA in developing countries

Recent environmental economic literature nearly always points out that CBA can be employed as a useful aid in pollution management in developing countries. Its value is mainly seen in the fact that it may help make the real dimension of environmental pollution patently clear to governments and also make polluters aware of the cost arising from their own actions. It will also deal with all aspects of the environment on a rational basis and direct scarce financial resources to those areas of the environment where they are most urgently needed. The problem however is, CBA has only been applied to pollution in developing countries to quite a limited extent due to the time and money they require, methodological problems, political and administrative barriers and ethical reservations.

CBA can be used to develop a local regulatory impact method with a multidisciplinary and intersectoral approach so that all potential measures directed towards local pollution problems are analyzed with focus on the recipients. A local database can be developed as a support to the existing valuation techniques, help check already valuated benefits and increase the general information about CBA and environmental benefits estimation.

Addressing the constraints associated with developing countries discussed in Chapter 3, CBA can play a very important role in legislative and regulatory de-

bates on improving the environment. For instance, it can help illustrate the trade-offs that are inherent in public policy-making as well as make those trade-offs more transparent. It can also help environmental agencies in developing countries set pollution management priorities by helping decision-makers reach a decision. A flexible cost-benefit test would help decision-makers to justify the reasons for their decisions.

In the OPiC framework, CBA is treated as potentially useful but is not as an obligatory element. It may be used as an evaluation tool to access the efficiency of the impact on final values for human beings and the practicality of the norms of the final values for human wellbeing. With that, CBA is only one of the tools that may be used for assessing efficiency. In situations where not all benefits or cost can be easily quantified or where transparency and grip on the assumptions is valued more than are overly sophisticated outputs, more qualitative and mixed descriptions of the pros and cons associated with a contemplated action can be helpful. In such situations the use of the following approaches may be more appropriate:

- *Cost effectiveness Approach* – Cost effectiveness analysis has all the features of CBA, only that it does not require monetization of all costs and benefits. CEA is usually applied if monetary valuation of benefits is not feasible. CEA may be applied to activities and projects for which there is no market and price. It is not able to assess overall efficiency, since it does not tell whether benefits outweigh cost. However, when a decision is taken to undertake an activity anyway, for example to mitigate environmental impacts, cost effectiveness analysis ensures a rational use of financial resources.
- *Multi criteria analysis* – MCA is used to analyze and evaluate pollution problems by assigning weights and standardized scores to the criteria employed. MCA is useful if not all effects can be monetized, and efficiency is not or is only one of the criteria used in the analysis. MCA incorporates non-monetary effects and may account for all types of criteria used. Using MCA to evaluate the effects of activities can be done through quantitative, qualitative and mixed methods, for which advanced software is available.

4.5.3 Illustration of the application of CBA in Tema

Here, I present examples of how CBA is applied or could be used in Tema, Ghana. The examples highlight the parameters that need to be analysed.

- Cost Benefit analysis is used in qualitative way as a component of environmental impact assessment (EIA) to assess the potential negative and positive impact of proposed actions. This helps companies to determine the advisability of a course of action. This implies building on the existing EIA process and system in Ghana.
- According to officials of EPA in Ghana, heavy companies such as Ghanacem, the company producing Portland cement and one of the major polluters in

Tema, are applying CBA to reduce air pollution and improve production processes in their factories. A discount rate of 10% is used to calculate present values and the economic rate of return on their investment. The cost analysis is made up of capital cost and operational cost and benefits relate to the total value of raw material, health improvement, SOx/NOx reduction, personnel turnover, agriculture and forestry, real estate value, soil reduction and tourism receipts. Examples are: raw materials and personnel turnover accrue to the company; forestry and agriculture benefits to the forest owners and farmers; reducing soil and material damage to the communities from where the raw material is collected, and health to workers of the company and residents of Tema, Ghana and West Africa.

- Qualitative CBA could be applied by companies in Ghana to (1) carry out project investment analysis, and take decision regarding funding investment present a clearer demonstration of the development impact of environmental investment, (2) help in developing investment plans, by estimating the returns to specific environmental investments, (3) improve cooperate image and public relations, and (4) help create environmental awareness, providing incentives, justifying environmental regulations and establishing penalties for non-compliance of regulations (2007, pers. comm.).

The above applications of CBA in Ghana show its applicability as an evaluation tool in OPiC, in spite of the scarcity of data and the absence of market transactions for some of the factors. In the context of all tools that OPiC offers, even semi-quantitative and partial CBA may add to the total of understandings and motivations for action.

4.6 Problem-in-Context framework: problem explanation

Explanation is insight in causes. Problem explanation is important because if one desires to solve a pollution problem, it is good to know the causes of the problem. Any change in the causes, e.g. brought about by government regulation or economic incentives, affects the problem. In explaining the relationship between the problem and its causes, the problem needs to be put in its causal context. In this study I refrain from an overview of all possible explanatory strategies that the social sciences may offer. In stead, I focus on the tools supplied by the Problem-in-Context framework (De Groot, 1992). The reasons are largely the same as for PiC's role in the problem analysis: its tools are broadly applicable (e.g. based on broad rational choice), designed to generate practicable solutions in environmental problem situations, and close to common, natural reasoning. Illustrating the latter, PiC's tool of the 'actors field' is basically nothing but a systematic exploration of the common question of 'Who is behind this?' when people search for social causation.

4.6.1 PiC problem explanation summarised

Explaining an environmental problem in the PiC framework implies the contextualisation of the problem in one or more of the following three directions, see Figure 4.10:

- *Normative contextualisation*: Normative contextualisation refers to the justification of the final variable norms that guide the problem analysis. Such norms, implicit or explicit, make choices in terms of human health, biodiversity, economic growth and so on. The question then is: why should the norms be so? This brings the researcher to the field of ethics, foundation of economics, environmental philosophy and sustainability discussions (see Chapter 2). Answers to these questions are not only of interest as a foundation for environmental science but often also quite practical, for the consistency and public legitimization of environmental policies.
- *Ecological contextualisation:* Ecological contextualisation is used to understand why the elements within the environment react they way they do. Here models are used to determine the environmental capacity and the fundamental processes in the environment that are connected to the environmental capacity.
- *Social Contextualisation:* Social contextualisation involves understanding of why people undertake the activities that cause an environmental problem. The structures of the relevant parts are first the activity, the actor field and the culture, environment, and the socio-economic background of actors shown in figure 4.10. Social contextualisation involves actors (defined as social entities with a significant decision capacity regarding activities). The actors make choices on the basis of the alternatives for actions ('options') and the perceived pros and cons of the actions ('motivations'). Due to the great practical importance of especially the social contextualization for the solution of pollution problems, this will be my major focus below.

All the three explanatory routes involve searching wider and deeper step by step, taking into account the relevance of what you are searching. The social contextualisation builds on identifying the direct ('primary', 'proximate') actors behind the problem-relevant activities, identifying the options they have, the motivations attached to the options, and then identify other actors and factors influencing these options and motivations. This process is referred to as 'Action-in-Context' (AiC) within PiC (De Groot, 1992). First, the pollution problem is defined and with that, the activities causing it. Then, actor fields are constructed around these through progressive contextualisation, to help identify the factors and associated actors that lead to the problem. Thus, AiC emphasises the social relations within which resource users are embedded and the effect of the social relations on their actions. The seed notions for AiC stem from Vayda (1983).

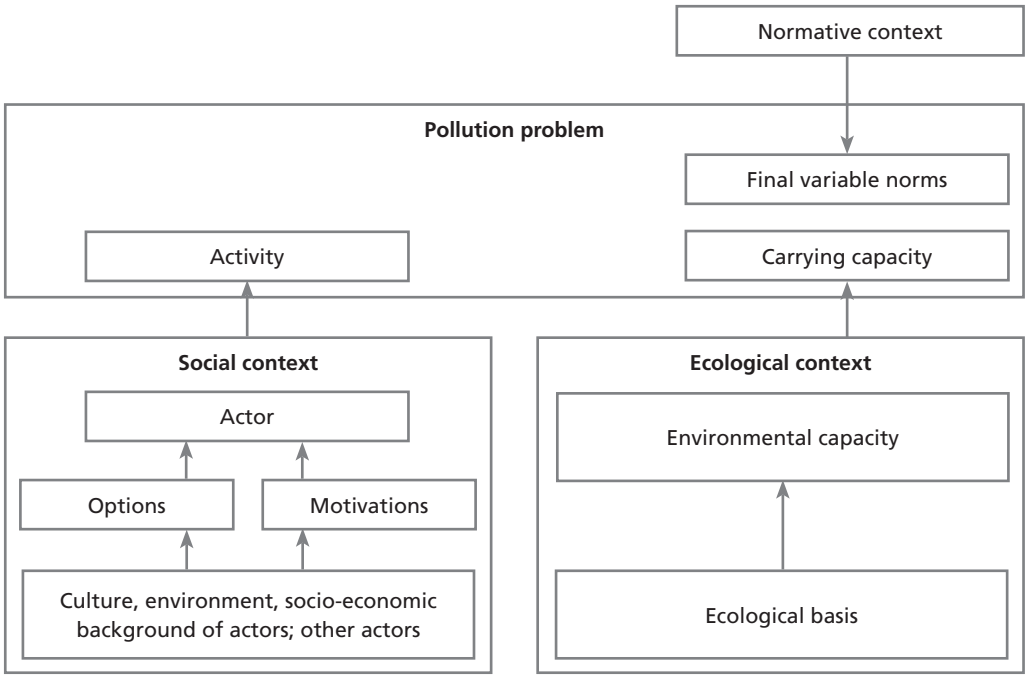


Figure 4.10 ■ Three contexts of the environmental problem, representing three routes of problem explanation, in the Problem-in-Context framework (adapted from de Groot, 1992)

In applying AiC, the participation of actors and victims as participants and partners rather than as subjects and beneficiaries is recommended. This will give multiple perspectives of the actors involved. Much of the relevance for concrete decision-making depends on the quality of participation during the process.

4.6.2 Action-in-Context scheme for social contextualisation

As said, the problem analysis of PiC identifies the actions to be explained by AiC. In the AiC schema, 'actors' refer to both individual people and other social entities that act, individually or collectively with respect to a certain activity. Actors are assumed to make their decisions on the basis of what they are able to do ('options') and the criteria that they apply to these options ('motivations'). Options are formally defined as the list of possible actions that are considered by the actor as being connected with the objective of the actor. Tools that could be used to identify options are observation, common sense and the actor's statements. Motivations are formally defined as what the actor sees to be normatively relevant operational characteristics of the options under consideration (de Groot, 1992). Motivations tell what is important about the options and also show us where the actor places or considers the options when making decisions regarding the activity.

Activities, actors, options and motivations together form the core element of the AiC schema. With this element, searching the causal links between action and context may proceed in two main directions. The first is called the 'actors field' where the same core element is used repeatedly to identify actors that influence the decision of the primary actors. The second direction is called the 'single-actor deeper analysis', representing the linkage which looks at how and to what extent options and motivations of each actor are connected to the culture, environment and social structures in which the actor is embedded (De Groot, 1992, 1998).

With this, Action-in-Context offers a fully actors-based explanation of environmental problems, with social systems, culture etc. functioning as decision-making factors for each involved actor. The advantage of this approach is that it is causally strong, since actors rather than systems are the social units that act, i.e. directly cause change. Moreover, actors-based explanations easily identify relevant actors as for policies and also identify possible policy instruments, as we will see.

The actors field

The actors field principle is illustrated in Figure 4.11. It shows an emission (or any other problematic action) caused by two actors that both make their decisions on the basis the options available to them and the motivations attached to these. Secondary actors are attached to these options of motivations (or both) through actions that affect these options or motivations. Such secondary actors could be, for instance, government agents issuing a levy on pollution by and industry, or an NGO offering agroforestry as a new land use option to farmers. These actions are chosen by the secondary actors on the basis of their own options and motivations, to which in their turn tertiary actors are connected, and so on.

The process of actors field identification reveals actors and factors with different levels of decision making influence on the problem in question. Actors and factors with low influence will usually also have a low relevance to the solution of the problem and that would be a reason to not further search for further reasons of why the actors act the way they do and search for further actors behind them. This depends on the problem at hand and the 'power reach' of the agency doing the analysis, however. For many problems and agencies, a factor such as the fertilizer price, for instance, may be treated as a simple factor to be left as it is but for others, the actors behind this price might be worthy of study, i.e. with the actors field expanded in that direction.

Single-actor deeper analysis

The single-actor deeper analysis schema looks at one actor, focusing on the cultural and structural factors and their interconnectedness as they pertain to each actor in making decisions.

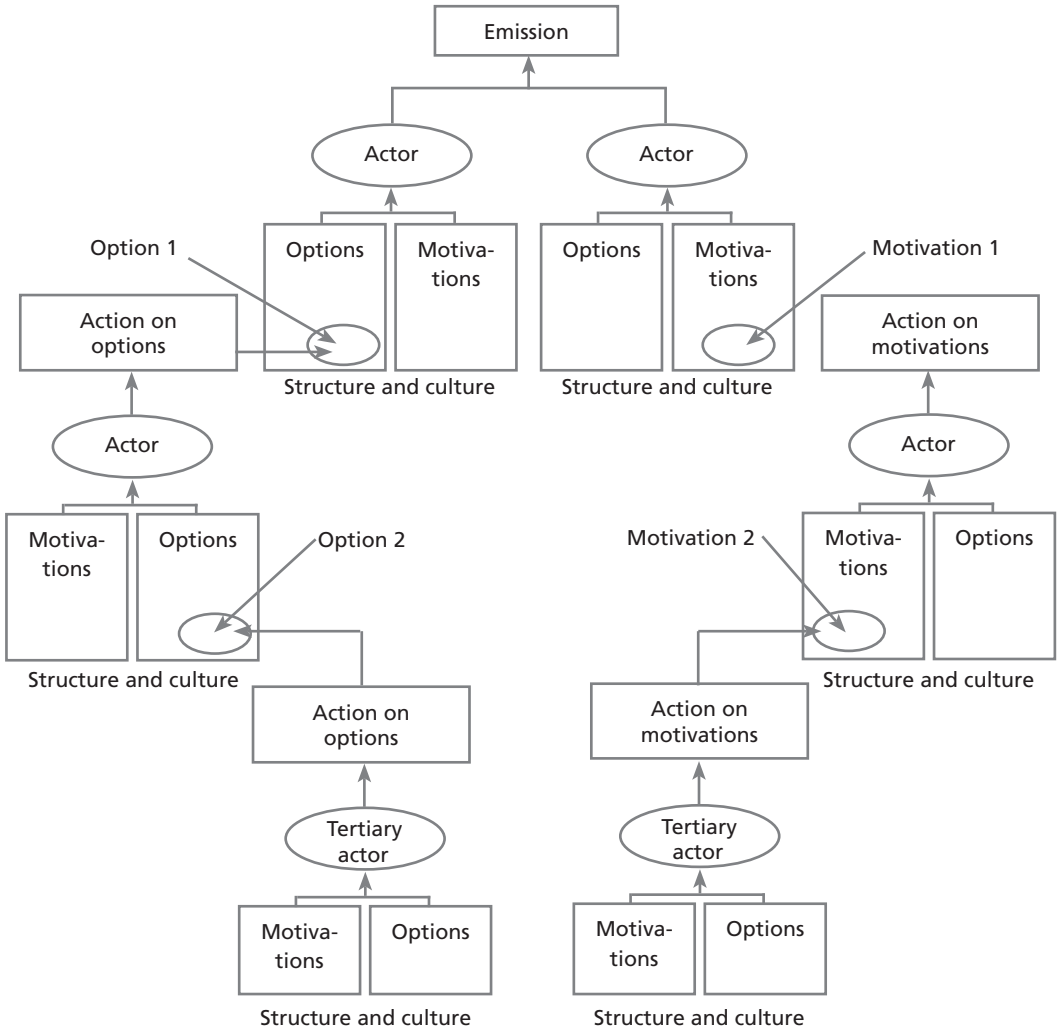


Figure 4.11 ■ An example of actors field with actions, options and motivations of primary actors connected to those of secondary and tertiary actors (adapted from De Groot, 1992)

Actors to do this additional analysis for should logically be the ones that appear to be the most influential in the actors field. Key issues that are considered in the single-actor analysis are, for instance: why did the actor consider only these options and how do the characteristics of the actor's structural and cultural context connect to the activities of the actor? Figure 4.12 presents the single-actor deeper analysis schema of the Action-in-Context framework. In theoretical terms, it could be described as a representation of broad rational choice.

The single-actors schema in addition to analysing effects, activities and actors discussed above looks deeper into to the actor by considering the following issues (De Groot, 1992):

- *Implementable options and motivations as interpreted* – Implementable options are the options the actor can do from the start while motivations here are the advantages and appropriateness of the options (including negative advantages and appropriateness) as interpreted by the actor.
- *Potential options, autonomy, objectified motivations and interpretations* – Potential options are all options known to the actor that the actor might do if he were infinitely resourceful. Autonomy is 'resourcefulness'; it is the degree to which the actor can in fact implement his potential options. Autonomy has two dimensions: the positive dimension stands for all the actor's capitals (economic capital, social capital, cultural capital, access to natural resources etc.), while the negative dimension stands for the restrictions on options, such as legal prohibitions or traditional taboos. Objectified motivations refer to advantages and appropriateness of actions that are easily quantifiable, such as financial costs and benefits, hours of time worked, calories produced and so on. Interpretation refers to cognitive and affective process that gives weight and colour to objectified motivational factors (the pride one can take in profit; the taste of food calories; the gendered appropriateness of what a good man or woman should do).
- *Micro and macro structure and environment, interpretative frames, self image, world views* – Micro and macro structure and environment refers to the social and physical structures that have links with potential options, autonomy of the actor and the objectified motivations. Micro-structures are all those in which the actor himself makes difference; they are distinguished from the macro-structures because actors tend to behave more responsible and reciprocal in such structures. (As the adage goes: actors behave altruistically in the family, reciprocally in the workplace and selfishly on the market.) 'Macro' does not refer here to spatial scale, therefore. Interpretative frames, self-image and world views denotes the patterns underlying the actors' interpretations. They are the way things are seen, the scientific paradigms, the self-image of what it is to be a good farmer, a true man or a responsible business.

An alternative format of analyzing actors can be founded in what is usually called 'stakeholder analysis'. Stakeholders analysis is used especially when a policy has already been basically defined and the focus is on how to this envisaged policy may best be embedded in with least possible resistance in the actors field. Stakeholders analysis is used to generate knowledge about the relevant actors so as to understand their behaviour, intentions, interrelations, agendas, interests, and the influence or resources they have brought – or could bring – to bear on decision-making processes concerning the envisaged policy (Babiuch and Farhar, 1994; Brugha and Varvasovszky, 2000). The analysis include stakeholder characteristics

as knowledge of the policy, the actor's interest related to the policy, their position for or against the policy, potential alliance with other stakeholders, and ability to affect the policy process. These characteristic elements of stakeholder analysis are done through the following eight steps: planning the process; selecting and defining the policy; identifying the key stakeholders; collecting and recording the information; filling the stakeholder table; analysing the stakeholder table and using the information to develop strategies for managing these stakeholders, to facilitate the implementation of specific decisions or organizational objectives, or to understand the policy context and assess the feasibility of future policy directions (Brugha and Varvasovszky, 2000).

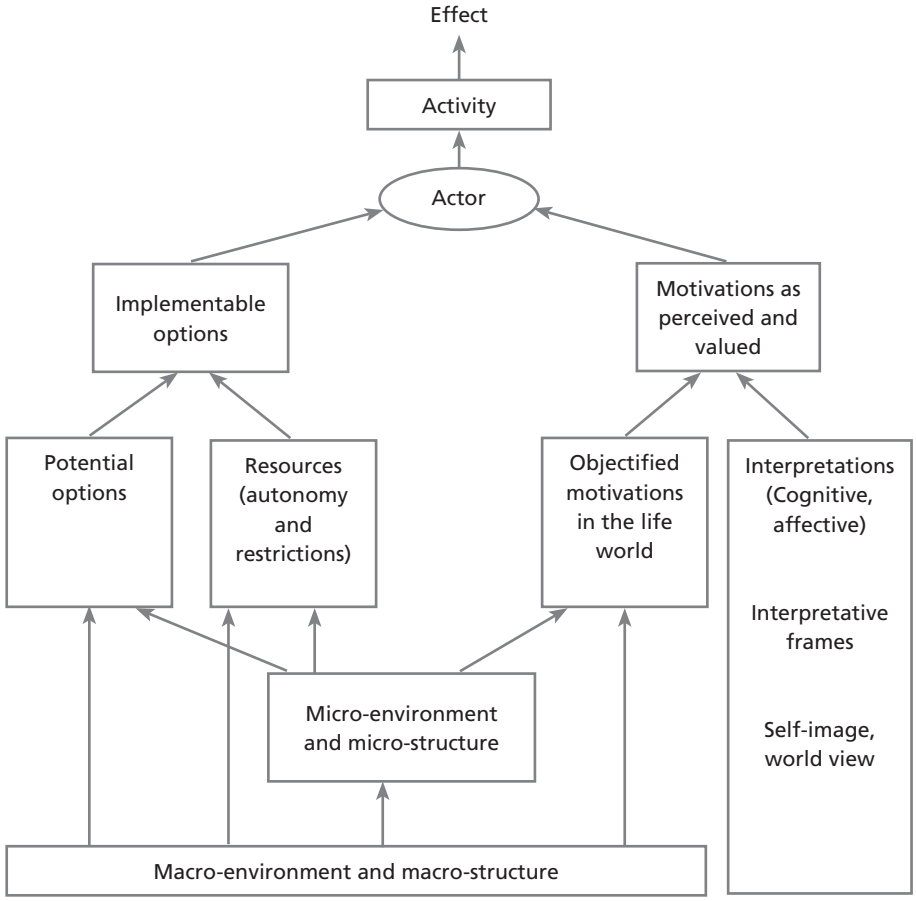


Figure 4.12 ■ The single-actor scheme of the Action-in-Context framework (from de Groot, 1992)

From problem explanation to the design of solutions

An actors-based explanation of an environmental problem through AiC is usually an iterative process but the basic direction is that of contextualisation from the problematic action outward, identifying more actors and factors along the way, paying most attention (e.g. with a deeper analysis) to what seems most relevant. This may be done either by the scientist(s) alone or with the participation of problem actors or problem victims, and anywhere between purely intuitive exploration, via semi-quantitative explanation to sophisticated, computer-aided modelling (e.g. multi-agent modelling).

The cross-over to the design of solutions is conceptually straightforward. All relevant actors in the actors field are potential target groups for policy action, and all relevant options and motivations of these actors are potential leverage points for policy content ('policy instruments' in De Groot, 1992). The limitation remains, however, that all the policy options thus identified remain rigidly connected to the problem. The analysis does not invite more creative thinking to help solve the problem. That is why the presents study adds the element of opportunity identification; see Chapter 5.

4.6.3 Problem explanation illustrated in Tema

In the present section, I present an informal application of the Action-in-Context framework. In analysing the social causes of pollution, one has to explain the actions of actors not based on one's own values and perceptions but that of the actors. For this purpose, I collected information through interviews with actors in Tema, supplemented with literature review. The social causes of the pollution problems in Tema are analysed here based primarily on the actors field principle of AiC.

Industries as primary actors

Industries in Tema are polluting the environment. The major source of pollution is from the oil refinery, food cannery and textile manufacturing. Examples of major industries operating in Tema are Bridal Trust International Paint Company Limited, Super Paper Products Company, Nestle Ghana Limited, West Coast Dyeing Company, Cocoa Processing Company Limited, Aluworks Limited, Ghana Aluminium Products Limited and Wahome Steel Limited. By law, the industries are required to carry out pollution prevention activities. This is hardly done although some of the industries have environmental management plans.

There is a general lack of environmental awareness among employees of industries. Industries interest is concentrated in making profits rather than environmental issues. The uncertainty about the lack of environmental awareness or knowledge makes it difficult to differentiate who does right and does not need to

reduce their pollution, who is misinformed or who is well informed but does not have enough willingness to do something.

Tema Municipality as primary and secondary actor

As a primary actor, the Tema Municipality is a major polluter in terms of noise and organic pollutants in water. For example it is reported that Tema Municipality is responsible for 65% of the BOD in the Chemu Lagoon (EPA, 1998). The underlying cause of communities in Tema polluting the environment is the attitude of people living in Tema. Tema Municipality does not have in place the necessary infrastructure for proper treatment and disposal of domestic waste. The community sewerage treatment plant constructed is not currently used because of technical and social problems. This has made parts of Tema, especially where the low to medium income level people live, full of pollution in the form of visible domestic wastewater discharged to the environment and solid waste disposed off at open places.

As a secondary actor, Tema Municipality does not put pressure on industries to carry out pollution prevention activities. Tema Municipality is a secondary actor because they have been given the mandate to help with pollution management in the municipality, including the influencing of the activities of industries. Other issues such as economic ones are given more attention, however. The municipality is in charge of the economic and non-material welfare of the population, and the authorities frequently see environment and socio-economic issues as two different and separate fields without linkages.

In spite of the fact the Tema municipal assembly has the mandate to management pollution; there are no proper institutional structures in place that will help in carrying out this duty. For instance the environmental department of the municipality is not well staffed with environmental personnel and there are also inadequate logistics and equipment. The municipal Assembly does not have a strong environmental management committee. Other identified causes of the weaknesses of the municipality include the lack of finance support to develop and implement a strategy towards pollution management and the lack of pressure on the municipality by the media, NGOs and the general public.

Ghana Environmental Protection Agency as secondary actor

The Ghana Environmental Protection Agency is responsible for the national environment and the coordinator of all activities relating to the environment, such as to perform monitoring and inspection and to ensure law enforcement in co-operation with other law enforcement agencies, as well as to request co-operation from any governmental ministry or other institutions on behalf of the government. GEPA has not lived up to these expectations in Tema, largely due to capacity ('autonomy') factors such as inadequate funding, exacerbated by overdepend-

ency on foreign funding and expertise. Behind this is the Ghanaian government as tertiary actor that largely presents a lack of political will (motivation) to back up environmental plans and empower GEPA to enforce these.

Pressure groups, NGOs and CBOs as secondary and tertiary actors

NGOs such as religious groups and professional associations as well as community-based organisations (CBOs) are concerned with the promotion of pollution management practices in Tema township. Several of these groups are able to gain easy access to the grassroot level to engage community members in development activities. NGOs and CBOs are secondary actors when they try to influence primary actors and they are tertiary actors when they target motivations (e.g. attitudes) of authorities or help them through building capacity for pollution management, programmes on environmental education and information or, indirectly, through public opinion and the media. In Tema, NGOs and CBOs tend to focus on controlling pollution instead of identifying the causes of the pollution. In practice, even these issues fail to rise to the top of the political agenda, because priority is given to other, more directly developmental issues.

Research and academic institutions as tertiary actors

Research institutions are (tertiary) actors towards the solution of pollution problems because they have professionals from almost all the disciplines that may be needed and also have laboratories and equipment that can be used. They play an active role in the formulation and definition of policies and strategies for the government. For instance, the Science and Technology Policy Research Institute of the Council for Scientific and Industrial Research advices the ministry of Science and Environmental on science and technology policy issues.

Research Institutions actually or potentially working in Tema have not done enough to help manage pollution in the area. One reason is the inadequate co-ordination among the various research institutions. For example the water research institute of the Council for Scientific and Industrial Research is responsible to carry out research in water pollution while the Zoology Department of the University of Ghana is responsible to carry out research on the effect of pollution on wildlife. There is no coordination between the two institutions about sharing of information or exploring the possibility to work together on pollution problems that require their input.

Politicians

The politicians who are part of the ruling government often use their office to bend decisions taken my the Environmental Protection Agency and the Tema Municipal Assembly to be in their favour with regards to polluting the environment and the acquisition of environmental permits for industries (who then pay for the service). In actors field terms, the ruling politicians help supply the pollut-

ing option to the industries. Politicians in the opposition party often act to some degree as watchdogs with regards to how those in power abuse their office.

Ministry of Environment and cooperating ministries as tertiary actors
Issues regards pollution management are dealt with at the strategic level by the Ministry of Environment and cooperation ministries such Ministry of Local Government and Rural Development. These ministries provide technical and financial support to the Ghana Environmental Protection Agency for the development of policies related to the environment and the coordination of environment management activities. Many of the problems associated with this structure are discussed already in Chapter 3.

4.7 Synthesis: framework for pollution problem analysis and explanation

The objective of this study is to develop a framework for pollution management in developing countries based on the analysis of problems and opportunities. In this section I try to put together the different aspects of the tools reviewed and link them together to show how and when they could be used in pollution problem analysis (see figure 4.13).

4.7.1 Choices explained

PiC's problem analysis is taken as template because it is conceptually clear and close to daily life reasoning, hence it can be used well to give structure to participation of all levels of people (local political, experts) in the problem analysis. PiC can be used for qualitative reconnaissance up to fully quantitative levels of problem analysis. Moreover, PiC is comprehensive, covering both the empirical ('facts', 'effects') and normative ('values', 'norms') sides of environmental problems and the full causal chains between human activities and final impacts. Due to that, it embraces and interlinks approaches like environmental impact assessment, life cycle thinking and economic evaluation. With that, PiC gives context and insight for the use (if needed) of such tools.

The functions concept is taken up in the OPiC framework because ecological functions lists such as CPSH+PR use can work well for developing countries, since their use is cheap and not necessarily computerised. Using the functions concept as a prime entry to the environmental problem analysis focuses actors on general needs rather than on their own positions, which enhances creativity and prevents conflicts (Mitchell, 2002). The functions concept also provides a cross-sectoral approach to solving pollution problems by involving all ministries. The function concept can be used to specially to support a systematic problem analy-

sis in complex cases such as regional level environmental analysis and participatory environmental planning. Moreover, ecological functions can also be used to establish Total Economic Value (TEV).

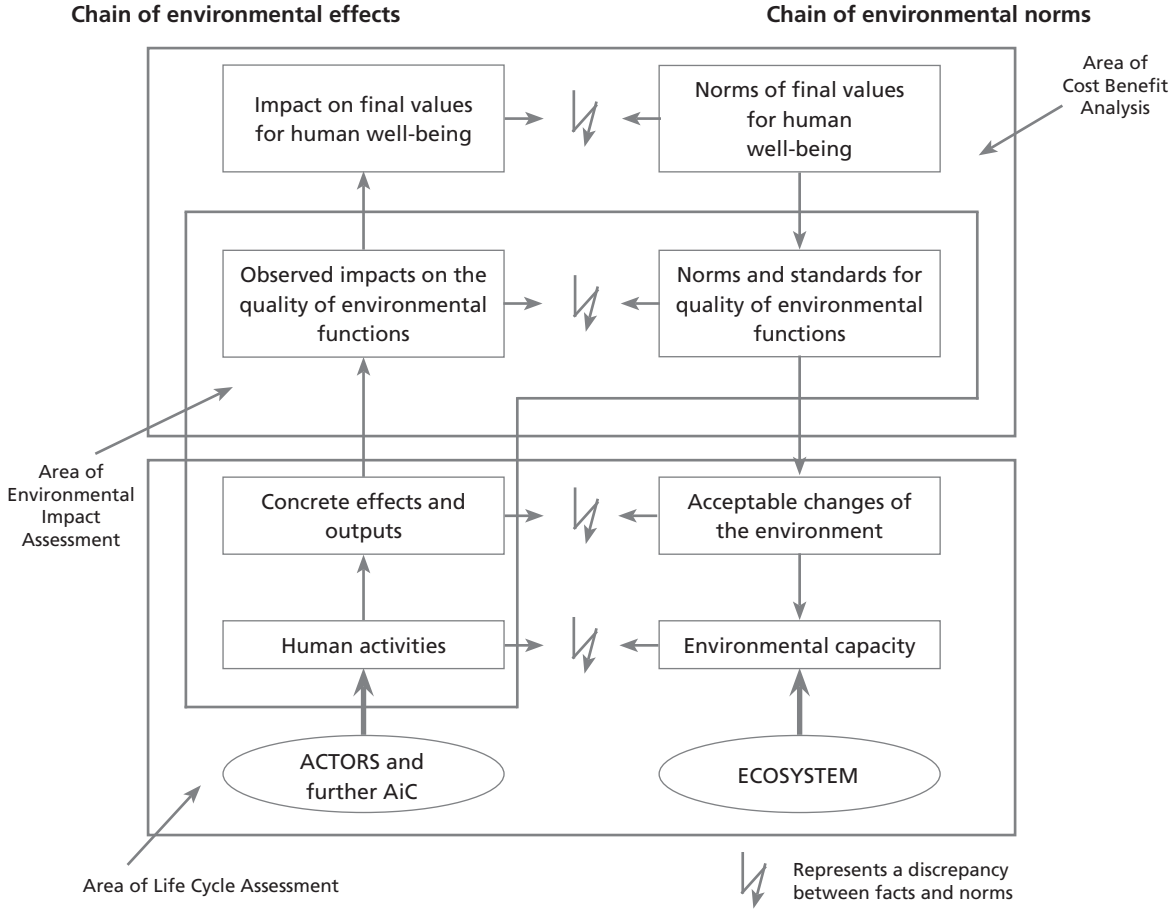


Figure 4.13 ■ Positions of environmental functions, Environmental Impact Assessment, Cost Benefit Analysis, Life Cycle Assessment and Action-in-Context in OPiC problem analysis and explanation.

Qualitative CBA can be used to evaluate the human activities and the expected level of actions that will not affect human well being. The analysis may then be used as the basis to for trade-offs and take a course of actions with the view to not affecting the welfare of human beings

The conceptual structure of LCA thinking is used to expand the 'activity' element in PiC because it gives more detail to this element with a pollution focus, and makes the full life cycle explicit without reducing the freedom of users to narrow down the analysis, e.g. focusing on a specific geographic area. The acceptable

changes of the environment determines the areas or sources of pollution and also give insight in the resilience or carrying capacity of the environment connected to the human activities.

The EIA approach is part of the framework (see Figure 4.13) but not made explicit because it does not deliver anything new on this level. Various specific EIA tools (for examples matrixes) can be used, of course, e.g. to assess the impact of human activities on environmental functions. Actors and stakeholders are are essential issues in EIA because consultation is a key component of the EIA process.

Action-in-Context is explicit in the framework because it is able to give a solution-oriented explanation of problems by focusing on the actors and factors ('drivers') behind the problematic activities. AiC allows but does not require formal study, statistical procedures or models. This makes it easy for actors in developing countries to apply or participate in it.

4.7.2 Framework overview and use

This section summarizes the analytical part of the OPiC framework and how it works to give structure to environmental problem analysis and explanation. Figure 4.14 gives the overview. The section has the following headings: basic structure, the physical context, the activity block, the actor component, and the social context.

The basic structure

When we find pollutants in the environment above the maximum accepted limit, we say there is a pollution problem. In this case there is a discrepancy between facts and values, that is, a discrepancy between what we see happening is or predicted to happen (facts) and what should be the case (values). These discrepancies are the result of a structured and separate analysis of pollution facts and acceptable levels of pollution, with the two expressed in the same terms for easy comparison (example kg of emission or mg/m^3 in soil).

As can be seen in figure 4.14 the facts about pollution problems form the effect chain that runs from the emissions to environmental concentrations ('immissions'; 'ambient concentrations') and decline of environmental functions performance to their impact on 'final variables' of human health, economic and non-economic welfare and biodiversity. Typical elements in pollution issues are, for instance, human exposure to pathogens and chemicals, disease and toxic effects, contamination of food, soil pollution, and odour nuisance. These variables are called 'final' by De Groot (1992) because they are the variables that usually do not require further normative justification and are therefore the logical endpoints of the effect chains. In society; they are the objectives of health, economic, bio-

diversity etc. policies. Studying the effect chains involves biological dose-effect relationship, chemical dispersion models and so on. On the other side of Figure 4.14, it is expressed that every fact has its normative mirror (legal and informal environmental standards and norms, acceptable or desired levels of functions performance and so on). They are interconnected to form the 'norms chains' that run downward from the final variable objectives to acceptable emission levels and further down to 'environmental capacity', defined as the levels of waste, emissions etc. that the environment can handle without adverse consequences. Studying norms chains is called 'norms derivation' because one derives lower-level norms from the higher-level objectives. Doing so, the same knowledge is used as in the effect chains, only in reversed causality. For instance, if a certain level of algae in a lake determines the water transparency and the transparency in turn determines the 'swimmablility' of the lake, then the objective of swimmability determined the transparency standard and that standard in turn determines the acceptable level of algae. With that, the analysis of the structure and severity of the problem depends as much on the political and ethical legitimacy of the standard setter ('normative observer' as De Groot puts it) and the standard setting process as it does on the scientific grounding of the pollution problem facts.

A full problem analysis establishes all relevant facts along the effect chain plus all norms in the same terms, on the relevant level of detail and certainty. This level should be more or less equal over the whole of the analysis; it does not make much sense to spend budgets on detailing one area of the problem field if other empirical or normative areas are blank. The chain of discrepancies (the backbone of the problem, so to speak) depends on values as much as facts; changing norms directly changes a problem. It is therefore possible for an environmental NGO that uses strict standards can define a pollution problem as much more severe than, say, an industry that uses lower standards. In such a situation, an analysis of the degree of certainty and legitimacy of environmental norms can be quite useful to establish a more stable problem analysis.

Being focused primarily on pollution issues, OPiC specifies the human activity in the form of the LCA-based structure that includes the cradle and the grave of industrial products. Analyses focusing on other subjects (e.g. land use) may, of course, use other specifications of human activity. Actors are connected to each activity element, and the Action-in-Context approach (see preceding section) is specified as the methodology to search for the social causes of the environmental problem though concepts such as options, motivations and actors field. Action-in-Context is a multi-purpose scheme. For instance, one can also start out from an event, current situation or proposed intervention, instead of starting out from an environmental problem, and from there, construct the biophysical and social chain of causes and effects leading to these changes (Vayda and Walter, 1999).

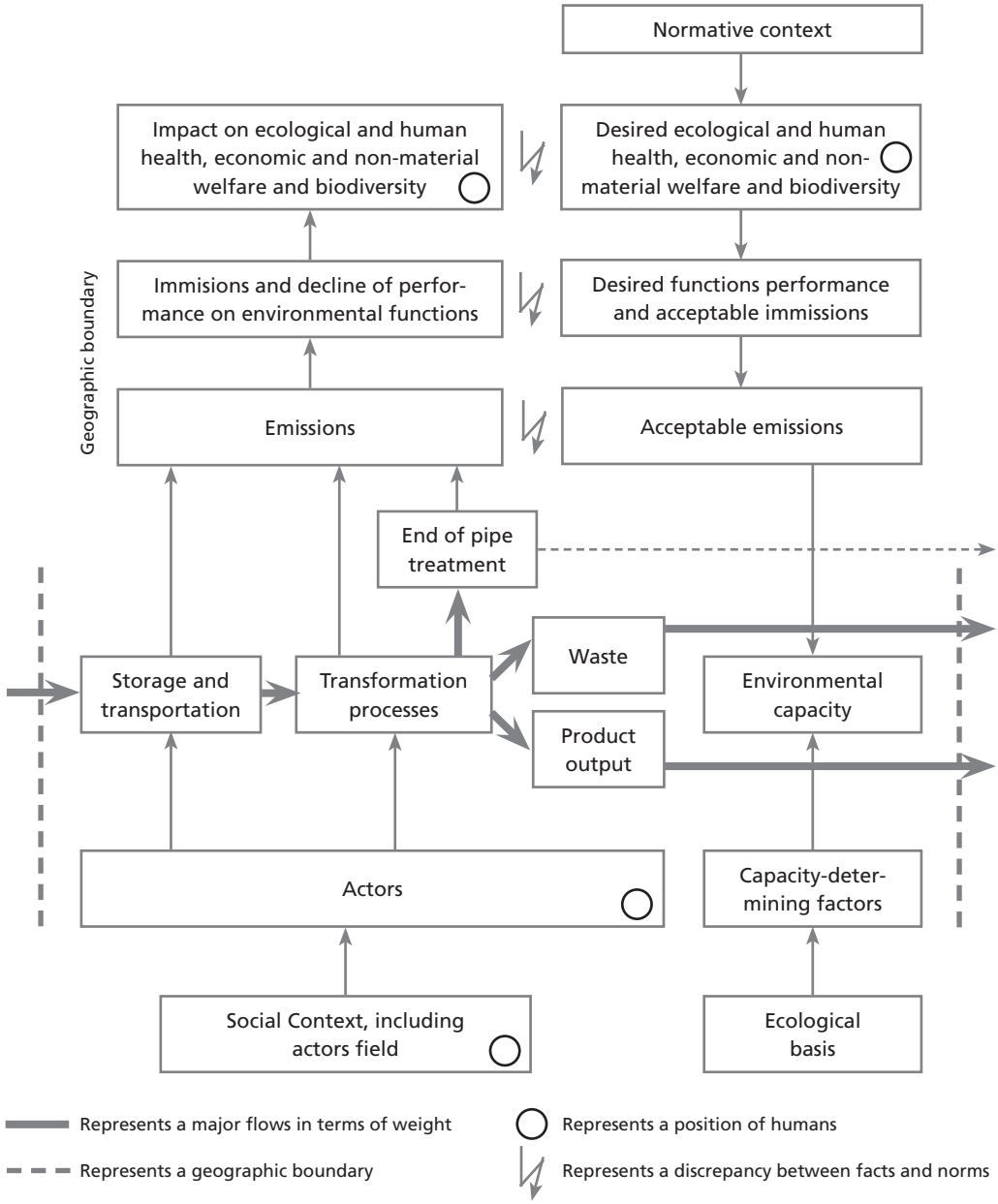


Figure 4.14 ■ The analytical part of OPiC framework for pollution problem analysis and explanation. All arrows except those listed below represent regular causal chains, either of effects (left side) or of norms (right side). Humans are present in the problem analysis in three positions: as actors (primary and indirect) in the south-west corner, as victims ('recipients') in the north-west corner and as norm-setting agents ('normative observers') in the north-east corner.

The comparison of facts and values in terms of the final variables ('impacts' versus 'policy objectives') is usually called evaluation. This is an essential part of many problem analyses, because norms derived from the final variable norm (i.e. norms lower in the norms chain) are usually politically less established. Evaluation may be carried out in the form of Cost-Benefit Analysis (e.g. with contingent valuation and other methods used to translate functions performance in monetary terms), but also Multi-Criteria Analysis may be used with final variables translated into criteria, or any other less formal and possible more participatory method, as long as moral balance is preserved.

Environmental capacity is defined as the normative counterpart of human activities (i.e. a description of what humans should do), derived from the acceptable emissions and the characteristics ('capacity determining factors') of the local environment. If the human activity is specified as a chain of industrial activities as in Figure 4.14, the environmental capacity may be described as the interconnected set of prescriptions on product design, manufacture and waste management, that together give rise to the acceptable (or lower) emissions per pollutant. Life Cycle Assessment thinking is the methodological basis here; see below.

The ecological context

Below the environmental capacity are the 'directly capacity-determining factors' and the ecological basis', which are the fundamental patterns and processes in the local environment. Going into this context helps explain why the environmental capacity is finite. There is therefore often a need to understand the ecosystem in its spatial context and time horizon. This could be done by assessing different areas within the ecosystem that are used for purposes that are consistent with social and ecological goals. The self-renewal capacity of the different areas could be measured using qualitative and quantitative sustainability indicators. This would help determine the potential of the ecosystem to regenerate, the degradation situation of the ecosystem, and to identify areas for effective investment that will protect the environment.

The principles can be made operational by first knowing the historical and current state of the environment such as the ecological processes (economic carrying capacity, levels of acceptable change, the capacity to absorb pollution) and interactions with human activities. Second, because of lack of information and uncertainty surrounding our understanding of environmental functions, precautionary measures in the form of reduced human pressures, maintaining and creating buffer areas, developing monitoring and management systems are important. Good monitoring and flexible management systems enable 'adaptive management' (Gunderson et al., 1995; Roome, 2001).

The human activity

Human activities such as manufacturing, transportation and farming are the main causes of pollution problems. A geographical boundary of these activities could be defined for the area that is being assessed, as Figure 4.14 indicates. I identify storage, transformation processes, and waste and product output as components in the activity block of the activity model. Raw materials that are produced within the defined geographical area should also be assessed while those produced outside should not be assessed. Note that a confinement of the human activities to a certain area does not imply that the same boundary should be used for assessment of the impacts. Human activities may be confined to Tema area, for instance, but the effects of the Tema pollutants may be assessed anywhere that they occur.

The OPiC framework recommends LCA thinking instead of LCA as quantitative assessment system to be used to analyse the human activity in a region of choice. Tools from Environmental Impact Assessment such as dose-effect relationships and matrixes may then be used in a qualitative or (semi-)quantitative manner to assess impacts further on in the effect chain. The following actions adapted from LCA thinking could be applied in the analysis and work towards solutions:

- Actors should observe impacts as a result of product development upstream and downstream in the production chain in the chosen region. Use should be made of criteria such as the types of resources used, types of emissions, reusability, degradability, purchase of resources and utilities, in-house production processes and waste management systems. Also, the life span of the product should be assessed qualitatively within the defined boundary.
- Undertake physical measurements of their products, use of products and the impact of the product through the development of technology or provision of services with the goal to promoting sustainable production processes through more efficient use of resources and the pollution emitted at every stage of the production processes.
- Actors in every stage of the production process within the chosen region should be made responsible for the impact of their activities. This will make every actor in the production process in the chosen region concerned about the impact of the production cycle of the product.
- The effects on human beings should be assessed to see whether it provides the basis for consumers to live an environmentally friendly lifestyle, and whether such information may change the purchase behaviour and lifestyle of consumers with the chosen region.

The social context

For the explanation of the human activities, Action-in-Context may be used as explained in Section 4.6.2. Elements of this framework are the identification of the actors (e.g. industries, consumers or farmers) that directly decide on the activities, the options these actors may choose between and the criteria (motivational

factors) they use to arrive at their choices. From these, the secondary actors may be identified that exert an influence on these options and /or motivations, and the tertiary actors that in turn influences these actions, and so on, thus forming the whole 'actors field' that is involved in the social causation of the polluting activities. Theoretically, Actors field never really end because there will always be a next actor identifiable as influencing the problem. The precise shape an actors field will get therefore depends much on the objectives of the study and the practical reach of control of the commissioning agency, for example whether being academic or government, local or national.

The analysis of social context is a rich source for the identification of target groups and policy options for solving the pollution problem. Stakeholder analysis may be used as a tool to further strengthen this cross-over from social insight to policy design and implementation.

5 Tools for opportunity identification and discovery

As said in Chapter 2, problems also have their flipside, 'the positive problems' as it were, which may be called opportunities. Opportunities comprise all actions that may be taken in order to solve a problem at hand but possibly other connected problems too. In this section, I review tools that can be used for identifying and realising opportunities for environmental management.

Section 5.1 ■ *Options identification based on problem analysis and explanation*

In this section, I discuss how tools such as Problem-in-Context and Life Cycle Assessment, discussed in the preceding chapter, can be used to identify options to solve environmental problems. A conclusion for developing countries is presented and the applicability of analytical tools is illustrated for Tema, in Ghana.

Section 5.2 ■ *Options discovery based on industrial concepts*

The focus of this section is on broad concepts from which opportunities can arise to solve environmental problems, as a source additional to the problem analysis and explanation. Cleaner production, eco-industrial development and dematerialization principles of industrial ecology and process improvement concepts are reviewed, with a focus on sustainable industrial development in developing countries. The relevance of these tools in developing countries is also addressed in the section. Tema is used as case study to show how normative concepts can be applied in the discovery of opportunities.

Section 5.3 ■ *Options discovery based on creativity*

Here, I emphasise the use of participatory incentives that encourage motivation, information sharing and collaborative learning. I then try to explain how positive use of knowledge systems, the concept of creativity, and the concept of dreams could be exploited to identify opportunities to solve pollution problems. The section has some roots in philosophical thinking but it does not seek to give a detailed analysis of the theoretical underpinning of these concepts since that is outside the scope of this study.

Section 5.4 ■ *An enabling context for options discovery*

The context of discovery is very important for successful opportunity identification. In this section, I present other activities and tools such as environmental management systems, environmental accounting tools that in one way or the other contribute to the identification of opportunities, taking into account

their relevance and application in developing countries. I also discuss how self-efficacy is linked to opportunity discovery.

Section 5.5 ■ Synthesis: backbone for opportunity in discovery in OPiC
In the last section, I present the backbone for opportunity identification and discovery. Here I try to link ideas and insights presented in the different sections into a more formal 'mode' or framework. I used the insight gained from the illustrations of tools in Tema to improve the opportunity identification model developed. I also present how and when the different tools should be used in opportunity identification and discovery.

5.1 Options identification based on problem analysis and explanation

5.1.1 Options identification based on OPiC's causal chains

As noted in Chapter 4, OPiC employs on two parallel causal chains in the problem analysis: a chain of facts of human activities, their effects on the environment and the final variable such as health of human beings, and the chain of values which expresses the assertions about the desired state of the final variables, the environment and human activities. Going from the human activities, final variables and environmental capacity standards outward, the chains of causes of the problems are then established, to give the problem's social-scientific, normative and physical-scientific explanation.

Essentially, all steps in all causal chains generate points of leverage for interventions to alleviate or solve the problem (i.e. less fact/value discrepancy in the final variables). Looking at the problem analysis for example, one question may be: how could the allowable pollution towards a lake be increased so that current emissions do not anymore exceeding the acceptable emission standards? Or: what could be the ('end-of-pipe') options to reduce emissions without reducing the causing activities? All options such as construction of treatment plant and preventive measures have to be noted and the resultant options that would be used to solve this problem would come from a list of both simple and multi-level opportunities. And looking at the social-scientific explanation of the problem, one can argue that every actor and every factor influencing the problem-related activity could be influenced, resulting in a change in the problem generating activity. This change may involve all actors identified in the actors field connected to the problem as well as the underlying factors influencing the action of the various actors. For instance, as noted by De Groot (1992), if an actor's motivations are basically environmentally friendly, improving this actor's implementatory capacity may well result in more environmentally friendly activity. Figure 5.1 gives the

overview of options arising from the problem analysis and explanation, which then enter into the activity of the design of plans and policies to solve the problem. (As the Figure shows, there are other ('outside') sources of options too; these are the subject of other sections in the chapter.)

As a technical remark, it may be noted at this point that options identified this way are options for interventions which are different from the options of the used in explaining the actors' choices (see section 4.2). Moreover, interventions should be understood as not only related to government but also to communities and other organisations analyzing their own local problems and aiming to promote ways out of it.

Underneath I give more detail on the options generated by the problem analysis and the social problem explanation, respectively. Table 5.1 gives the overview.

Policy options arising from the problem analysis

Options identified from problem analysis alleviate the problem without changing the problem-causing activity. They are usually physical interventions. This class of options is sometimes the only applicable one, example when an activity has already stopped and only the waste is left. As shown in Table 5.1, these policy options can be categorised into the following five subtypes:

- *Options for interrupting causal chains* in the environment or from the environment to human beings. Causal chains can often be 'broken' in a practicable manner such that ongoing human activities of environmental circumstances have less adverse impacts. One example to isolate waste from surface or ground water flows. A second example is to divert toxic flows away from areas where they do much harm, e.g. as may be done in Tema, leading eutrophicating substances away from the Chemu lagoon. A third example is zoning plans that separate vulnerable communities from pollution sources.
- *Options for integrated ecosystem restoration and management* are based on the concept of ecosystems as interconnected bundles of causal linkages, including feedback. Integrated ecosystem restoration and management looks at these interconnected causal chains and picks out a number of key targets for most effective intervention. One example is to combine the reduction of eutrophicating emissions to a lake and combine that with the removal of whitefish from the lake. This results in a increase of macrofauna that eat away the algae, thus preventing that the lake would remain stuck in a eutrophic equilibrium state. In a shallow lagoon such as Tema, such measures could be combined with the dredging of sediments in the Chemu lagoon.
- *Options for reducing environmental burden,* focusing on the connection between human activities and emissions.
- *Options for increasing environmental capacity,* which aim to make the environment more robust to handle emissions or exploitation. Like the farmer who

applies manure so that the soil is more robust against the extraction of nutrients, the environmental manager may help the environment to better handle acidification, pollution etc.

The analysis and explanation of pollution problems can be a participatory process, thereby creating a broad basis for the identification of opportunities. For instance, industrial actors in Tema would be able to add their knowledge of toxic chemicals used in their production processes, the quantities used and possibly about their potential effects. Involving these actors along with NGOs and communities would help to create consensus rather than conflict.

The ecological context could also serve as a source of identifying opportunities. For instance, knowing the human carrying capacity in the form of the maximum number of people that may make a sustainable living off the land with acceptable income and space for biodiversity could help identify if technology changes such as agricultural intensification are necessary. In such cases, knowledge on the factors that determine this capacity (e.g. the soils), would also help to define what opportunities for such intensification would exist.

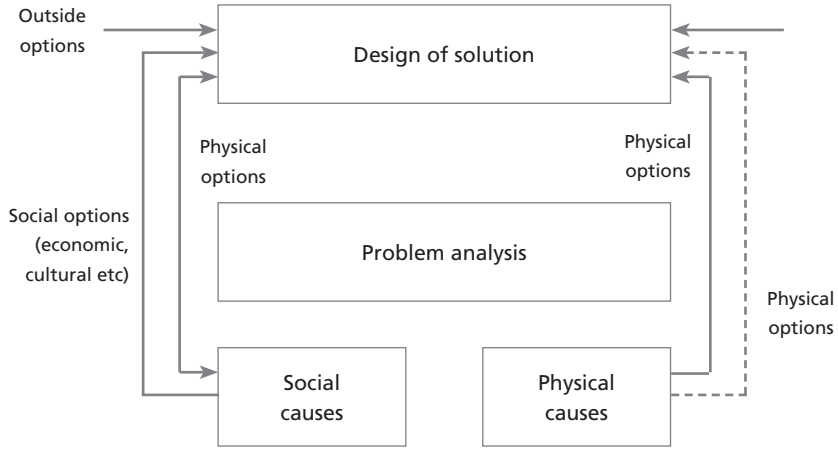


Figure 5.1 ■ Options for solutions arising from the problem analysis and explanation (adapted from De Groot, 1992)

Policy options directed at the actors' options

Actors face certain limitations of choice. Relaxing or tightening these limitations of the actors' options is a next class of options to alleviate pollution problems. De Groot (1998) identifies two main types of policy options that are directed at the actor's options.

- The first subtype focuses on increasing the number of options that actors know and can implement. This class of policy options include environmentally friendly research and demonstration projects to make new options available

to industries or households (for example waste recycling equipment), credit schemes and other support to help industries to implement options that they are technically able to carry out, including to help organise collective action of industries. As an example of the letter, industries in Tema could be supported to re-use waste flows of each other or share a common wastewater purification unit.

- The second subtype focuses on restricting rather than increasing the range of implementable options of the actors. Direct regulation tools such as prohibitions, standards and conditions for licences and assigning of quotas are the main types of policy options here.

Policy options directed at the actors' material motivations

Motivations of actors concern both short-term and long-term benefits, investments and risk that the actor will derive from undertaking a particular activity. Two main subtypes are identified here (De Groot, 1998):

- First, options working through the actors' contextual macrostructure – these policy options deal with financial and juridical internalization of externalities. Financial internalization options that falls under this category are levies, subsidies and deposit-refund mechanisms and tax reform such as green tax. One example is the imposition of taxes on activities that causes serious environmental problems so that actors' would change their attitude. With this option, the actors are motivated for new designs of products, improvement in production process and regulation on pollutants in the environment. A detailed discussion of the different type of financial internalisation options is presented is section 6.2. Juridical liability is another type of options here, standing for all legal activities that aim at security of activities preventing environmental damage that will affect other present or future actors (that is, sanctions against 'downstream' pollution). On the other hand, environmental investment security is aiming to reduce risk for actors investing in pollution prevention.
- Second, options working through the actors' contextual microstructure – these policy options relate to the more personal relationships between actors among each other and with the environment. These options such as partnerships, participation, information sharing and negotiation could be used to articulate, and attend to, new forms of pluralism in the management of environmental problems. In this way, attitudes focused only on short-term benefits and reluctant environmental compliance may be changed into more pro-active and caring relationships with environment and community. Moreover, actors may discover ways to deal with local environmental by making it their joint 'property' and solving it through collective action.

Table 5.1 ■ Type of policy options based on OPiC's problem analysis and explanation (adapted from DeGroot, 1998)

Type of options	Features
Options identified in problem analysis and explanation	■ Actions such planting trees against erosion and using lime against acidification to increase environmental capacity ■ Integrated ecosystem restoration and management actions. ■ Other actions that interrupt causal linkages between human activities and impacts on human health, biodiversity and other final variables, such as waste treatment and diversion of toxic flows.
Options directed at the actors' options	■ Increasing the number of potential options by undertaking opportunity-oriented research and extension ■ Undertake actions that increase the implementation capacity of actors through the provision of economic, social, environmental, moral, organisational and physical resources ■ Reduce the implementation capacity of actors through the use of direct regulations
Options directed at the actors' material motivations	■ Financial and juridical internalisation through the use of price mechanisms, juridical liability and environmental investment security ■ Social internalisation through decentralisation, partnership, participation, Information sharing and negotiation with actors with varying views ■ Establish environmental problems as a common property
Options directed at the actors' culture	■ Environmental information and education on the causes and impacts of environmental problems ■ Present the beauty of nature and the environment and ways through which old and young generations preserve the ecosystem ■ Support the spread of an environmental ethic views and practices

Writing in the social psychology tradition, Kilvington and Allen (2001) have proposed a scheme of the causation of an actor's intention to undertake environmental management. It is reproduced in Figure 5.2.

The figure shows that the following are key issues that determine an actor's motivation for environmental management:

- How much importance the actor places on environmental management; this is influenced by: incentives, understanding the problem, perception of the risk, sense of community responsibility, pride in environmental management and priority of environmental management against competing tasks.
- The nature of the available methods for environmental management methods; this is influences by factors such as cost, time involvement, relative simplicity, ease of measuring the success and the acceptability of the method.
- The actor's intention to undertake environmental management will be influenced by the preceding plus by the extent of peer involvement and the attitude of those close to them, the support of social norms and the extent to which the actor perceives the environmental issue is significant to the community.

Kilvington and Allen's (2001) 'nature of available methods' largely coincides with the 'objectified motivations' of environmentally friendly options in OPiC's sin-

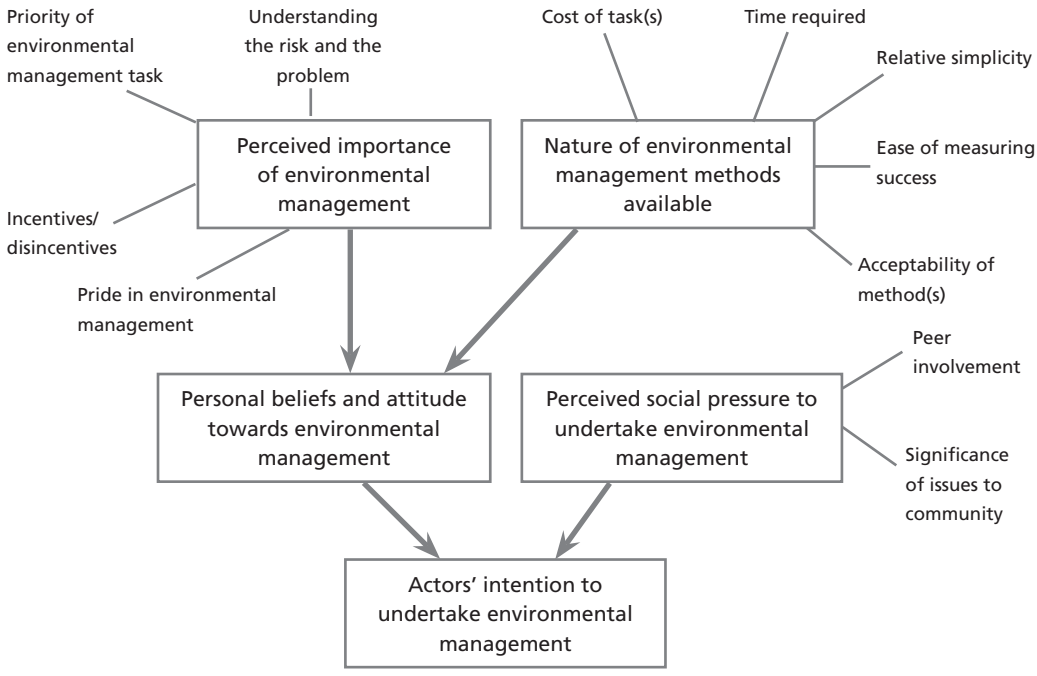


Figure 5.2 ■ Illustration of factors affecting actors' motivation for environmental management (adapted from Kilvington and Allen, 2001)

gle-actor scheme (Figure 4.14). Kilvington and Allen do not pay attention to the potential options and autonomy factors. Figure 5.2 does supply, however, a wide array of factors that make up OPiC's 'frames' and 'interpretations' such as social norms and sense of community. Consequently, the policy options that may be based on Figure 5.2 (such as the strengthening of social norms and strengthening the ties between actor and community) may be regarded as a good specification of OPiC's general policy option directed at the actor's culture.

As said in the preceding chapter, the behaviour of people is contextual, i.e. dependent on the social context. This implies that also in the search for policy options to change problematic (pollution) behaviour, it is important to develop a supportive environment through the creation of links between people which will allow information and learning to occur across social networks.

5.1.2 Options identification based on OPiC's product chain

The product chain is OPiC's expansion of the 'activity' element of PiC – see Figure 4.14. Based on the preceding chapter, this section presents Extended Producer Responsibility and product improvement analysis as two main approaches to identify options for solutions, rooted in life cycle thinking.

Extended Producer/Product Responsibility (EPR)

Extended Producer Responsibility (EPR) was first used and defined by Lindhqvist in a report for the Swedish Ministry of the Environment and Natural Resources in 1990. The English definition reads as follows (Lindhqvist, 1992): 'Extended Producer Responsibility is an environmental protection strategy to reach an environmental objective of a decreased total environmental impact from a product, by making the manufacturer of the product responsible for the entire life-cycle of the product especially for the take-back, recycling and final disposal of the product. The Extended Producer Responsibility is implemented through administrative, economic and informative instruments. The composition of these instruments determines the precise form of the EPR'.

The concept emerged as a result of prioritization of preventive measures and a shift to non-prescriptive policies that include incentive mechanisms for actors to continuously improve their production activities. The principal rationale for allocating responsibility to producers is their power to create changes through the procurement of source materials of the products or services that they manufacture and usually their capacity to reduce environmental risks after take-back of the used product (Davis, 1998). Responsibility over the entire life cycle then creates incentives to the producer to minimize effects over the entire life cycle, thereby enhancing environmental efficiency (Lindhqvist and Lifest, 1997). Some authors such as VROM (1998) and Shoita (1999) tend to confine the focus of EPR on waste management. This understanding reflects the present application of the concept. Others find that EPR should guide policy design over the entire life cycle (Davis, 1998; Lindhqvist, 2000: Kroepelien, 2000; Tojo, 2001; De Tilly, 2004); the ultimate aim of EPR then is the promotion of sustainable production-consumption systems.

The range of responsibilities allocated to producers varies between EPR programmes. Lindhqvist (1992, 1998) has categorised the types of responsibilities into the following, as also shown in Figure 5.3

- *Liability* refers to a financial responsibility for proven environmental damages caused by the product in question. The extent of the liability is determined by legislation and may embrace different parts of the life-cycle of the product, including usage and final disposal.
- *Economic responsibility* means that the producer will cover all or part of the costs for the collection, recycling or final disposal of products. These costs could be paid directly by the producer or by a special fee.
- *Physical responsibility* implies that the manufacturer is involved in the actual physical management of the product, use of the product or of the effect and impacts of the product through the development of technology or provision of services.

- The manufacturer may also retain the *ownership* of his product throughout its life cycle (e.g. by leasing it out in lieu of selling it) and consequently also be linked to the environmental problems caused by the product.
- *Informative responsibility* signifies several possibilities to extend responsibility for the products by requiring the producers to supply information on the environmental properties of the products and its effect during various stages of its life cycles.

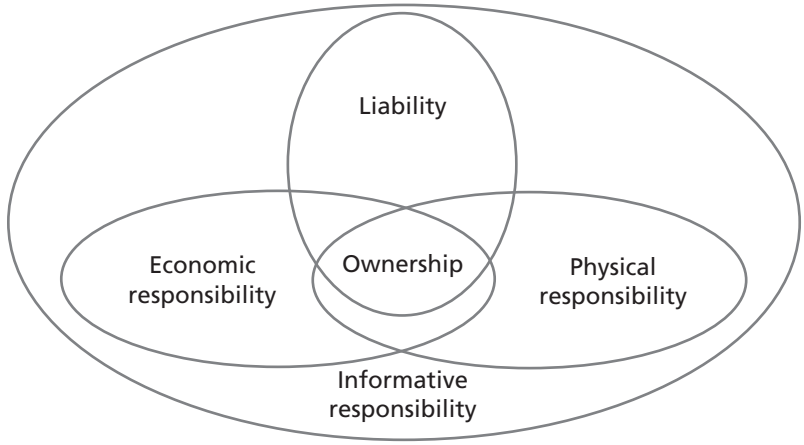


Figure 5.3 ■ Types of Extended Producer Responsibility. (Adopted from Lindhqvist, 1992)

The aforementioned responsibilities can be implemented through the following types of tools:

- *Administrative tools* such as obligations regarding the collection and/or take-back of discarded products, landfill and other discarding options, reuse and recycling, environmentally sound treatment standards and so on.
- *Economic tools* such as material/product taxes, subsidies, advance disposal fee systems, deposit-refund systems, upstream combined tax/subsidies and tradable recycling credits.
- *Informative tools* such as reporting to authorities, labelling of products and components, consultation with local governments about the collection network, information provision to consumers about producer responsibility/source separation, and information provision to recyclers about the structure and substances used in products.

In all this, EPR does not necessarily prescribe technologies and because of that, EPR allows flexibility of producers in achieving environmental goals, thus encouraging efficiency and innovation. A further discussion of these tools is presented in section 6.1.

Improvement analysis in LCA

The improvement phase of LCA involves finding ways to reduce environmental impacts of the product under study (CSA, 1994) such as pollution prevention, reduction of energy and resource use and maximisation of the use of sustainable resources and energy through product development and process improvement. It proceeds through a systematic evaluation of the quantitative and qualitative needs and opportunities to reduce the environmental impacts throughout the life cycle of a product, for example, by redesigning it with more environmentally friendly component materials.

Before improvement analysis is undertaken, good interpretations of the results of life cycle inventory and life cycle impact assessments are necessary, for example by following the steps below:

- *Consistency and completeness check* – Here, assumptions, methods and data are checked to see whether they are consistent with the goal and scope of the LCA study. It is done for the product under study and the products are compared. The compatibility of the methods, models and assumptions is done with the goal that it is necessary to check the completeness of the LCA. This could be done by peer review and by comparing the study to similar ones (Fiksel, 1996).
- *Sensitivity and uncertainty analysis* – Here, the accuracy and the uncertainties in the results and how sensitive the results are to uncertainty is also determined. This helps to determine how robust a product analysis is (Wenzel, 1998; Chen and McRae, 2003).
- *Contribution analysis* – Here, the contribution of various components of the LCA is analysed. The results from the contribution analysis are used to determine which intervention can best be changed in order to reduce environmental problems in the production system. This type of intervention can be identified if all linkages among the different process are covered (Wenzel, 1998; Guinée, 2002).

Although LCA has traditionally been oriented towards improving the environmental performance of products, LCA can also be applied to processes for the selection of the best environmental practices and technologies and for the optimization of the environmental performance of existing processes (Azapagic, 1999). LCA applied to processes normally excludes product use, recycling and waste disposal. Such LCA provides the manufacturer with insights in significant environmental performance issues that are addressed through improvement and innovation of processes, for example, through the application of cleaner production and eco-efficiency tools (Van Baerkel, 2000).

Normally, options from improvement analysis that are useful for solving pollution problems focus on the following (Frank et al., 2000):

- *Material selection* – These options are concerned with materials that are cost-effective, have high performance and are of a quality with respect to the amount of hazardous waste produced over the product life cycle. The options are identified as a result of looking at the possibility of using both recyclable and virgin items, and reintroducing the material at the end of the cycle into in the same product stream as raw material into new product streams.
- *Manufacturing processes* – Options from this analysis are concerned with reducing energy consumption while minimizing waste within different processes. The options are identified by monitoring the inputs and outputs of the process.
- *Consumer utilization* – Here options are identified because of analysing the environmental impacts during use of the product.
- *Material recovery analysis* – Options are identified by taking into consideration the possibility of designing for recycle, remanufacturing and reuse of components or subassemblies. The idea is to liberate components more easily at the end of the product life.

These options found by improvement analysis are either direct options or indirect options. Direct options are those generated because of undertaking the foreground processes required to produce a particular product. Indirect options are those arising from background processes by assessing the possibility of reduction of resource requirement to the foreground processes.

Eco-design is a product-oriented option that takes much from LCA improvement analysis but aims to take a deeper view, designing new products rather than improving existing ones, applying environmental criteria. Eco-design may sometimes focus on the waste disposal stage of products but usually it aims at environmentally optimal products throughout their life cycle. The latter approach integrates aspects of societal needs, local technologies and skills and local natural conditions in order to fulfil elementary needs, better quality of life and environmental harmony (Van Weenen, 1997). Ecodesign may therefore result in fully new ways to fulfil existing functions, e.g. packaging in palm leaves rather than plastic or paper.

5.1.3 A conclusion for developing countries

Option identification based on OPiC's causal chains

Criteria for the relevance of options for developing countries have been developed in Section 3.3. It follows from that section that options of special interest to developing countries are low-cost and use available technologies and skills. Moreover, options should be preferred that may create synergies with local economic development. A clean-up of waste, for instance, could aim to employ local labour in stead of foreign machinery, and then try less to get to the last toxic molecule

but rather to create an area that may be used again for local development, e.g. for new industry or the creation of a park that enhances local quality of life or local prestige.

In contexts of poverty and weak development of regulatory structures, options directed at the actors' material motivations may turn out to be of special relevance. A deposit-refund system for waste materials, for instance, may invite spontaneous responses of waste collectors at low refund rates already.

Information levels and especially the sharing of available information may often be on a quite low level. Options for research, communication and education (including those about local traditions) may therefore show to be of great value without great cost. Such actions may easily be combined with the enhancing of the implementation capacity of actors, e.g. through credit schemes or the stimulus of collective action partnerships.

The actors field element of OPiC, describing as it does how primary and indirect actors hang together in the causation of environmentally problematic actions, can be used to identify target groups for government policies, but also as a social backbone for platforms that may also include NGOs, CBOs, local government, academic institutions and environmental agencies (see Section 4.6). The opportunities resulting from OPiC may then be identified by a joint inquiry of these stakeholders. In an under-institutionalized context such as often prevailing in developing countries, a joint enquiry approach moreover builds trust and networks that may greatly enhance the social capital available for collective action and the co-management of the environment through joint action of government and local actors. Finally, a joint problem analysis and options identification lays a basis for successful implementation, because the more people have had their voice heard in the analysis, the more they are likely to accept the changes that may be required of them.

Option identification based on OPiC's product chain

Extended producer responsibility (EPR) could become a vital tool for waste management in developing countries. This is because an EPR programme will help to reduce the financial and physical burdens upon waste management authorities. The adoption of EPR will involve the private sector in waste management and would increase the efficiency of waste management practices such as better logistic for transportation of waste. The demand for separation and recycling that goes with the introduction EPR may also induce the development of separation and recycling technology in developing countries. This may lead to a reduction in waste generation and also create a wider demand and supply for second-hand products there by transferring the cost associated with end-of-life management of the product to the beneficiary instead of leaving the burden to tax payers. Moreover, EPR will work 'upstream' in the product chain, up to the point that producers

in developing counties could introduce not only product improvement but also more fundamental eco-design in their commercial strategies. Eco-design would appear to have a good potential in de developing countries because industrial products have their usual source in the North, with quite different natural and social factors built into their design.

LCA-based improvement analysis of products addresses both the demand and supply side of the economic equation (Jansen, 1995). As said already, looking at the possibilities for improvement analysis in developing countries, rediscovery of local raw materials and the upgrading of indigenous and existing processing technologies would appear to provide many new opportunities. According to El-Mosley (1997), the discovery of local raw materials means imagining, thinking, designing, carrying out research and producing indicates that in principle, ideas and technologies from developed countries can be combined with those of developing countries to improve product development prospects.

For an effective application of life cycle thinking in developing countries there is a need to address not only the engineering aspects of LCA but also the social, institutional and political preconditions. This implies the development of a realistic and concrete life cycle based environmental policy to direct initiatives and the organisation of actors to survey existing knowledge and build institutions.

5.1.4 Applying analytical tools to identify opportunities in Tema

The preceding chapter has provided an OPiC-style problem analysis and explanation of the pollution of Chemu lagoon and its actors in Tema, and a product chain of paper in Tema. In this section, I use these to exemplify some specific opportunities that exist in Tema.

The following are some of the typical and relatively innovative opportunities that exist in Tema. (see also Table 5.2):

- Industries in Tema could explore the possibility of using local materials in production and also make available to the public environmental information about their products and processes and ensure policy design to address pollution issues are participatory.
- There is the opportunity for the transfer environmentally friendly technologies to industries in Tema. This is due to the fact that some of the industries in Tema have links with industries in the developed world. Mother corporations could also help in the environmentally friendly re-design of products and processes, e.g. through the secondment of design engineers and process managers.
- Many economic and social policy options exist, such as low-cost deposit-refund systems and making visible the consequences of environmental prob-

Table 5.2 ■ Actors and opportunities available for the development of solutions in Tema.

ACtors	Opportunities for solution
Industries	Improve upon their institutional arrangements to take mutual advantage of the variety of industries to manage the pollution problem in the lagoon. Research into the re-design of products.
Tema Community	Organise forum to protect against the pollution of the lagoon by industries. Form a monitoring team to monitor the activities and pollutant release by industries in the environs of Chemu lagoon. Demand participation in the development of further plans.
Pressure groups (NGOs, CBOs etc.)	Educate people and industries on the importance of clean environment and the economic benefits associated with environmentally friendly production. Support formation of an information and action platform.
EPA	Develop policies that would bring actors polluting the lagoon to bear the environmental impact of their activities. Some of these policies are imposing taxes on actors that pollute the lagoon so that they are encouraged to undertake environmentally sound production processes. Actions such as removal of subsidies on unsustainable activities, regulations to promote energy efficiency, investment incentives to encourage eco-efficiency, adjustment measures for sensitive sectors (e.g. energy), and information campaigns should be undertaken to realize opportunities. Support the industries to apply for support from their mother corporations and global organisations.
Tema Municipality	Develop municipal level legislations and policies to stimulate pollution management and control of the lagoon aimed at environmental and economic benefit of the lagoon. Take steps to acquire assistance from the government and donor agencies to undertake restoration of the lagoon to that people who depend on the lagoon for their source of livelihood and industries that uses it as their sink. Support new national policy statement and approaches that are geared towards the promotion of civil society and traditional institutions in environmental management.
Research institutions	Carry out research into the physical and social causes of the pollution problem of the Chemu Lagoon and propose cost-effective and innovative ways of dealing with the problem.

lems created by different actors in Tema. It will also help to show the potential beauty and economic potential of a restored lagoon; this will stimulate NGOs and CBOs to work and harness social opportunities in Tema.

- With the presence of the Environmental Protection Agency in Tema, there is the opportunity for the effective implementation of many options in the area.

5.2 Option discovery based on industrial concepts

In this section I discuss how opportunities can be identified taking the concepts of cleaner production and industrial ecology as a source of inspiration. Some of these options will overlap with those identified in the preceding section but that

is not my worry here, because of the importance to reach an exhaustive array of opportunities.

5.2.1 Options based on 'Cleaner Production'

The term of cleaner production (CP) is used here to refer to process-oriented (rather than product-oriented) pollution prevention, waste minimization and eco-efficiency. My reason to include all these elements is that, although they have slight variations in terms of terminologies and approaches, the core element of all these concepts is the shift of emphasis from how to treat waste to how to reduce and eliminate waste at the source. This is essentially equivalent to maximizing resource productivity at the firm level, taking into account scarce environmental resources as well as energy and raw materials, rather than simply minimizing pollution associated with a given product (Ayres and Leynseele, 1997).

The official and worldwide recognition of cleaner production has been achieved through a number of national and global projects. The UNEP Industry and Environment Programme and the UNEP/UNIDO National Cleaner Production Centre Network are two examples. UNEP/UNIDO defines cleaner production as 'the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase eco-efficiency and reduce the risk to humans and the environment. For processes, CP includes conserving raw materials, energy, eliminating toxic raw material and reducing the quantity and toxicity of all emissions and waste. For products, CP involves reducing the negative impacts along the life cycle of a product, from raw materials extraction to its ultimate disposal. For services, the strategy focuses on incorporating environmental concerns into designing and delivering services' (UNIDO, 1999). Consequently, a holistic and multidisciplinary approach has been taken in which engineering, management and other competence areas are used in a mix to find the most effective solution to pollution problems (Strahl, 1996).

The central tool used in cleaner production is the Cleaner Production Assessment framework. The basic reference is the US EPA Waste Minimization Opportunity Assessment Manual from 1988, which describes the cleaner production assessment procedure or waste minimization opportunity assessment procedure (US EPA, 1988). The assessment procedure describes the essential elements and steps to be undertaken at the company level as:

- Planning and organizational phase – This is where the need to reduce waste is recognized and commitment from management sought. Overall assessment goals are set and assessment programme task forces organized.
- Assessment phase – Here, process and facility data are collected and prioritized to select assessment targets. Stakeholders for the assessment teams are

selected. Sites are inspected and data reviewed to generate, screen and select options for further study.
- Feasibility analysis phase – In this phase the options selected are evaluated technically and economically to select suitable options for implementation.
- Implementation phase – This is when projects are justified and funding obtained in order to install equipment and implement procedures. When projects that are not implemented, assessments are carried out to select new targets and previous options re-evaluated.

The key elements of the cleaner production assessment lie in the analysis of the processes. A good analysis of the inefficiencies and their root causes makes many improvement options visible and obvious and includes:
- Characterizing the process steps by using flow diagrams, which show the interrelations between parts of the process and also identifying sub-parts that need closer investigation. This requires a thorough understanding of energy and material flow in the process.
- A root cause analysis technique is used to identify and structure the causes of pollution problems. The basic diagram used which consists of four root causes of pollution includes the methods, machines, people and material**.** The root cause analysis technique illustrates that causes are not only technical; there exists a variety of causes for a problem.
- The generation of options for environmental improvement is the overall objective of this analysis. This is easy if previous steps have been performed even though the methodology varies with the type of improvements. More substantial changes in the processes may require a closer analysis of the operation.

A multidisciplinary preventive strategy, involving training, education and design, faces the risk of losing out to more tangible solutions. Furthermore, a multidisciplinary preventive strategy having a broader focus than production processes must come to include not only technological systems but also stakeholders (customers and suppliers) interacting with these systems. Thus, the identification of improvement areas beyond technical improvement must be sought after.

As noted above, CP is an organisational initiative that seeks to promote the use of concepts such as eco-efficiency and waste minimization with a focus on individual production activities or sites rather than examining the impact of the particular activity or site in the life cycle of the given product or service. On the other hand, life cycle thinking (discussed in Chapter 4) gives a more holistic approach to health, environmental and resource problems (Kjaerheim, 2005).

5.2.2 Options based on 'Industrial Ecology'

The concept of industrial ecology already appeared sporadically in the literature in the 1970s that marked the early years of the United Nations Environment Programme (UNEP). The main idea behind Industrial Ecology is to understand how industrial systems work based on the principle of material balance, how industrial activities are regulated, and their interaction with the biosphere. Then, on the basis of what we know about the ecosystem, to determine how the industrial ecology may be restructured to make it compatible with the way natural ecosystems function.

Currently, there is no standard definition of industrial ecology. However, all authors more or less agree on at least three key elements of the industrial ecology/metabolism perspective (Den Hond, 2000):

- It is a systemic, comprehensive, integrated view of all the components of the industrial economy and their relation with the biosphere.
- It emphasizes the complex pattern of material flows within and outside the industrial system, in contrast with current approaches, which mostly consider the economy in terms of abstract monetary units, or alternatively energy flow.
- It considers technology development as a crucial but not exclusive element for the transition from the actual unsustainable industrial system to a viable industrial ecosystem.

According to Ayres, (1994), the industrial system as it exists today is unsustainable. Based on material cycle analysis, it would appear that industrial society has drastically disturbed, and is still disturbing the natural system (Simonis, 1994). Curbing this requires the reduction of the dissipative losses by near–total recycling of intrinsically toxic or hazardous materials, and increasing economic output per unit of material input. This recent move by industrial experts seeking solutions to pollution problems has resulted in a search for the modification and restructuring of existing patterns of energy and material use from high-volume production to high-value production (Simonis, 1994).

Currently, two main directions are explored in Industrial Ecology in order to complement and improve current wisdom in pollution management (Truman, 1997). One direction is the local application of the principle of industrial ecology in 'eco-industrial development' and referred to in some literature as eco-industrial parks or islands of sustainability (Den Hond, 2000). The other is dematerialisation, which explores ways of reducing the intensity of production and consumption at the societal level.

Eco-industrial development is a 'food web' created between industries by the waste of one the used as resource by another (Den Hond, 2000). That is, eco-industrial

development is a community of different local administration, manufacturing and service industries seeking to enhance environmental and economic performance through collaboration in managing environmental and resource issues. By working together, the community of businesses tries to achieve a collective benefit that is greater than individual benefits each industry would realise if it optimised its individual performance. Besides the desirable socio-ecological and socio-economic perspectives, eco-industrial development seeks to demonstrate the proposition that business and environmental success can be linked and mutually supportive in ways that enhance the surrounding communities and the natural environment. Several conditions for success however need consideration. Some of these are: a clear vision of the community values and performance objectives, careful screening of existing and new companies, methods and information to support companies in their production and management strategy. Even though eco-industrial development looks promising, it is faced with undesired resource dependencies, technological lock-in, leaking of information, and uneven quality among industries (Lowe, 1997).

Dematerialization on the other hand refers to the absolute or relative reduction in the quantity of materials used and/or the quantity of waste generated in the production of a unit of economic output (Cleveland and Ruth, 1998). That is, dematerialisation seeks to optimise the total material cycles from virgin material, to finished material, components, products, and ultimate disposal so that the economy may function as sustainable (Graedel and Allenby, 1995). Dematerialisation is a strategy to optimise the flow of materials within the economy, which is largely based on technological evolution. As noted by De Bruyn and Opschoor (1997) a 'change in market and demand and material substitution is a way to achieve dematerialisation.' This is because dematerialisation depends on the relative importance of the rate of economic growth measured as income and the rate of efficiency gained in material use.

One policy option derived from the dematerialisation is the transition from products to product-based services. Here, consumers do not buy products but instead pay for services. This creates the involvement of the producer with the product in its use phase. This option encourages producer take-back, leasing and pooling arrangements instead of buying and selling. This option is based on the understanding that value is not created by creating a product with a certain value added but by the function that is provided by the producer with the product being a means of delivering the function (White et al., 1999).

Material flow analysis

As mentioned in Section 2.2.3**,** material flow analysis (MFA) is a major method of industrial ecology, laying the analytical basis of eco-industrial and dematerialization strategies. MFA studies the fluxes of resources used and transformed as they flow through a region, through simple or multiple processes. The method

analyses the flux of different materials through a define space and a certain time. In this method, materials or material mixtures – which are chemical elements and their compounds – with functional values for society are defined as 'goods'. The 'processes' denote the transport, storage and transformation of goods and materials. Transport and storage do not change the chemical composition of goods but it requires energy and involves other goods and materials. With transformation, goods are changed into new products with new qualities and usually new chemical composition (Brunner and Rechberger, 2003).

The system for which the method is applied comprises of processes within the system border, the fluxes between these processes as well as the import and export fluxes to and from the system. The environmental compartments – atmosphere, groundwater and surface waters and soil – which act as sink for residual fluxes are placed outside the system border. The processes in the system are viewed as black boxes; where material transfer from input goods to output goods describes the input mass distribution amongst the various products. Mass and element fluxes in the system can be determined through literature review, field measurement and calculation of mass balances over a process or process chains or through a combination of these methods. Detailed assessment and measurement procedures are not within the scope of this study. However, in order to introduce MFA at least to some extent, Table 5.3 presents goods, their origin and destination processes and the method for determining flows, typical for MFA. Figure 5.4 present a characteristic MFA flow

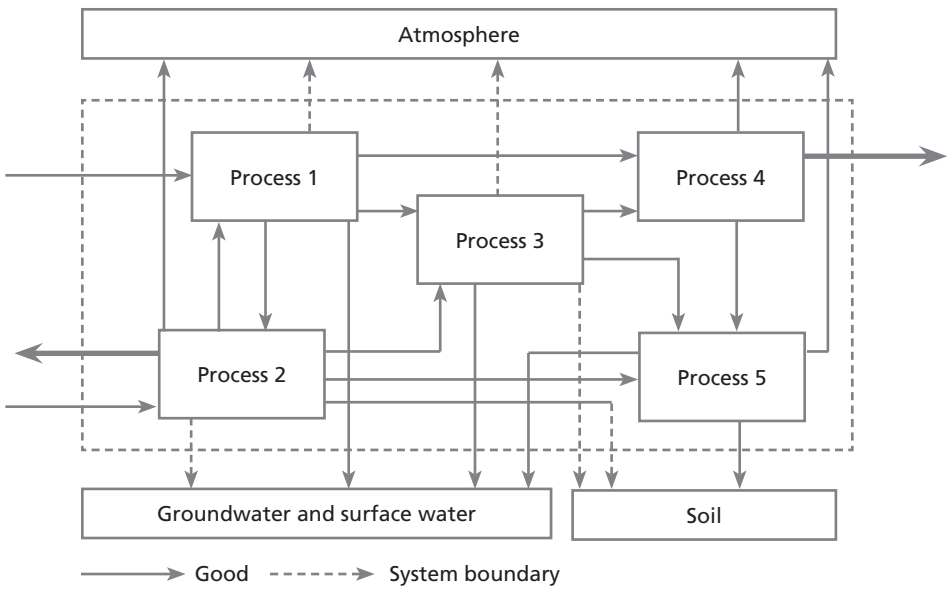


Figure 5.4 ■ Illustration of streams of different materials through a defined space

chart of a material fluxes in an environmental system with defined boundaries and five processes which may be industrial, agricultural or natural.

Table 5.3 ■ Typical goods, processes, destinations and determination methods for mass and element fluxes, used in MFA.

Good	Origin Process	Destination Process	Determination Method
Raw material	Outside the system border	Industry and agriculture	Available information from actors and literature data
Gas emission	Industrial, treatment of excreta farming activities and composting	Atmosphere	Mass balance and literature data
Leachate	Agriculture	Groundwater and surface	Literature data
Energy	Industry, transport and distribution	Household, transport and distribution	Measurement and literature data
Wastewater	Treatment of wastewater and composting	Groundwater and surface waters	Mass balance and literature data
Solid waste	Households, industries, transportation and distribution and composting	Agriculture, landfill, composting, soil, groundwater and surface water	Mass balances, measurements and literature data
Food	Outside the system and agricultural activities in the system	Transportation, distribution and households	Measurements and literature data
Consumer Product	Industry	Transportation, distribution and outside the system border	Available from company and literature data
Excreta	Household	Treatment of excreta, soil, groundwater and surface water	Mass balance, measurement and literature data
Biosolids	Treatment of excreta	Landfill, groundwater and surface waters	Literature and theoretical values based on future scenarios

5.2.3 A conclusion for developing countries

Since in developing countries many decisions are centred on resources, a resource flow analysis should be useful in contexts of development. The special power of these methods lies in the long-term environmental analysis and planning rather than the shorter-term alleviation of specific environmental problems. Nevertheless, they may have their uses there too, as explored in the present section.

Cleaner Production

Currently, developing countries have a lot of opportunities for cleaner production strategies because of the new industrial facilities that are being built. The

introduction of cleaner production strategies in developing countries will enable industries and society to achieve optimum resource (energy and raw material) consumption per unit product through improved production efficiency. The result would be an improvement in the competitiveness of industries in developing countries which will eventually result in improved environmental quality. The promotion of cleaner production can be stimulated through the following two main approaches.

The first approach is to address the technological challenges hindering the use of cleaner production, e.g through improvement of the technical and managerial skills and capabilities in developing countries. This calls for a concerted action to improve technology and capacity networks, which comprise of all stakeholders involved in the development, operation, evaluation and promoting of cleaner production.

Second is the addressing of financial challenges associated with the use of cleaner production in developing countries through primary financing and supportive strategies. Primary financing by groups of end-users should be the main source of funds. Such groups take advantage of end-user creditworthiness or proven cleaner production equipment technology. Support from commercial credit providers is also important since they may understand the merits of cleaner production investments as well as provide special-purpose funds with a well structured, planned and targeted strategy to finance cleaner production in developing countries. This approach could also include the establishment of cleaner production service companies or remodelling of existing cleaner production and environmental sound technology centres into such service companies.

Material Flow Analysis

MFA could be used to carry out resource flow analyses for single industries or industrial areas in developing countries. Here, actors consider how they might leverage the availability of the resources, for example creating new linkages between industries in different industrial sectors. This will result in a community of different local administration, manufacturing and services industries seeking to enhance environmental and economic performance through collaboration in the management of pollution problems. Specific application of resource flow analysis in developing countries might take different forms and depths depending on the scope of the region, the nature of industrial activities in the geographical location, and the desirable objectives to be achieved. In most cases, a single material flow or branch-activity focus might be fruitful. However, in other cases, a comprehensive and integrated approach is essential in order to bring about a long-term and sustainable impact. With non availability and accessibility of data, and the huge informal sector involved in industrial activity resources flow analysis could be used in a semi-quantitative manner to establish trends that would provide sound

background for sustainable development planning and decision making. As an example, Figure 5.5 shows a resource flow chart of the textile industry in Tema which is one of the major producers of pollutants. A rough quantification of these flows can be the points of departure of the design of improvement strategies.

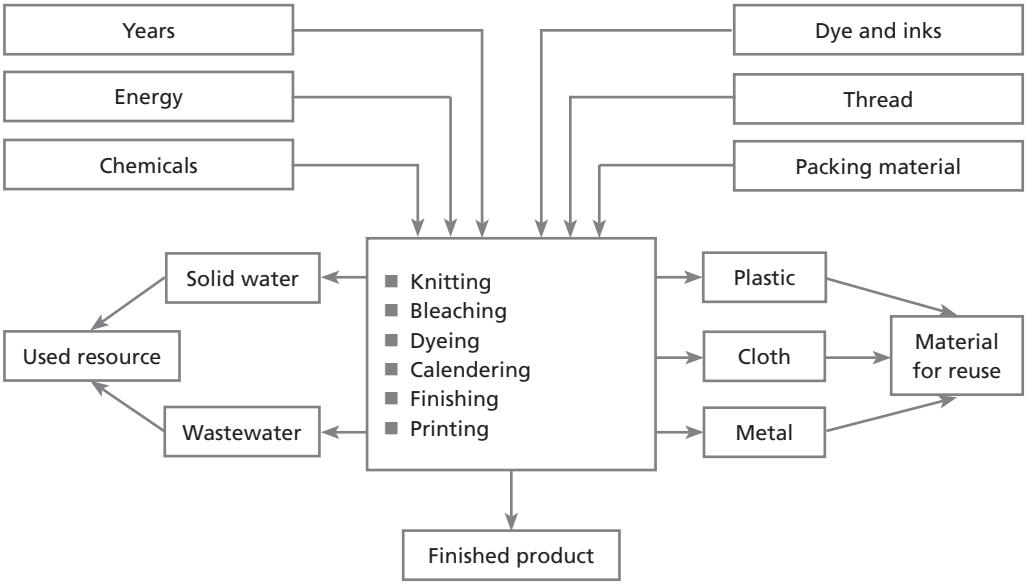
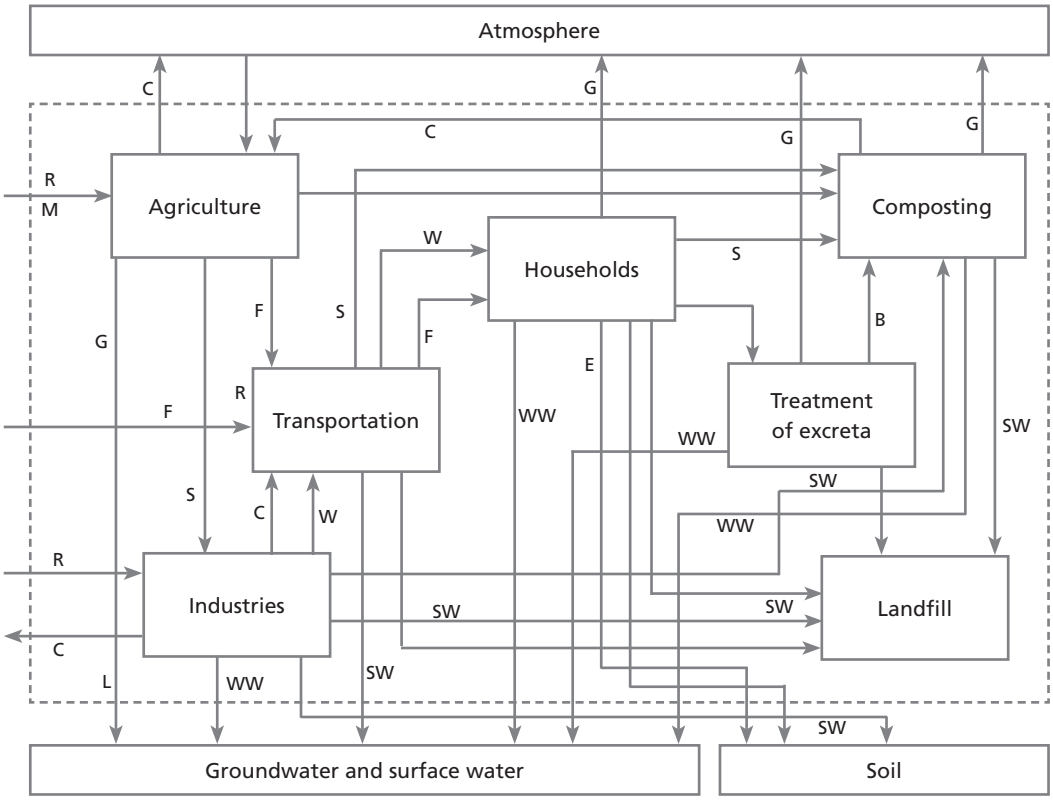


Figure 5.5 ■ Resource flow analysis of the textile industry in the city of Tema

MFA may also be used to carry out area-wide analyses to support local and regional government decision making in developing countries. It can be used for early recognition of environmental problems, priority setting, to analyse and improve the effectiveness of measures and to design efficient material management strategies in view of sustainability. It is important that this tool is used to complement traditional environmental and resource management strategies, which have tended to focus heavily on specific environmental compartments, and measure the concentration of substances in various media. The use of MFA could also provide an overview of the total system by linking the anthroposphere with the environment shifting focus away from the back-end so-called 'filter strategies' to more pro-active front-end measures. The key advantage here is short- and long-term loadings are examined rather than ambient concentrations. This highlights current and potential material accumulations (e.g. hidden sinks) which represent either potential environmental problems or a potential source of future resource. In this way, the use of MFA can assist precautionary policy making by highlighting future environmental or resource issue problems without relying on current signals of environmental stress.

5.2.4 Tema: An illustration of system analysis to material flows

As an illustration of what such an area-wide application may look like, Figure 5.6 presents a flow chart of key processes and nutrient fluxes in the city of Tema and the associated sources and emissions.



SW: Solid Waste; WW: Wastewater; CP: Consumer Products; G: Gas;
E: Excreta; C: Compost; L: Leachate; F: Food; W: Wood

Figure 5.6 ■ Illustration of system analysis of material streams in the city of Tema

This illustration shows input and output to various transformation processes in Tema. The type of input, output and souce and destination of these flows. Calculation of fluxes (which is outside the scope of this study) could show the percentage of pollutants transfered to soil, water, air and landfills, the percentage contribution of transformation processes to the total pollution load in Tema. This could allow planners and decision makers in Tema identify key processes for environmental management and desgin an optimum resource recovery system by using a combination of relevant mass and material fluxes.

5.3 Option discovery based on creativity

This section presents the resources and skills that human beings have which could be exploited to generate opportunities to deal with pollution problems. These resources have the special relevance that they are in ample supply in developing countries. My idea is to show that these resources and skills vital tools in the identification of opportunities and not to discus the theoretical underpinning of the concepts since that is beyond the scope of this study. Traditional ecological knowledge, enabling creativity and dreams are the resources and skills presented in this section.

5.3.1 Tapping traditional ecological knowledge

Currently there is no generally accepted definition of traditional ecological knowledge in spite of the fact that there has been growing interest in recent years, partly in recognition that such knowledge can contribute the management and conservation of biodiversity and ecological processes (Gadgil et al., 1993; Berkes et al., 2000; Huntington, 2000). According to Berkes (1993), traditional ecological knowledge is 'a cumulative body of knowledge, practices and beliefs, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment'. The term 'traditional' used in the definition is ambiguous and sometimes other terms such as local knowledge or indigenous knowledge are used to avoid the debate about 'what is traditional about traditional knowledge' (Berkes, 1998). Usually, the term traditional is understood as a 'filter through which innovation occurs' (Posey, 2001). This means that even knowledge acquired from outside, if acquired through a filter of tradition could be regarded as traditional ecological knowledge.

Many frameworks for the analysis of traditional ecological knowledge as a knowledge-practice-belief complex have been developed (Berkes, 1999). Traditional ecological knowledge is often classified into the following four interrelated categories (Berkes, 1999; Usher, 2000) – see also Figure 5.7:

- *Category 1:* Factual and rational local knowledge about the environment. This includes knowledge of the identification, classification, life cycle, distribution of species and ecological relationships among species and their physical environment. This category of knowledge is based on empirical observation by individuals of specific events or phenomena, generalised observation based on numerous experiences over a period of time and generalised observation based on personal experience reinforced by the account of others both living (shared experience, stories, and instructions) and dead (oral history and customary teachings).

- *Category 2*: Environmental management system. This consists of knowledge about the past and current use of the environment, or other statement of facts about social or historical matters that bear on the traditional use of the environment. This knowledge is used to develop environmental management systems which include practices, tools and techniques.
- *Category 3*: Social institutions. This layer consist of culturally based rules and value statements about how things should be, and what is fitting and proper to do as well as moral and ethical statements about how to behave with respect to the environment in terms of human and ecological well being in holistic sense. It includes a set of rules, social and cultural norms and customs.
- *Category 4*: Worldviews and religious philosophy. This is way people see their environment and the meaning they give to it. This category of knowledge is the framework with which people construct knowledge from facts and also the basis on which information derived from observation, experience and instruction is organised to provide explanations and guidance.

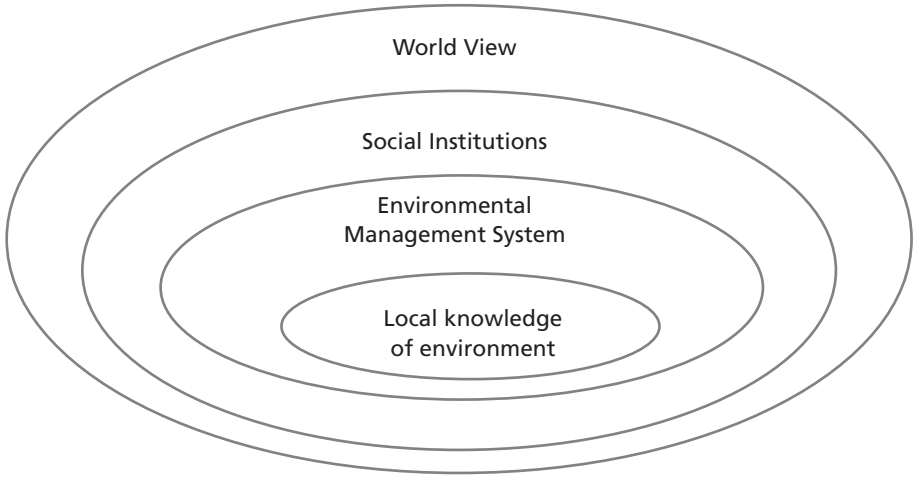


Figure 5.7 ■ The Knowledge-Practice-Belief framework for analysing traditional ecological knowledge (Adapted from Berkes, 1999)

Based on the work of Johnson (1992) and Sudley (1998), Table 5.4 presents an overview of the key features and sources of traditional ecological knowledge.

Table 5.4 ■ Identification parameters and key features of traditional ecological knowledge (adapted from Sudley, 1998)

Identification parameters	Key features of traditional ecological knowledge
Means of knowledge acquisition	Generated through observation and experiments of uses and by identification with the object of knowledge.
Process of knowledge acquisition	Usually recorded and transmitted orally, sometimes through sacred text.
Basics of cognition	Intuitive and subjective.
Integration with worldview and culture	Holistic, subjective experiential, embedded and integrated in the social, cultural and moral spheres
View of life forces and the universe	Views all matter as having life forces, including inanimate forms. Sees all entities in a rational context.
Perception of nature and life forms	Based on worldviews which emphasis on social and spiritual relations between life forms.
Basis with relationship with nature	Shaped by the ecological system in which it is located.
Equality between life forms	Stresses inter- dependency and equality of life forms.
Basis of self worth and view of technology	Predicted on the grounds of group values or holism. A phenomenon to be rejected or integrated into world view.
Dealing with phenomenological change over time and time measurement	Diachronic: based on long time series in one locality and time is measured cyclically.
Contextual validity and geographical contextuality.	Bound by time and space, social contextuality and moral factors. Requires a commitment to the local context.

Participatory Local Appraisal

Participatory local appraisal is a method for studying local knowledge systems. It is a semi-structured activity, carried out in the field by multidisciplinary teams and designed to acquire new information and new hypotheses about rural life (Conway and McCracken, 1990). Methods such as *interviews*, *direct observation (*where the researcher observes events, processes, relationships or patterns in the local systems where knowledge is being sought while gathering information), *visual models (*the use of diagrams of the both the local people and the normative persons to know the knowledge system of local people), *workshops (*where the researcher meets with the local people to examine the information collected, share analysis and interpretations, consider opportunities and look for initiatives) and *storytelling (*where the researcher and the local people tell stories from which the local knowledge and values of the people is traced) are identified for use in different combinations for participatory local appraisal (Conway and McCracken, 1990; Mitchell , 2002).

Participatory local appraisal methods allow local people to participate in local knowledge tapping through a learning process with the information ultimately owned by the participants. This happens because local people have a greater ability to assess their situation than outsiders. Through the use of these methods,

a relaxed rapport is established with the local people leading to an easy flow of information and communication. The use of these methods has the potential to identify opportunities for pollution management and will depend on the situation and the people involved in the process (Chambers, 1994; Mohan, 1999). For example participatory local appraisal methods were used in Uganda to identify natural resource degradation problems and develop a system to manage crop production and reverse degradation trends (Samalulu et al., 2004).

Focus groups

Focus groups may be part of a full participatory local appraisal but also used as a stand-alone method. Focus groups typically consist of 6 to 10 people often with some shared characteristics participating in an informal session in which their key concerns and expectations and worries about problems such as pollution are elicited. It provides a forum for identifying and talking about concerns of participants, which often results in useful insights to pollution management. There is usually a facilitator with the desired goal of having a better understanding of the participants' reasoning about environmental problems and actions (Morgan, 1998). Focus groups can be used to obtain information about what people already know, the additional information they would like to receive, and how this information would be processed in terms of the underlying values. In a pollution context, focus groups may be used to examine the basis for people's risk perception, to pre-test risk communication material and to design more effective risk mitigation policies that can be tailored to the special needs of particular stakeholders (Desvousges and Smith, 1988).

Advisory committees

Advisory committees are made up of small groups of people from diverse social, academic, religious backgrounds and neighbourhoods, who have experts' views about pollution problems and have a group discussion in order to find possible solutions by evaluating pollution issues in terms of perception and reaction of people as well as economic and risk factors. It is used to determine values when a group of individuals interact. Advisory committees require a high degree of commitment and provide a forum for identifying and talking about concerns of participants. They are used in the design and dissemination of information towards finding solutions to problems. It is crucial for members of the committees to know their role and their mandate and they should also have prior information about available and feasible management strategies. Facilitators are often used to put the committee's work in progress and to present information in a clear and understandable way to members and the public. Liette et al., (1997) noted that 'the diverse values and priorities of members and issues related to pollution considered require the use of indicators in order to summarise issues, to speed up the process and to increase the chance of reaching consensus about a problem.'

5.3.2 Enabling creativity

First of all, I would like to explain what creativity is about. More than 100 definitions have been formulated to describe the rather enigmatic concept of creativity and several attempts are documented in both scholarly and popular literature. The scope of this section is not to define creativity extensively but rather to apply it the identification of opportunities for dealing with pollution problems. I define creativity here as the ability to look at the same things everyone else does, but see things differently and find hidden connections to create something new. That 'something' may be a campaign against an activity that is causing pollution in an area, for instance, or a better way of organising activities to avoid pollution (Weiss, 2002).

Being creative is not easy. Buggie (1997) identified several barriers to creativity. One is that organisations, even more than individual people, work largely on routine procedures and fixed ideas. Another barrier is that people tend to view new ideas as sources of problems and are afraid of change. Other mental blocks are implicit social norms such as 'follow the rules', 'be practical', 'stick to your area' and 'play is frivolous'. To remove obstacles to creativity, Schutz (1994) suggests that we must identify the hurdles at each stage of the creative process.

How can human beings be creative? Most creative people use techniques in the form of deliberate thinking designed to help them find ideas and solve problems. The following are three common methods that could enhance creativity:

- Step back from implicit assumptions, limitations and routines. This simple exercise would help move from the habit of 'this is how we have always solved the problem' and open up the mind to more imaginative scanning of possibilities. Johnstone (2006) mentions one variant of this method he calls 'provocative operation'. It refers to something that stops you in your track in a way that encourages you to consider a wider range of options and to think more laterally. Pollution problems may well serve as an effective provocative operation, e.g. when a polluting actor is jolted into awareness and reflects upon questions such as 'Why am I doing what I am doing? Is it out of habit, because other actors are doing it, or because I have not good reason for doing it?'
- Abstract opposites. This method is a line of reasoning characterised by moving up to a reflective level, reflect on the common directions of the options found until that moment and define a new, opposite direction on that abstract level and then move down again to the level of concrete design (De Groot, 1992).
- Brainstorm and allied group methods. These methods seek to strengthen the creative capacity of actors by means of group interaction. This method differs from the normal group discussion in that participants focus on generating a large volume of information. It is where wild, even preposterous ideas are de-

vised and every one jotted down without criticism and evaluation taken into consideration (Davis, 1992; De Groot, 1992).

Davis (1992) gives a number of allied ideas such as (1) analogical thinking (the transfer of an idea from one context to a new one), (2) attribute listing (a specific idea finding technique where the key characteristics or attributes of product or processes in question are identified), and (3) morphological synthesis (where attribute listings are elaborated through changes, idea combination, and synthesis to arrive at different surprising combinations). In my own experience, I have noticed that the following steps could guide to creative finding of solutions to pollution problems:

- Try to destroy the familiarity of the relationship of everything you know about the problem. (Before the onset of pollution prevention, pollution control was the main way to deal with pollution problems and every actor was a prisoner of that familiarity.)
- Then, one is left with a rich reservoir of bits and pieces of information, a vast storehouse of unconnected facts and fantasies, thoughts and ideas that do not mean until they are selected and re-assemble them into a new coherent whole.
- Finally, rearrange everything you know and look for new relationships among the pieces by using a new form of arrangement.

In al this, it remains worth noting that none of these techniques are guaranteed to identify new opportunities to solve pollution problems. But they can surely help find ideas without having to wait for an uncooperative muse.

5.3.3 Using dreams to find opportunities

In spite of the fact that dreams often seem so weird, some dream theorists say that dreams have a problem solving function. Dreams supposedly deal with problems we can not solve in the waking life. My argument in this section is based on the understanding that we can develop uses for our dreams. Looking at dreams in the light of waking day, and believing that they may be full of insight, we may sometimes come up with new ideas or insights while studying or solving pollution problems.

Many people have purposely trained themselves to use their dreams to find opportunities. Weintraub (1995) has proposed the following ways to crank up one's unconscious mind:

- Just before sleeping, write in detail about the issue you like your dreams to help solve. This will help your conscious mind to be focused on the issue and provide a subject matter for your dreams.

- As you go to sleep, ask your unconscious mind to answer your questions, and tell yourself that you will remember this dream when you wake up.
- As you doze off, repeat the areas in which you want to identify the opportunities softly to your self, with the mental expectation of receiving an answer. If your mind wanders, gently bring it back to the proposed action you want to visualise in a dream.
- Record all words and images of any dream that you remember as soon as possible after you awake.

Box 5.1 gives an example of the success that dreams sometimes create.

Floyd Ragsdale, an employee at Dupont in 1992, was having problems with a machine that manufactured Kevler fiber, the material in bullet-proof vests. Because downtime on this machine cost $700 a minute, Dupont assigned its best engineers to fix the problem, but none were successful. One night, Ragsdale had a dream in which he saw the tubes of a machine and springs. He came to work the next day and told his boss about the dream. He received a typical reaction: his boss scoffed and told him to forget about it. When Ragsdale's shift ended, he went ahead and inserted springs into the tubes, and the machine worked perfectly, saving the company more than $3 million.

Box 5.1 ■ Example of using dreams to solve problems (adapted from Weintraub, 1995)

These suggestions of using dream information to find opportunities may meet negative responses from some academics. Most people are receptive to linear thinking since it appears to give a sense of predictability and control. However, in reality, most inventors and successful executives in developed countries rely on intuition for many major decisions.

5.3.4 A conclusion for developing countries

Tapping traditional ecological knowledge

Traditional ecological knowledge reviewed in section 5.3.2 has a potential to contribute to environmental management in developing countries. Integrating traditional ecological knowledge in environmental assessment will improve environmental management. It could be used for instance in the scoping and identification phase of EIA (section 4.3) to help establish the current use of lands and resources for purposes by people that may be adversely affected. Traditional ecological knowledge may also play a vital role in the environmental assessment by providing different perspectives on the ecosystem and human-environment interrelations and help define risks to ecosystem components. Traditional ecological knowledge could also be used in the public review phase of EIAs to contribute to understanding the cumulative effects of activities.

Enabling creativity

There is rich creativity in developing countries but most of these opportunities are not documented. Creativity may, however, contribute much to the proper management and improvement of knowledge for individuals and organisations in developing countries. Creativity could be enhanced in developing countries through joint inquiry by stakeholders (industrial, political or traditional) and local people with the aim to learn and seek innovation potentials.

Using dreams

Moreover, it is important that a positive approach is taken towards dreams so that people will know what dreams can do to point at options for problem solving. Presently, environmental managers in developing countries could be said to think linearly since this, to them, creates a sense of predictability and control. However, in reality, inventors and successful executives rely on intuition for many major decisions. Therefore, the promotion of dreams as a way of developing one's intuition should be encouraged.

5.3.5 Tema: An illustration of finding creative opportunities

In our example city of Tema, several elements exist that can be put to use in creative opportunity finding:

- Tema has a community of elders and the chieftaincy institution could be exploited to play a role in the pollution problems**.** The city has a diverse culture because of people coming both from within and outside Ghana.
- There are a lot of untapped potentials of women in Tema. One of them is the utilisation of women groups in pollution issues. The potential for women to organise themselves to deal with pollution issues is readily available but has not been fully exploited. Also, women have great potential to help grow the awareness of pollution problems that exist in Tema.
- There is good environment for learning because of the presence of different industries and institutions from different parts of the world. Moreover, there is an office of the Ghana Association of Civil Mediators and Arbitrators in Tema, which was established mainly to carry out alternative dispute resolutions. This office has the potential to deal with community based pollution problems and also supplement the judiciary system that exists in Tema in dealing with pollution issues.

Focus groups and methods from the Participatory Local Appraisal repertoire are well-suited to support creative opportunity identification, because they are cheap and establish an easy rapport with people, which supports the richness and validity of findings. Advisory committees that include local leaders could well be used in more formal settings, e.g. in Tema for manufacturing companies such Tema Oil Refinery and Valco Aluminium Company.

5.4 An enabling context for option discovery

As detailed in the preceding sections, the effective identification of opportunities for the prevention of pollution and the solution of pollution problems can work from a focus on causal chains, systems concepts or creative methods. All this work requires an enabling context, which is, in my perception, a good basis in adequate data gathering routines, in adequate people and in learning. These elements of enabling context are the subject of the present section.

5.4.1 A basis in routines

A 'basis in routines' here means the regular environmental activities undertaken by firms or government that in one way or the other lay a good data basis for the identification of opportunities. Environmental monitoring is obviously an important activity here; it will be discussed in chapter 6. In the present section, I focus on environmental accounting.

Environmental accounting

Environmental accounting is a tool that evolved because of the need to integrate environment and ecological aspects in the general management of organizations. With the emergence of environmental accounting, various perceptions have been developed (Gray et al., 1993; Schaltegger, 1996). Environmental accounting uses methods of traditional accounting systems to gather and analyse environmental information (Schaltegger, 1998). Environmental accounting involves the generation, analysis, and use of financial and non-financial information in order to integrate environmental and economic polices of firms to build a sustainable business with less pollution (Gunther, 1998). 'Eco-efficiency' used in this context is the ratio of the value added by a firm to the resulting environmental impact (Schaltegger and Storm, 1990). Based on the work of Gunter (1998) I distinguish two types of environmental accounting tools (*i*) environmentally differentiated accounting and (*ii*) ecological accounting.

Environmentally differentiated accounting

Environmentally differentiated traditional accounting is a set of information systems for measuring the economic performance of a firm. This approach is concerned with financial impacts of environmental issues, which express environmental cost in monetary terms and are internally relevant. The financial impacts are differentiated from other financial impacts within the main areas of accounting (Schaltegger, 1998). Within traditional managerial accounting, for instance, the environment is dealt with by determining, tracing and tracking of environmental costs and how the cost and responsibility are allocated in the firm. On the other hand within traditional external accounting (aimed at the external stakeholders), environmental issues considered are the types of standards and guide-

lines that need to be adopted for the disclosure of liabilities and ways to treat these liabilities.

The main information gathering tools used in environmentally differentiated accounting are environmental investment appraisal and eco-oriented cost accounting (Gunther, 1998). Of these, eco-oriented cost accounting is the most relevant as a general basis for opportunity identification because it is a permanent activity of the firms that apply it. Eco-oriented cost accounting is used to obtain information on internal and external ecological cost for all activities or each activity of the company in two main forms, internal and external ecological costs and differentiation and extended cost. Internal and external cost accounting is used to define all cost of ecologically scarce resources and energy and the cost of prevention and control strategies. The internal cost refers to the cost of internal effects that are already part of the firm's cost accounting while external cost is considered as cost that arises from external effects through the use of resource.

Ecological accounting

Ecological accounting is used to measure the ecological impacts of firms on the environment in terms of non-monetary physical units such as material fluxes of substances and goods and their reaction with the environment. It is used to account for the ecological impact of firm's activities, products and processes both internally and externally. The information collected for internal management of firms' products and processes on the environment is used to provide ecological information for the firm's management and for external stakeholders interested in environmental issues. Various approaches have been suggested for use in ecological accounting. Of these, eco-balancing is by far the most widespread. Eco-balancing is a structured method for reporting the physical flows of materials and energy of an identified entity or organisation (Hallay and Pfriem, 1992; White and Wagner, 1996). The aim is to record, describe and assess all ecological relevant resources and output. The information gathered is later analysed to classify all material and energy with respect to their risk potential to human health and the environment (Gunther, 1998). Eco-balances can be prepared for a whole firm or for a particular product or production process by considering the unit in its entirety as a 'black box' where inputs are raw materials and energy and output are products and waste.

5.4.2 A basis in people

An enabling context for opportunity discovery also comprises the human element, a 'basis in people'. Information levels, environmental motivation, diversity and many other issues play a role here, but I will focus here especially on what has been called 'self-efficacy'. Self-efficacy is an inner resource, defined by Bandura (1986) as 'people's judgement of their capabilities to organise and execute courses

of action to attain designated types of performance'. Self-efficacy has a special relevance for developing countries because people in pollution management often feel inferior to Western experts or are locked up in authoritarian management systems that reward the passive execution of tasks rather than the development of self-confidence needed to identify, create and defend opportunities.

Dutton and Jackson (1987) established a relation between confidence in skills and perceived opportunities. Kruger et al. (1994) extended this by linking opportunity recognition to self-efficacy; they found that changes in perceived self-efficacy resulted in changes in opportunity perception. The mechanisms through which this relationship comes about concern both the actor's confidence regarding the technical and managerial elements of the opportunities and the actor's confidence that he can successfully engage in the activities necessary to help realise the identified opportunity, within and outside the firm.

Considering this, improving the self-efficacy of workers in pollution management is an important goal (Pell and Jarvis, 2001). According to Bandura (1997), self-efficacy can be enhanced through the following four processes:

- Verbal persuasion, sometimes referred to as social persuasion, relies on using subtle clues to reinforce desired behaviours. Pollution management institutions should use positive reinforcement to reward actors who are working to establish positive pollution management habits. Rewarding an actor who is thinking about adopting creative pollution prevention approaches may be as simple as praising their intentions. Another method is to provide a little extra attention to positive behaviours. Quickly actors will discern that you are very interested in hearing what they will try to do and have little time for hearing only about problems and limitations.
- Stimulating enactive mastery, sometimes referred to as performance mastery, is a process that allows an individual to acquire cognitive, affective and behavioural tools that lead to a belief that he can effectively accomplish his goals (Crippen and Earl, 2004). For instance, in developing countries when actors are being taught new skills in pollution management, it is important to break tasks up into small manageable units, so their self-efficacy gradually increases. This approach should be coupled with goal setting and stimulating actors to make contracts with themselves or with each other. Enactive mastery is also enhanced when people are allowed to give in to the physiological arousal created when being at work on a challenging task, including the self-talk that often occurs where individuals engage in an iterative personal dialogue while engaged in problem solving (Bielacxyc et. al., 1995).
- Vicarious modelling or role modelling helps people learn how to cope and what to expect through the experience of others. Modelling occurs when actors learn intentionally from other individuals to increase their self-efficacy by observing a model of similar ability level performing the skill (Crippen and

Earl, 2004). For example, industrial actors that have implemented sustainable pollution management strategies could serve as role models for other industries that face similar problems and are as yet struggling to design sustainable solutions. While face-to-face meetings (e.g. support groups) are the optimal stimulus in this respect (Bandura, 1997), role modelling can also occur through the media or reading literature.

5.4.3 A basis in learning

This section looks at how learning can create an enabling context for opportunity discovery and what type of learning is best suited to enable effective opportunity discovery for pollution management in developing countries. Some find learning to be under-theorized (Parson and Clark, 1995) while others claim the concept of learning is over-theorized (Bannet and Howlett, 1992). Many definitions of learning exist (see Howell, 1994, McGill and Beaty, 1992; Koo, 1999; Smith, 1997; Keys, 1999; Bourner et al., 1996). I will follow Lietch and Harrision (1999) who cite Revans' (1987) distinction between two interdependent learning variables, namely 'programmed knowledge' that embraces facts, theories and existing models, and 'action learning' that resembles an alternative way of solving problems by means of questioning methods that search for unknown solutions. Revans' works suggests an important role of programmed knowledge in action learning. This point is echoed in Robinson (2001) who states that the integration of programmed knowledge is supportive to action learning and shows empirical evidence of that.

The distinction between programmed knowledge and action learning is reflected in the following four dominant theories of learning that underlie how we understand human learning and behaviour change. Figure 5.8 shows the relationship of these different theoretical perspectives.

- *Behaviourism* – Where learning is seen as the conditioning of human behaviour through habit formation. It implies the dominance of the teacher, with learners characterised as essentially passive and knowledge and social reality seen as external and objective. Rewards and punishments can be manipulated to change behaviour of actors. This insight also underlies the use of policy mechanism such as fines and incentives in environmental management.
- *Cognitivism* – Here the concern is with the processes and structures inside actors' brains (Atkinson et al., 1993). The focus is on the learner as an active participant in the teaching-learning process with the teachers using teaching strategies that help the learner acquire knowledge more effectively. A common denominator with behaviourism, however, is knowledge is also seen here as external and objective.
- *Constructivism* – The essence here is that people are active sense-makers who are continually assessing their environment and acting according to the ways

in which they interpret the situation (Ross and Nisbett, 1991; Allen et al., 2001). This perspective highlights the fact that actors may react to the same information in different ways and learning is seen as an internal process of interpretation, rather than a process of knowledge transmission. Here behaviours emerge from what actors' think they have made of what is happening, what should and/or might happen if they change their behaviour. Actors here use information that is credible and relevant (Reynolds & Busby, 1996). The cognitive-constructionist perspective of knowledge is beginning to underpin contemporary efforts to help people learn about, and change their behaviour towards the environment. Teaching then is the process that supports this construction and reconstruction of new knowledge, rather than being the communication of knowledge.

- *Humanism* – Here liberal values are the main drive and the focus is on what should happen rather than describing what does happen during the learning process. This perspective is based on the notion that actors have a natural desire to learn and they need to be empowered to have control over the learning process. The realisation of these values has the potential to contribute to environmental management (Endter-Wada et al., 1998), especially when teachers act as facilitators to create an educational environment in which learners can reach their full potential.

The above theories suggest that learners pre-existing knowledge, skills, beliefs and concepts influence what they notice about the world they live in and how they organise and interpret it. Learners therefore take ideas communicated to them and assimilate them with their pre-existing notions and experience to modify their knowledge and understanding in a more complex, complete and refined way. Against this background, Kolb (1984) sees learning as an ongoing process with a continuous series of cycles, each containing four stages – experiencing, reflection, conceptualisation and planning. This learning cycle is the basis of principles of action learning where individuals, groups or organisations follow a series of cycles in which they experience-understand-plan-act as shown in figure 5.9.

The type of learning that is best suited to enable effective opportunity discovery for pollution management in developing countries, in my view, embraces the dynamics of action learning and constructivism. This learning should be anchored in personal experiences of pollution management actors. Preferably, this should be organized with an emphasis on groups that enable interaction among these actors. The outcome of this collective learning (Holland, 1995) is then not only the emergence of collective understanding of the problems studied and discussed, but also an openness of mind that stimulates the discovery of creative options for solutions when windows of opportunity present themselves.

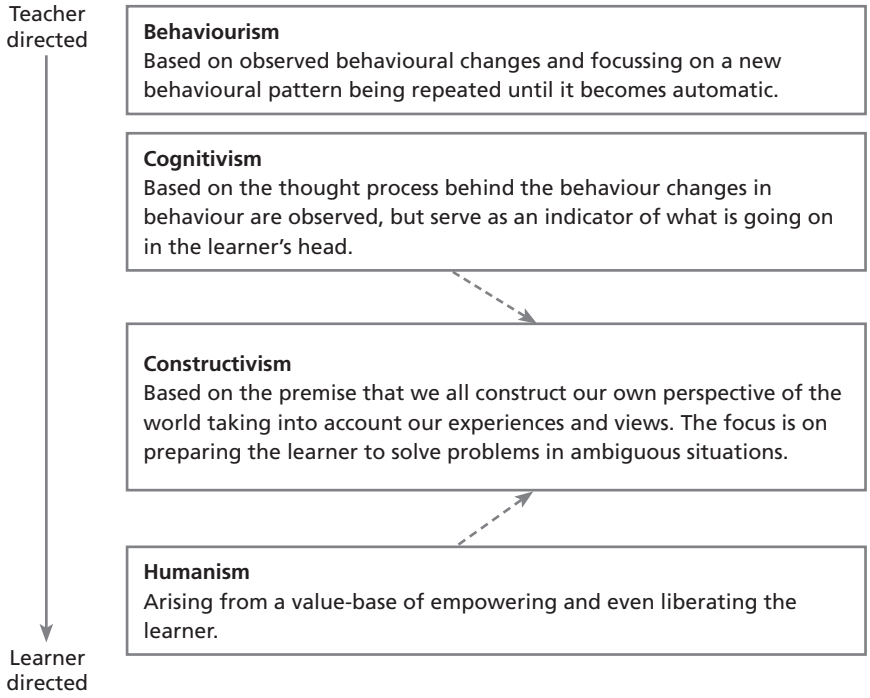


Figure 5.8 ■ Dominant theories underpinning models of learning by human beings

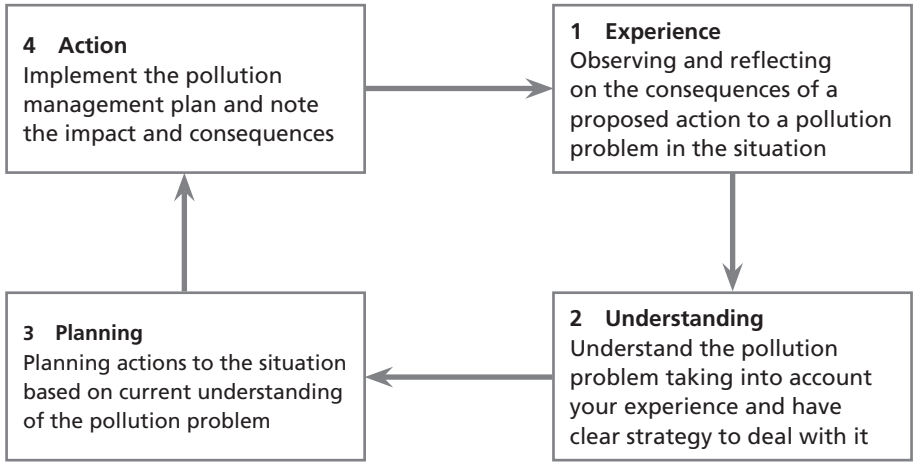


Figure 5.9 ■ Principles of action learning (Adapted from Pedler et al. 1991, McGill and Beaty, 1992)

5.4.4 A conclusion for developing countries

A basis in routine activities

Environmental accounting will help analyse the strength, weaknesses, opportunities and threats that exist in the accounting company. Especially in developing countries, it is essential to integrate environmental issues with economic issues so that management awareness about the potential importance, positive or negative, of environmental impacts on corporate economic performance is raised. Since environmentally induced monetary impacts of a company are interrelated with corporate environmental performance measures in physical units, integration may help to measure eco-efficiency.

With traditional accounting systems already existing in many organisations and institutions in developing countries, environmental accounting experts should team up with traditional accounting experts to develop an environmental accounting system based on the strength of their accounting information data base and the environmental information database. This will provide the opportunity to utilise local knowledge and resources, since it is only with a proper gathering and management of environmental information that stakeholders and actors can assess the actual and potential economic threats and opportunities that reside in of environmental issues. The adoption of environmental practices induced by environmental accounting would encourage people involved in pollution management to favour preventive alternatives over end-of-pipe approaches. The potential benefit that environmental accounting brings is through integrating environmental issues into the day-to-day decision making of industries with the ultimate goal of adopting voluntary pollution prevention strategies.

A basis in people

The self-efficacy of industrial, NGO and government organisation actors is a capacity to cause positive change. Actors should have confidence regarding the technical elements of the opportunities and also the confidence to be able to successfully engage in activities to help realise the identified opportunity. Self-efficacy has a special relevance for developing countries because people in pollution management often feel inferior to Western experts or are locked up in authoritarian management systems that reward the passive execution of tasks rather than innovation. Actions that reinforce self-efficacy, such as social persuasion and role modelling, do not require any funding or technologies that developing countries are in short supply of.

A basis in learning

Organisations involved in the management of environmental problems in developing countries currently appear to engage mostly in adaptive behaviour ('single-loop learning') rather than changing both beliefs and practices ('double-loop

learning'). Since organisations are inherently focused on efficiency and routines, organisational learning does not happen easily. A lot of research is required to understand the interwoven nature of conditions that enable and constrain it. Opportunities for environmental professionals to learn and share their learning, e.g. to be involved in critical debate and participatory decision making, are essential. On such a basis, members of organisations can look for multilevel learning from mistakes and for mechanisms used to ensure that values/goals are systematically re-examined and articulated.

Visible behaviours of industries or indicators in isolation can be misleading and incomplete. Especially in developing countries, organisations often lack an underlying cognitive structure and culture that would support meaningful organisational learning. Actors in developing countries should therefore engage in collaborative learning such as working in teams to accomplish common pollution management goals. The core of this approach of active learning is a combination of positive interdependence, individual accountability, the appropriate use of collaborative skills, group processing and face-to-face interactions (Medellin-Milan, 2005).

5.4.5 Tema: An illustrative case of enabling context

Here I present a short description of how contextual factors could enable the identification of opportunities for pollution management in Tema. The following positive and negative factors in the enabling context of Tema may be identified:
The self-efficacy of the actors in Tema is low even though some have the ability to undertake activities that would realise opportunities. Locally trained professional are considered to be inferior to their colleagues trained in western countries and this dampens their confidence. The main problem identified by the actors, even those trained in Western countries, is that the environmental training is not practically oriented and they find it difficult to translate theoretical understandings into solutions that can work in the Tema context.

- Local NGOs and CBOs have emerged in Tema to educate the people on the pollution of Chemu lagoon and its impact on the environment and livelihood of community. Awareness campaigns are undertaken and the mass media disseminate messages about the pollution of the Chemu lagoon, the actors that are responsible for the pollution and what measures need to be taken to save the ecosystem of the lagoon. This concern is also echoed by external NGOs such as Friends of the Earth Ghana.
- There are knowledgeable waste recyclers and recycling companies in Tema. Currently recycling of paper and metals is undertaken by industries. The industries engaged in the recycling of water and metals have developed programmes for the collection of materials for their activities. For example, industries involved in the recycling of scrap metals buy scrap metals from scavengers.

- One positive element in Tema that creates a positive enabling environment is the closeness of all the factories to each other. This makes it easy for the possible development of a closed-loop approach to deal with waste generated by the industries. Waste from one industrial could be used as resource for another industry and actors in the different industrials could also share experiences in the area of pollution management. Thus, the development of an eco-industrial park is a possible option.
- The presence of the Lagoon. It is nothing of much value now, but the with the current restoration programme underway, it could become the focus of inspiration and collective action for the industries, in a programme of shared responsibilities.
- Even though environmental accounting is not currently practised in Tema, there is the potential for use since all industries have knowledge and personnel in the area of financial accounting.
- In Tema, young and small industries in could learn from the large industries that have adopted sustainable pollution management activities and adopt ways to improve their production processes.
- With the presence of the Ghana Environmental Protection Agency in Tema, technical support can be provided to industrial actors in the areas of process improvements and product development techniques. Moreover, monitoring and other regulatory activities are not expensive to organize.
- Expanding on currently rising awareness on problems and opportunities in Tema, industries, government and communities could establish a platform for information exchange and the development of a common vision.

5.5 Backbone for opportunity discovery in OPiC

The objective of this study is to develop a framework for pollution management in developing countries based on the analysis of problems and opportunities. In this section, I try to draw conclusions from the preceding discussions that would help in the identification of opportunities for environmental management. As shown in figure 5.10, opportunities may arise from problem analysis, from general industrial concepts and from human creative capacities, all of which may be enhanced by a stimulating context of discovery.

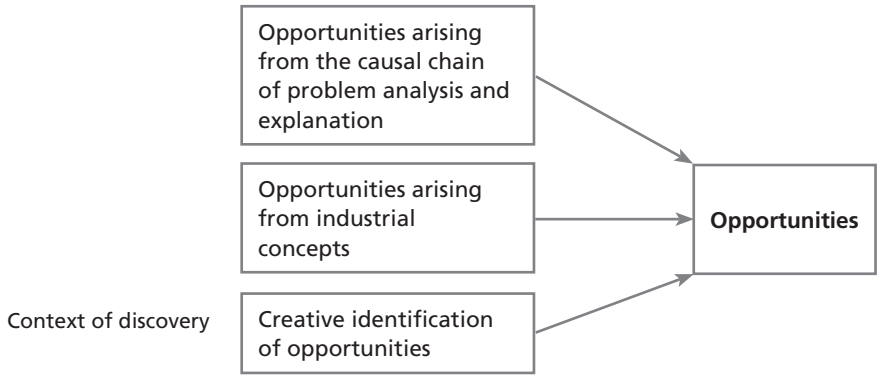


Figure 5.10 ■ Components of opportunity identification and discovery

Options arising from analytical tools

Option identification based on the causal chains of OPiC's problem analysis and explanation

Each causal connection identified in OPiC's problem analysis and explanation is a potential source of an option for problem abatement. Roughly, the problem analysis generates the physical options for solution while the problem explanation generates the social, economic and cultural ones. The full list is:

- *Options identified in the problem analysis* may either concern to interrupt the causal chains that connect problem components to each other (e.g. isolate toxic substances from recipient populations) or to improve capacities to withstand environmental stress. Typical features are, for instance, clean-up and dredging that decrease environmental burdens, planting trees against erosion and using lime against acidification to increase environmental capacity, integrated ecosystem restoration and management actions, waste treatment activities and waste mitigating measures.
- *Options directed at the actor's options,* e.g. by undertaking opportunity-oriented research and offering these new options through extension, carrying out actions that increase the implementation capacity of actors through the provision of economic, social, environmental, moral, organisational and physical resources (for example credit or training programmes), or use direct regulations to decrease the implementation capacity of actors for non-sustainable activities. In developing countries, the revival of traditional technical and social options should always be one focus of attention.
- *Options directed at the actor's structural motivations, which* could be realised by financial and juridical internalisation using price mechanisms, juridical liability and environmental investment security and social internalisation through decentralisation, partnership, participation, information sharing and negotiation with actors with varying views. Actions such as removal of 'perverse'

subsidies on unsustainable activities, regulations to promote energy efficiency, investment incentives to encourage eco-efficiency, adjustment measures for sensitive sectors (e.g. energy), and information campaigns could be undertaken to realize these opportunities, all depending on the findings of OPiC's problem explanation.

- *Options directed at the actor's culture* focus on the interpretations of actors of the structural motivational factors. Types of options here are environmental information and education, for example using storytelling as a tool to present the potential beauty of nature and the environment and the ways through which older generations preserved the ecosystem, and support the spread of environmental ethics views and practices.

OPiC's problem explanation does not only yield options for policy *content* as described above, but through the tool of actors field analysis, it also helps to identify potential policy *target groups* (which may include government agencies insofar these contribute to the proliferation of environmental problems because of inappropriate policies or corruption).

As part of the options directed at the actors' structural context, actors causing environmental problems should be made to bear the majority of the responsibility of the environmental impacts of their products. That is, the actors must be involved in physical management of their activities and the impact of their activities through the development of technology or provision of services. Policies that would bring actors to bear the environmental impact of their products should be developed. In addition, actors should be encouraged through incentives to under take eco-designs to improve product design and improve production processes by utilizing existing knowledge about products, ideas and technologies from solutions developed with local raw materials and upgrade indigenous and existing processing technologies to provide new opportunities for product development.

Options for opportunities from OPiC should preferably be identified by joint inquiry of stakeholders focusing on performance and stakeholders who are in a position to provide opportunities in their own practices. Networking among different organisations and departments in order to share information about pollution management goals is also helpful. The presence of institutional structures such as already existing environmental, social and economic departments may provide the opportunity to enhance pollution management. Also, positive institutional changes such as legislative changes and the adoption of new policy statements and new approaches, which can give rise to the promotion of traditional institutions in pollution management and the adoption of centralisation and decentralisation polices where necessary are potential opportunities for pollution management. These opportunities could be identified by carrying out an institutional analysis.

Options based on life cycle thinking

The life cycle of products is the second major element in OPiC's problem analysis. One great opportunity enhanced by this approach in developing countries is the introduction of local materials and processes in industrial and infrastructural activities.

Moreover, life cycle thinking lays the basis for Extended producer responsibility (EPR) as a pollution management opportunity. The use of EPR will make actors try to find ways to minimise the cost associated with end-of-life management by changing the design of products. Such changes to the product would result in the reduction of waste problems and the provision of appropriate infrastructure for separation and recovery. The demand for separation and recovery crated by EPR moreover has a positive effect on employment and reduces the burdens of waste management authorities and tax payers, stimulating as it does the participation of the private sector in waste prevention and management.

Opportunities arising from industrial concepts

Cleaner production

The concept of cleaner production should fully be adopted and supported. Since this will enable actors to achieve optimum resource (energy and raw material) consumption per unit product through improved production efficiency. This however requires taking concrete steps to address the technological and financial challenges as well as promoting a more holistic and customized CP concept as the basis for a more outward looking and synergy-searching attitude, overarching idea and opportunity that fits the activities or task at hand.

Resource flow analysis

A resource flow analysis approach should be used in a qualitative or semi-quantitative manner to understand the various resource flows in an area and use it for planning. That is, knowing the resources that are coming into the geographical areas, the type of finished product produced and the waste generated and how the waste is managed. This is because of non-availability and accessibility of data and the often large informal sector involved in industrial activities. Such an understanding could help societies and communities assess the opportunities available to them by maximising productivity, and to more fully assess the threat from of the use or misuse of resources. This would advance positive radical change in industrial resource efficiency reduction in environmental problems in developing countries. Specific applications of industrial ecology concepts in developing countries might take different forms and depths depending on the scope of the region, the nature of industrial activities in the geographical location, and the desirable objectives to be achieved. Typical opportunities arising from resource flow analysis would concern the efficient use of resources and the development

of industrial parks where waste of one industry is used as resource by another industry.

Material Flux Analysis
Material Flux Analysis should be used as a tool to support policy decision making in the field of resource and environmental management in developing countries especially in early recognition, priority setting, to analyse and improve the effectiveness of measures and to design efficient material management strategies. It should used to complement traditional environmental and resource management strategies, which have tended to focus heavily on specific environmental compartments, and measure the concentration of substances in various media to highlight current and potential material accumulations which represent either potential environmental problems or a potential source of future resource. Such use of MFA could assist precautionary policy making without relying on signals of environmental stress. It could also be used on regional basis as part of a regional environmental management and audit system and would allow planners to identify the key processes for environmental protection and resource recovery and provides information which allows the adoption of most effective measures and strategies in the defined system. Typical opportunities arsing from material flux analysis comprise, for instance, the sustainable use of resources, improved production processes and reuse and recycling of waste.

Creative identification of opportunities
The third route for the identification of options for solutions includes the following:

Traditional ecological knowledge
Traditional ecological knowledge is an important source of identifying opportunities. Knowledge and innovation systems should be developed to provide room for a learning perspective. Methodologies and tools like participatory local appraisal, focus group discussion, advisory committees and multi-attribute elicitation should be used to bring out technology and insights from lay persons and experts so that they can learn from each other and develop or renew environmental management practices. The creative use of traditional knowledge may also be built into existing regulatory participation such as in EIA.

Using dreams
Actors in developing countries are receptive to linear thinking since it appears to give rise to a sense of predictability and control. However, in reality, inventors and successful executives rely on intuition for many major decisions. Therefore, the promotion of dreams as a way of developing one's intuition should be encouraged. Actors should be made aware of the potential of dreams in solving problems.

Enabling creativity
Identify opportunities to improve the knowledge and information system of organisations (industrial, political or traditional) in their decision-making process and exchange information among actors with the aim of improving the potential of learning and innovation. The opportunities here should be identified by joint inquiry of stakeholders.

An enabling context for opportunity discovery
All three main routes for the identification of options for solutions will be much more fruitful if some basic conditions are fulfilled. These form the context of options discovery.

A basis in routines
Environmental and ecological accounting are tools that could not only help much to support decision-making of industrial actors in developing countries, but also lay a basis for opportunity discovery. For the effective use of environmental accounting, there is a need to identify the internal and external functions of firms in the form of a common database. Organisations should accurately measure their own environmental cost and the effects of environmental measures and define the time frame being addressed, the length of time and the routine of information which is necessary for the development, and operation of effective environmental accounting systems. Where traditional accounting systems already exist in organisations, environmental accounting experts should team up with traditional accounting experts.

A basis in people
All identification and implementation of innovative options require a certain degree of daring from the side of environmental managers and decision-makers. With that, the self-efficacy of actors becomes an important element in the context of options discovery. Self-efficacy is defined as a person's judgement of his/her own capability to organise and execute courses of action. Self-efficacy has a special relevance for developing countries because people in pollution management often feel inferior to Western experts or are locked up in authoritarian management systems that reward the passive execution of tasks. Self-efficacy can be enhanced by way of persuasion, training, support groups and role modelling.

A basis in learning
Learning behaviours and strategies are an essential element in the context of discovery of options for solutions. At the same time, they are often a weak spot in pollution management especially in developing countries, e.g. because of too static perceptions of what learning entails. Organisations involved in the management of environmental problems in developing countries currently appear to engage

mostly in incremental adaptations ('single-loop learning') rather than changing both beliefs and practices ('double-loop learning').

Since organisations are inherently focused on efficiency and routines, organisational learning does not happen easily. For more dynamic learning in pollution management organisations in developing countries, constructivism and action learning appear to be the most suited paradigms. This learning should be anchored in personal experiences of pollution management actors. Preferably, this should be organized with an emphasis on groups that enable interaction among these actors. The outcome of this collective learning is then not only the emergence of collective understanding of the problems studied and discussed, but also an openness of mind that stimulates the discovery of creative options for solutions.

6 Design, implementation, monitoring and evaluation

Design, in the words of De Groot (1992), is the selective combination of options (opportunities) to form the higher system level of a plan. Rephrased for the subject matter of the present study, design is the selective combination of opportunities identified through the methods of chapter 5 to form the higher system level of a pollution prevention or management strategy. The chapter is organised as follows:

Section 6.1 ■ Instruments for pollution management strategies
This section starts out by a round-up from the preceding chapter and then continues to review the general policy instruments that overarch especially the social options for pollution management. These are the economic, legal and social policy instruments, and conflict resolution.

Section 6.2 ■ Overall features of pollution management strategy
In this section I present co-management, participation, adaptive management as the key strategic principles for pollution management in developing countries. At the end of the section I present selective combination of features guided by a 'participatory adaptive co-management' style of strategy.

Section 6.3 ■ Design, evaluation implementation and monitoring
In section, I present a design process for pollution management guided mainly by efficiency and sustainability principles. A two-tier evaluation which involves an equity test, an efficiency test and an adaptability test of designed solutions before implementation of the optimal design is sought. Ways to support the implementation of the chosen solution are proposed. Aspects of monitoring that are essential for the improvement of the implementation strategy through adaptive feedback are noted.

6.1 Instruments for pollution management strategies

As shown in the preceding chapter, the study of specific environmental problems may yield a wide array of opportunities that are well grounded in the specific problem in its context. In the present section, I will take a look at the same array of opportunities. I move away, however, from their embeddedness in specific problems and contexts but take a look at a more fundamental level. In other words, I will discuss some basic characteristics that broad groups of opportunities have in

common. I will do so under the purview of the classic distinction between market-based, regulatory and communicative policy instruments, added to which are conflict resolution tools. The insights gathered that way are of great relevance to the design of pollution management strategies because they help define combinations of options such that coherent and synergistic overall pollution management strategies in developing countries may be reached. For the sake of completeness of the chapter, the next section starts out with a simple round-up of types of options identified in Chapter 5.

6.1.1 Round-up from the preceding chapter

Every actor or factor that influences a pollution problem directly or indirectly, can potentially be changed, i.e., generate an option that contributes to solve the problem. In chapter 5, this principle has been used to identify options based on the causal chains of problem analysis and problem explanation (Fig. 4.14). Going from top to bottom in the Figure (*i.e.* upwards in the causal stream), types of options are (1) those that leave environmental ('ambient') concentrations intact but reduce their impacts on humans and biodiversity, (2) those that leave emissions as they are but reduce the resulting ambient levels, (3) options to leave industrial products and processes as they are but reduce the associated emissions, (4) options that leave industrial processes as they are but focus on improved products, (5) options to improve industrial processes.

Identification of such options is helpful to clarify in which direction industrial actors should most effectively change their ways, but does not tell why actors should do so and how these behaviours might be influenced. It is here that the life cycle and explanatory parts of OPiC (see Fig. 4.15) come to help. The life cycle element, for instance, points at Extended producer responsibility as a tool to make actors try to find ways to minimise the cost associate with end-of-life management. Additionally, concepts from industrial ecology, especially those focusing on the analysis of material flows help to specify options such as industrial parks and preventive pollution management.

The social-scientific explanation of the behaviours causing the problem offers the second avenue to identify options that address pollution behaviours. These options concern:

- Options to enlarge the implementation capacity of actors. Examples of such options are credit schemes and training programmes.
- Options to restrict the implementation capacity of actors. This option serves as a deterrent for actors to undertake activities that are not environmental friendly. Typical examples are permit conditions and other regulatory instruments, see section 6.1.3.

- Options to redirect economic motivations of actors. This option is linked to the market-based tools discussed in section 6.1.2. A typical example is to put a levy on pollution.
- Options to redirect non-economic motivations of actors. This option builds on the principle of care for the environment where actors are made to understand and appreciate the non-economic benefits of natural resources. Here, communication tools are used to educate actors, e.g. on the ecological issues and community responsibilities towards the environment.

These socio-economic options can be directed at all or any actor ('target group') in the actor-to-actor causal linkages (the 'actors field') identified in the in the problem explanation component of the OPiC framework.

The discovery of options does not need to be based in analytical tools only but may also be enhanced by creative approaches, such as tapping traditional ecological knowledge and stimulating personal and group creativity and dreams to identify opportunities.

The identification of options is not an isolated process but embedded in a 'context of discovery'. Important enabling elements in the context are the self-efficacy of actors, the use of environmental accounting and actors engaging in collaborative learning.

6.1.2 A review of market-based instruments and principles

Various opinions exist about what market-based tools include. I follow the definition of OECD (1997) which states that market-based tools are 'those policy tools which may influence environmental outcomes by changing the cost and benefits of alternative actions open to economic agents. They aim to do so by making the environmentally preferred action financially more attractive.' Obviously, this definition coincides with one type of options identified already in Chapter 5 (see preceding section). This section is aimed to add general insights to this type of options, in order to give more depth to policy design.

The use of market-based tools in pollution management has long been promoted by economists for its unique feature of incorporating environmental concerns directly into the market economy. Because the market-based tools do not prescribe technologies to be used, they enhance the efficiency of pollution management, with actors (producers and consumers) free to search for the most cost-effective way to respond to the changed incentive structure. Based on the work of Stavins (2000) and Gee (1997), I categorize market-based instruments and principles into (i) charges and taxes, (ii) tradable permits, (iii) environmental performance bonds and deposit refund systems, (iv) subsidies and environmental funds, (v)

environment-oriented tax reforms, (vi) polluter pays principle, (vii) eco-labelling, and (viii) direct payments for environmental services or goods.

Charges and taxes

Charges and taxes are based on the polluter pays principle, according to which the party causing the pollution should bear the cost of the pollution falling on others (Gee, 1997; Winpenny, 1998). The idea behind taxes and charges is that to raise the cost of the offending parties will produce an incentive for actors to reduce or cease the practices concerned, and in some cases raise revenue for the parties that are affected. That is, the higher the cost of polluting, the less the polluters will pollute. Elements in an economic process that are taxable include input factors, emissions, production and consumption. In practice, the emphasis is on taxes on inputs and emissions (Verbruggen, 1998). The European Commission (1994) contends that taxes on input factors are preferable to taxes that intervene directly in the choice of production and consumption, because that this will help in eliminating pollutants and at the same time promote wise use of inputs.

It is important to differentiate between charges and taxes. Charges are payments which are administratively used for resources, infrastructure and services and are akin to market prices for private goods. They are compulsory required payments in proportion to services provided by the government. In contrast, taxes are compulsory unrequited payments to the government, with which specific collective goods are provided that are not directly related to the payments. Examples of charges include emission charges, effluent charges, and product charges. Some of these are direct user charges used to finance facilities. Others are indirect charges and fees imposed on beneficiaries of activities such as environmental clean-ups. An example of direct charges is in Thailand where they are used to address water pollution from households, small industries and large industries (Phantumvanit et al., 1994). Taxes include environmental emission taxes, effluent taxes, differential taxes and input and final product taxes. Taiwan has used tax differentiation between leaded and unleaded gasoline to address air pollution from mobile sources (O'Connor, 1994).

Tradable permits

Tradable permits are tools used to mimic market conditions in order to create markets in environmental quality in which the right to use or pollute the environment is assigned a price and traded. The basic idea of tradable permits is that firms sell or buy pollution permit quota of which the total amount corresponds to a tolerable level of pollution. It is based on the reasoning that if such market transactions take place, the cost of pollution abatement will be minimised. The tradable permits system involves determining the volume and nature of effects beforehand upon which the price for a permit is issued. In most cases, the market price of the permits is not known in advance because the price depends on the

interaction between the supply and demand curve, as well as the way the permits are initially issued. In situations where demand for permits is high, polluters will be motivated to abate pollution from the source (Verbruggen, 1998; Anderson and Sprenger, 2000; Rietbergen-McCracken and Abaza, 2000; Thomas, 2003). Hence, this tool is suitable in situations where the amount of available environmental space is fixed.

To date, there has been little experimentation with tradable permits in developing countries. Singapore has been a pioneer in this approach, using competitive tenders for permits to import and use ozone-depleting substances, specifically, Chlorofluorocarbons (CFCs) regulated under the Montreal Protocol (O'Connor, 1991). An example of tradable permits is tradable discharge permits which may be divided into credit programmes, which gives permits only to additional reduction from the standard, and the cap and trade system, which gives permits to all pollution and tradable emission permits which the right certificate is showing the pollution emission unit in a certain period (Stavins, 2000). At present, much experience on tradable permits is being gathered under the Kyoto protocol, and another source of knowledge on tradable quota, there called Individual Transferable Quotas (ITQs), is found in fisheries management. In both arenas, it is found that the argument that tradability guarantees overall efficiency meets counter-arguments that are based mainly in the principles of equity or other elements of distributional ethics. Is it justified, for instance, that rich countries could pay for all their carbon dioxide obligations in foreign countries? Or, could it be socially justified that all fishing quota would finally end up in the hands of a few highest (*i.e.* most efficient) bidders, so that local fisher communities would in fact cease to exist? Issues such as these are important for developing countries too, in order to arrive at morally balanced and politically defendable systems of tradable pollution permits.

Environmental performance bonds and deposit-refund systems

Environmental performance bonds and deposit-refund systems aim at shifting responsibility for controlling pollution, pollution monitoring and enforcement to individual producers and consumers who are charged in advance for the potential damage.

Environmental performance bonds are used as a means of dealing with uncertainty in activities and projects. It involves an independent analysis used to determine the social cost of the worst conceivable environmental outcome of an activity or project. Approval of the activity is then conditional on the party depositing a bond, which is part payment of the conceivable cost. The bond is fully or partially returned to the party at the end of the activity lifetime, defined by the longest-lasting conceived consequence of the activity. Environmental bonds may help ensure that resource extracting companies and potential polluters take ad-

equate measures to minimize the environmental damage caused by their activities and effect clean up activities and restoration of residual damage in the most cost effective manner (Anderson and Sprenger and Abaza, 2000; Thomas, 2003).

Deposit-refund systems, on the other hand, do not require monitoring of the environment to ensure performance of pollution but it is used to motivate potential polluters by letting them pay a deposit when buying or using goods and receive a refund if damage has not been done. In most cases, they are used in situations where pollution sources are numerous and different. Deposit-refund systems may help to reduce the return of by-products of production and consumption for recycling or treatment and safe disposal, or otherwise to finance their collection and return by others. This may make the use of deposit-refund systems in developing countries suitable for inducing labour-intensive waste collection activities in an environment of low-cost, abundant and unemployed labour. In the private sector, this may take the form of industrial and self-regulations. Examples of products in the EU in which deposit-refund systems are used are metals, glass and bottles (Winpenny, 1998; Anderson and Sprenger, 2000; Rietbergen-McCracken and Abaza, 2000).

Subsidies and environmental funds

Subsidies provide financial assistance to motivate individuals or firms to act more environmentally-friendly by promoting the consumption of environmentally friendly products and services. While it is argued that the economic rationale for such schemes is weak, contradicting as they do the polluter pays principle, subsidies play an important role in enhancing the acceptability of the taxes and charges. Thus, subsidies may be used to reduce compliance costs in relation to specific environmental regulations in the form of grants, soft loans, or tax allowances. Subsides could also be used to express positive external effects that are not included in markets, with the non-polluter receiving money to rectify the existing market distortion. Subsidies may be financed through the general budget or through earmarked revenues collected from specific charges and re-allocated for specific environmental purposes. An example of subsidy is in Indonesia where imports of equipment for effluent treatment plants are subject to a concessionary rate of custom duty (Phantumvanit et al., 1994).

Environmental funds are programmes which make available loans to finance environmental protection and resource management measures through public or private sector banks. Environmental funds may be refinanced partly from national budgets and partly from environmental charges, taxes or fines for violations of environmental legislations. A number of developing countries have established environmental funds to finance certain environmental expenditures.

Environment-oriented tax reforms

Environment-oriented tax reform is based on imposing taxes on environmental 'bads' such as pollution and the inefficient use of energy and resources, with the possibility of achieving multiple gains (Gee, 1997). The following working definition has been produced as part of a European-wide programme on environment-oriented tax reform: 'environment-oriented tax reform involves the shifting of a large portion of taxation from the value-adding activities of people such as employment and savings to the value-subtracting use of energy and resources and associated creation of waste and pollution'. An environment-oriented tax reform package includes measures such as removal of subsidies on unsustainable activities, regulations to promote energy efficiency, investment incentives to encourage eco-efficiency, adjustment measures for energy intensive sectors, and information campaigns.

There are three main reasons why environment-oriented economic tax reform is beginning to attract attention in pollution management (Gee, 1997). First, the combination of budget deficits, tax evasions and declining conventional tax basis. Secondly, the distortion effects of current taxes, especially the distortion caused by subsidizing economic activities that cause pollution problems, or taxes that encourage unsustainable behavior. Thirdly, the failure of market prices to capture the full cost of production, use of goods and disposal of waste.

Polluter pays principle

OECD member countries first propounded the idea of the polluter-pays principle in 1972 when strict regulations were introduced, and complaints about high costs and negative effects on competitiveness were beginning to emanate from industry (OECD, 1975). At that time, the polluter pays principle simply said that polluters should bear the full cost of meeting environmental regulations and standards and no subsidies were to be given to help in this process. It has since evolved to become a broader principle of cost internalisation and economic policy concepts used in relating the expenses of carrying out pollution prevention measures or to pay for the environmental damage that their activities produce. In other words, the cost of the measures is to be reflected in the cost of goods and services which cause pollution. The polluter pays principle does not easily fit situations where the product itself becomes the pollutant in a subsequent life cycle stage, or where the product embodies significant pollution from earlier life cycle stages, or where the use of the product creates pollution indirectly.

Eco-labelling

In spite of the fact the eco-labeling is not traditionally seen as a market-based instrument but as an information and communication targeted instrument, I have decided to review it under this heading because of its potential to lever behavioural change by making existing private markets work better.

Eco-labelling is a way of making distinctions on a product label on the basis of its environmental merits, usually assessed over its whole life cycle through some form of LCA. Currently, there are numerous eco-labelling schemes operating worldwide. As a result of this abundance, the International Standardization Organization (ISO) has developed a set of standards for environmental labels, the ISO 14020. These standards distinguish between three kinds of labelling. With one additional type, these are:

- Type 1 eco-labelling – These are third-party labels which are voluntary programmes that award labels expressing overall environmental performance of products within a particular product category (Kuhre, 1997). This means that products fulfilling requirements decided upon by an independent body are awarded a label to use when marketing the product. An example is the Nordic Swan.
- Type 2 eco-labelling – These are first-party environmental labelling programmes where labels and environmental claims are not certified by any independent body. The labels are done by producers as a way of marketing the products' environmental attributes. Claims can be like 'recyclable' or 'biodegradable' or have a neutral reporting character.
- Type 3 eco-labelling – These are third-party certified reporting cards providing neutral environmental information on which the consumer can base his/her purchasing decision (Kuhre, 1997). This type of eco-labelling is often geared towards professional buyers in the business and public sector.
- Mandatory labels – These are not part of the ISO 14020 labels but are typically eco-labels administered by government authorities that often have some kind of warning function. They are mainly referred to as negative labels with the objective to inform the customer on the health and environmental risks in the product (Davis, 1998). Examples are labelling of poisons and tobacco products.

Effective use of eco-labelling in developing countries requires a comprehensive and continuing campaign of public education so that the public will be aware of the environmental problems addressed during the production process of products. In addition, customers have to know that eco-label products exist and look out for them to make informed choices between products. Critical issues, such as openness during the design of the system and accessibility to the complex certification process by foreign producers of other countries should be considered during the design process.

Direct payments for environmental services and goods

The logical flipside of the polluter pays principle is that the producer of environmental goods should get paid. The moral and political status of this principle is ambivalent, however, since the production of environmental goods is to a large extent an element of normal citizen duties. If we stop for a red traffic light, for instance, we produce traffic safety but we do not get paid. Yet, the idea of direct payments has

recently drawn more attention, especially in cases where the production is regarded as lying above the unremunerated basic duty and payment is practically essential for the environmental quality provision, or an efficient alternative for indirect payment (Borgerhoff Mulder and Coppolillo, 2005). As an example of the latter, direct payments to farmers in the Netherlands for the number of meadow birds on their land may be a good alternative for subsidies on meadow birds, enhancing measures such a low manure gifts or late mowing dates. Or: why should the world community not pay per hectare of high-quality rainforest, in stead of financing rainforest protection projects (De Groot and Kamminga, 1995)? The idea of direct payments is also at the basis of the concept of Payment for Ecosystem Services (PES) that is being applied, for instance, to compensate upstream communities for watershed protection on behalf of downstream interests.

Application of market-based instruments in developing countries

Charges on water polluting effluents are relevant for developing countries because they can differentiate between the size and location of polluters. In order to overcome the problem associated with monitoring and enforcement, it should be considered to adopt methods for the determination of charges that do not depend entirely on monitoring. For instance in Tema, as is the case with private households in developed countries, industries could be charged a standard rate, to be reduced if the industry can show it has a (working) treatment plant.

Product charges should be used to discourage consumption of specifically harmful products and/or encourage reuse and recycling of reusable materials. For example in Tema, product charges could be imposed on plastic bags, which are causing a problem with solid waste management in the city.

Tax differentiation needs to be given the necessary attention in pollution management especially between taxes on environmentally friendly and unfriendly products for example through the use of differentiated value-added tax. For example in Ghana, differentiated taxes could be used to address air pollution from vehicles using leaded and unleaded gasoline.

Subsidies could be used to assist small firms that lack finance to meet capital investment in pollution control and compliance to new regulations and prevention strategies. Subsidies in the form of refunded charges for environmental improvement could be used as tools for obtaining the agreement of the industry of other financial tools. Subsidies should be institutionalized in the value of economic assets such as shares and infrastructure development, so that it results in capital gains with little influence on behavior towards more environmentally benign activities and practices. In addition, subsidies should be used for a short period in other to allow for the creation of incentives that would increase actors' compliance with environmental standards and also help focus on the improvement of specific en-

vironmental outcomes. For example in Tema, refund charges for environmental improvement could be instituted with industries and this would motivate them to carry out pollution management activities.

Tradable permits could be used to manage especially air pollution since they allow actors to set up new firms in highly polluted areas without increasing total pollution levels. With the current quest for economic growth in developing countries, the application of tradable permits is helpful so that efforts of industrialization and economic development are not retarded. For example in Tema, tradable permits programmes aimed at air pollution control could be carried out with effective monitoring and enforcement as the key backbone.

Deposit-refund systems could be used in solid waste and hazardous waste management sectors since they have high administrative efficiency by self-enforcement and require less administrative input. They may be suitable for reducing littering and waste disposal cost and for conserving material inputs. A possible way, for instance, is imposing deposit-refund systems on toxic and hazardous substances that are imported into the country, and the deposit refunded to the final recyclers or exporters of the substances.

Eco-labels could be applied to rectify trade. There should be transparency in the development and application of mandatory and voluntary eco-labelling systems by providing appropriate notice and opportunity for consultation with producers. The concept of ecological equivalence should be applied in the criteria setting process of eco-labelling schemes as presented in the preceding discussion. This includes greater harmonization of eco-labelling, convergence of procedures, and equivalence and mutual recognition approaches, where appropriate.

6.1.3 A review of regulatory tools

Environmental regulations (contrary to market-based instruments) directly prescribe desired states of the environment, emissions or technologies. The major trend of environmental regulation regimes is a shift from 'coercive regulation' to proactive 'co-regulation' thereby promoting the precautionary principle. The currently underlying ideas with most environmental regulatory tools are to improve economic efficiency, avoid and or reduce risk to human health and the ecosystems in a justifiable and equitable manner (Luneburg, 1998). Environmental regulations may be classified in three types: (*i*) environmental standards, (*ii*) international environmental regulations and (*iii*) domestic environmental regulations.

Environmental standards

Environmental standards are one of the oldest tools used in pollution management to protect the environment and human health by defining maximum per-

missible pollution levels. Due to scientific uncertainties, there is always a safety factor that is incorporated into the guideline values. Following OECD (!985), standards are established based on environmental criteria but also taking technical, economic or political considerations into account when necessary. Technological criteria are used to determine how feasible environmental standards are in terms of their enforcement and development. Economic criteria evaluate the costs and benefits of the environmental standards. Political criteria are used to determine constraints and opportunities with the use of environmental standards in society.

Going upstream in OPiC's causal chain and following the work of Field (1997), I classify environmental standards into the following three categories:

- *Ambient standards* – These are the acceptable average concentrations set in a certain period of time for a pollutant in environmental media like air, water and soil. They are set in accordance with geographical location, the concentration of population, and the nature of the pollutant. This makes ambient standards for average vary from one place to another.
- *Emission standards* – These indicate the amount of emissions permissible for a polluter. Emission standards can be formulated in various forms such as the total amount of pollution during a certain time period, concentration standards in waste lows, emission amounts per unit of energy consumption, emission per unit production, or recycling rate. Following OPiC, emission standards should be derived from the ambient standards, using empirical relationships between emission and ambient concentrations, e.g. in a diffusion model.
- *Technology standards* – These regulate production technologies and abatement technology. There are different regulations based on different types of technology standards. Typical examples include obligation for end-of-pipe purification, process prescriptions and input regulations. Technology standards should be derived from emission standards.

There are two different approaches for establishing environmental standards: (1) a substance-related approach and (2) an integrated risk assessment approach (Hens and Vojtisek, 1998). A substance-related approach is mainly used in setting health-oriented standards for individual substances. The limitation of this method is that it provides only very partial information on the impact on ecosystems and the impacts groups of substances, which may work synergistically. Effects on single species in a laboratory are often different from the interactive effect on and in ecosystems. Integrated risk assessment, on the other hand, attempts to take all relevant experimental and practical data into account in order to protect not only health but also ecological functions (see section 4.1).

Environmental standards appear to be useful in curbing the amount of pollutants released into the environment. The problem, however, remains that there is a lot

of dynamics and patterns involved between groups of pollutants and ecosystem are yet to be known. This calls for the need to use alternative approaches (Stara, 1984; Mumtaz et al., 1993). Two of these approaches that go beyond legal regulation of single substance are international regulations and voluntary agreements.

International environmental regulation

International environmental regulations refer to public agreements and declarations stipulating what countries should do and not do in order to tackle pollution problems that transcend national boundaries such as air pollution. Following Desambre (1998), international regulation is made up of international law, soft laws and scientific cooperation.

There are two main approaches to making international law. In the first, authority for regulation is delegated to a committee and/or organization. International law of this 'delegatory type' involves empowerment of representatives of the participating countries to make decisions on regulation through voting. In most cases, decisions taken through this approach are binding on actors and do not require rectification. However, countries who do not agree with the majority decision may decide to opt out. A major problem with this approach is the free riding of countries that decide to opt out and take advantage of the actions taken by the others.

The second and most common approach to making international law are the international conventions. In this, the initial convention is first negotiated and then followed by protocols, amendments and ratifications by member countries. The result is that country practices come into operation due to country obligations. A unique feature of the convention approach is that they are re-negotiated when circumstances change. This has made conventions a flexible approach to international environmental policy-making, responding to the changes in both the knowledge and understanding of environmental problems which are taken into consideration. This has helped in the gathering and sharing of information as well as monitoring of the environment. A typical example of an international environmental convention is the 1987 Montreal Protocol on substances that deplete the ozone layer. Other examples are the Convention on Biological Diversity (CBD), the United Nations convention to combat desertification (UNCCD) and the Kyoto Protocol concerning the global climate.

Soft laws often contain no legally binding obligations but countries are required to declare what they intend to do by adopting codes as a way of documenting their intentions. It is generally a way where countries' collective intentions are used to address international environmental problems and sometimes set principles about the way in which they intend to do so without accepting binding obligations. A typical example of this approach is the Rio declaration on Environment and Development, which urges all countries to conserve, protect and restore the

health and integrity of the earth's ecosystem, but does not state the way countries should do so. The result of this is that most countries take voluntary actions as well in order to comply with the international declaration though all in a different way and to different degree (Desambre, 1998).

Scientific co-operation in one way or the other includes the setting up of independent scientific bodies for the co-ordination of research efforts and sharing of information (Desambre, 1998). Scientific co-operation is used as a way to provide scientific evidence to countries in order to reduce the uncertainty involved in environmental problems. It is based on the consensus and evidence presented by scientists, which, in turn, is used to persuade countries that are reluctant to participate in international initiatives towards environmental problems. An example is the development of the Framework on Climate Change instigated by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP).

Not mentioned by Desambre (1998) but of great relevance especially for developing countries is international assistance. This is mainly in the form of establishing funding mechanisms and technology transfer programmes to help meet obligations that developing countries are expected to have for the protection of the global and domestic environment. Developed countries and major international organizations such the World Bank and IMF are the major players here. An example is the Global Environment Facility (GEF) that provides funds to address issues of global warming, biodiversity, international waters and ozone depletion, so that countries can afford to fund environmental management actions and meet international standards.

Voluntary agreements

Voluntary agreements cover a broad array of voluntary environmental commitments of industries and governments. Voluntary agreements provide a forum within which individuals formalise mutual arrangements and at the same time represent their own interests as they see fit. The key concept is the recognition of individual rights and obligations, governed by an ethical code. The characteristics of a number of voluntary approaches differentiated by several typologies have been developed (Salisbury and Weiderkehr, 1995; Storey, 1996). Using a simplified version of a typology by Borkey and Leveque (2000), I distinguish between three types:

- Unilateral commitments, consisting of environmental improvement programmes set up by individuals and firms themselves and communicated to their stakeholders. The parties individually determine the definition of the pollution targets, as well as the provisions governing compliance.
- Public voluntary schemes, in which participating firms agree on standards related to performance, technology, and management developed by public bod-

ies such as environmental agencies. The schemes define the pre-conditions of individual membership, the standards to be complied with by the firms, the monitoring criteria and the evaluation of the results.
- Negotiated agreements, sometimes referred to as covenants, which are contracts resulting from negotiations between public authorities and industry. The industry and the public bodies jointly define the content of the contract.

The goal of voluntary agreements is to achieve environmental benefits beyond what the law requires. They build on the consensus among stakeholders to jointly take concrete steps towards pollution management while the details of regulations are still evolving. The practical effectiveness and efficiency of voluntary agreements depend on a clear interpretation of the agreement and clear responsibilities of all the parties and also information on and monitoring of compliance parties' involved with the agreement.

Applicability of regulatory tools in developing countries

Most of the states in developing countries are weak vis-a-vis the pollution actors. They lack the technical power to control the fine-grained activities of many small actors such as individual waste recyclers or small local firms. They lack the political power to control large-scale actors and force them to comply with environmental regulations. Finally, they usually lack the necessary information to establish ambient standards and even more importantly, to translate ambient standards into technology prescriptions.

With this in mind, regulations used in developing countries should have a focus on technology prescription. This should be done in spite of the weak foundation in ambient standards. In other words it has to be based on some form of consensus between the state and pollution actors on what are the appropriate technologies in the given location. This consensus has to be strengthened by NGO and community involvement (see section 6.2) and environmental communication (see section below). A good approach for developing countries would then be an NGO-strengthened co-management approach with support from the state and the pollution actors. A typical example is the development of a public agreement, per sector or (probably preferably) per location, that is overseen by some (national or international) independent body, trusted by the state and the industries alike. For instance, in Tema, an agreement with industries polluting the Chemu lagoon could cover the restoration of ecosystem and identify more sustainable ways of disposing of pollutants.

Voluntary agreements could be used to tackle pollution problems within a framework that considers broad issues of inter-generation sustainability. This is because voluntary agreements give little room for technical details, making them less suitable as a means of tackling pollution problems that require detailed technical

analysis and need to be resolved as a matter of urgency. Voluntary agreements should be used to complement command-and-control regulations.

Environmental regulations may play a vital role in pollution management in developing countries. It is, however, recommended that environmental regulations are used jointly with other pollution management tools, since they will usually need the consent and support potentially created by market-based and communicative approaches, strengthened by NGO and community involvement.

6.1.4 Environmental communication and education

Currently there is no single agreed definition of environmental communication. According to Leal Filho (1998), environmental communication 'is a modality of communication concerned with environmental matters and which takes the particular characteristics of environmental issues into account, including their complexity with the ultimate aim of providing information which is clearly understood, unambiguous and scientifically accurate'. The modality referred to here deals with disseminating environmental information and communicating environmental issues to the public through different media. Thus, environmental communication is the sharing of information, insights and opinion on environmental issues, trends, conditions and solutions using any means of communication ranging from inter-personal methods to means of mass communication.

According to the Environmental Stakeholder Initiative (ESI) approach, environmental communication can be of a rather informative nature such as environmental reports or of a consultative and participatory nature such as stakeholder participation and political lobbying for achieving environmental improvement (Grafe-Buchem and Hinton, 1998). In this section, I concentrate on informative and consultative environmental communication tools that is, mainly a 'one way process' with an option of giving feedback. An important environmental communication tool based on this approach is environmental reporting.

Environmental reporting

Environmental reporting, a tool used to communicate environmental information to the public, evolved through the adoption of the National Environmental Act (NEPA) in the USA in 1969. The Stockholm conference in 1972 drew attention to providing environmental, social, cultural and economic information to be easily accessible. Recent developments in environmental communication take their roots in the Earth Summit in Rio de Janeiro, 1992, where the provision of relevant information in a readily accessible form was considered as a key to achieving sustainable development. According to Mitchell (2000), the aims of environmental reporting are (*i*) to provide warning signals to decision makers about changing environmental conditions, (*ii*) identify gaps in knowledge and

also sensitize the public about decisions and actions, and (*iii*) to encourage accountability of public agencies for their decisions and initiatives. This task has resulted in the evolution of a number of competing and complementary models of environmental reporting.

On the government level, environmental reporting is used to describe the state of the environment and to communicate information on the current and future trends in environmental quality and the state and the use of resources, and show their potential social and economic implications. Moreover, environmental reporting describes the policies, programmes and actions being taken at different levels to deal with effects on the environment, development and use of natural resources and outlines actions required to address weaknesses in current environmental management policies (Nelson, 1995).

On the company level, environmental reporting is the disclosure of information about a company's environmental status, performance and initiatives to a variety of stakeholders (Richardson, 1996). Environmental reporting should explain a firm's environmental management system and try to identify people who are responsible for implementing the environmental programmes and at the same time show levels of awareness of employees and explain measures taken to improve environmental performance. Company-level environmental reporting has taken a different turn recently such as companies preparing environmental reports even when there are no legal requirements. Two main driving forces are behind this change. The first is formed by governmental pressures in the form of defining activities that companies should implement in order to improve the quality and extent of environmental information. The second are market forces in the form of green customers, environmental associations and the mass media which influence the form and content of environmental reports (Azzone, 1996).

Concerning the subjects environmental reports should address, UNEP (1994) has presented a list of issues that should be taken up in environmental reporting. Additionally, we need to consider the institutions' perceptions about environmental issues, where these issues are placed on the management agenda and how the institutions are prepared to handle them, coupled with the identification of all stakeholders and the information they want to have (Kolk, 1999, 2000). As a kind of generally applicable structure for environmental reports, designed to reflect both the underlying structure of the environment and the inter-relationship within it, as well as the needs of the users, the 'DPSEA' model is usually recommended (Briggs, 1998: Mitchell, 2000). The DPSEA model consists of the following elements to be addressed:

- Driving forces (D) – the underlying factors such as economic development which leads to pressure on the environment. (This is represented in OPiC as 'social context')

- Pressures (P) – comprise the actions and activities associated with human use of the environment. (This is represented in OPiC as 'activities' and 'emissions')
- State (S) – refers to the measurable conditions of the environment, for example the extent and quality of its various resources and media. (This is represented in OPiC as 'environmental variables')
- Effects (E) – represent the wider consequences of the changes in the environment.(This is represented in OPiC as 'final variables')
- Actions (A) – relate to actions taken to protect the environment. (These are the 'activities' in OPiC.) The general trend of environmental reporting is to present past and present environmental initiatives and plans as well as evidence of an institution's environmental claims (Azzone et al., 1996).

In most cases, the content of environmental reports is influenced by who is producing them, the area for which it is being produced, the intended audience, the particular environmental issues that are of concern and availability of data. Key tools used in the preparation of environmental reports are adequate and agreed indicators.

Indicators and indicator systems for environmental reporting

Indicators and indicator systems are becoming a standard tool in environmental reporting and other activities such as pollution monitoring. They may also serve as criteria in multi-criteria analysis (MCA); see section 4.5. An environmental indicator is defined here as 'a measure which describes the state of, or trend in the environment or of factors affecting it in terms which are relevant to and readily usable by the decision–maker' (Briggs, 1998).

Currently, there are no standard procedures to identify relevant indicators to represent information about the environment. This is due to the diversity and variation of environmental problems and contexts. The following are some criteria for good indicators that may be used in pollution management (Bergquist, 1998):

- Indicators must be based on known and consistent relationships between the characteristics that are measured and the conditions which they are intended to indicate.
- Indicators should be relevant to the needs of the users and sensitive to the characteristics of the particular prevailing conditions.
- Indicators need to be practicable. Methods required to process data must be available and the cost involved in defining the data required by the indicator must be affordable.

De Groot (1992) gives a general discussion on the logical requirements for environmental indicators, including the need for indicators to be well-connected to normatively relevant final variables, *i.e.* environmental objectives. It does not make much sense, for instance, to describe chemical compounds as 'metallic' ver-

sus 'non-metallic'; a health objective should lead to a toxicity indicator, irrespective of chemical character. Or to take another example, it does not make much sense to describe animal species as 'mammals' versus 'non-mammals'; a biodiversity objective should lead to indicators in terms of endangeredness, red lists or suchlike.

Much experience in the development of aggregate indicators for emissions has been gathered in life-cycle studies (LCA). The aggregation takes various environmental themes (connected to environmental objectives) as foci for aggregation. One example is the global warming potential of emissions, that weighs and then adds up the emissions of CO2, CH4 and other gasses that contribute to global warming. Other examples of such indicators (e.g. Edward-Jones et al., 2000) are:

- *Ozone depletion potential (ODP)* which indicates the total potential of emissions of chlorofluorocarbon (CFCs) and chlorinated hydrocarbons for depleting the ozone layer;
- *Acidification potential (AP)* which aggregates the contributions of SO2, NOx, HCL, NH3, and HF to the potential acid deposition;
- *Eutrophication potential (EP)* which refers to the potential (e.g. of phosphates and nitrates) to cause over-fertilisation of water and soil, which can result in the increased growth of biomass and extremely low water quality;
- Human toxicity Potential (HTP) which aggregates the emissions of different amounts of human toxic substances released to air, water and soil towards their total potential to harm human health;
- *Ecotoxicity potential (ETP)* which aggregates the total potential of emissions to disturb the functioning of aquatic and terrestrial ecosystems.

The general limitation of these indicators is that they do not differentiate between locations. They focus on emissions without taking the next steps of the causal chains into account, hence not considering if any real impact in terms of final variables will take place at all. This is neatly expressed in the term 'potential'. This limitation may be a severe hindrance to relevance. It does not serve any purpose, for instance, to calculate a eutrophication potential if there is no water body around that may be eutrophicated at all. On the other hand of the relevance spectrum stands the global warming potential; every molecule of any pollution will enter the global atmosphere and surely contribute to the problem. Hence the potential is always realised. Other indicators are somewhere in-between these two extremes, depending on the local situation. It will vary much, for instance, how much of the human toxicity potential will actually reach humans and how diluted the substances then will be. On the other hand, risks are then still present, e.g. of substances accumulating in soils and representing a severe problem in the future.

For the use of these indicators on specific locations, therefore (i.e. outside of an LCA framework), it is always a matter of dialogue between science and politics to

which degree these 'emission indicators' may be taken as keys for environmental reporting and policy making. This being said, they do appear to have a high potential especially for developing countries, where data on emissions may be relatively well-known while data on environmental concentrations and effects may be virtually non-existent. In places such as Tema, for instance, theme-aggregated emission indicators may become the collectively agreed cornerstones for monitoring, benchmarking and environmental improvement.

Environmental education

The International Union for the Conservation of Nature (IUCN) defines environmental education as 'the process of recognising values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among humans, their culture and their biophysical surroundings'. Filho (1998) takes a more top-down stance, defining environmental education as 'a process directed towards increasing the general level of public concern about environmental dynamics as well as fostering awareness of the need for public participation in order to promote environmental conservation.' The search for alternative ways to promote sustainable development triggered the need for environmental education (Filho, 1993).

Taking a clue from the above definitions, environmental education is used to help people to interpret the environment and to stimulate them to:

- Appreciate the environment and acquire skills to understand the economic, technological, planning and political processes which affect their use of the environment.
- Understand some of the processes of the physical world, and to gain a basic knowledge of the ecological principles and relationships between organism and the environment.
- Develop some insight and concern about other people's environment and problems
- Acquire a basis on which to make informed decisions about environmental issues that affect them and society at large, and to develop the willingness to do so.

One issue is how environmental education should be integrated in pollution management strategies. Most basically, it should be a long-term partnership between institutions working in education and communication and environmental management fields (Filho, 1996). Second, the substantive foci should be decided upon in a participatory process. And thirdly, the communicative style and content should not have a too strong focus on problems and dangers; often, people respond much more deeply to messages that also include interesting empirical facts about ecosystem processes and the richness of natural patterns, diversity and values (WCED, 1987; Schneider, 1993).

Environmental education materials should be available in local languages and for different age groups. For developing countries especially, environmental education should stimulate human minds to question prevailing development patterns, lifestyles and governance systems and at the same time provide the opportunity to present their views. Methods and approaches such as learning by doing, environmental outdoor activities and adopting innovative approaches such as environmental clubs, legal groups, libraries, distance education facilities, information networks and databases should be explored along side the traditional channels of schools and mass media.

6.1.5 A review of conflict resolution approaches

Environmental conflict resolution is based on the principle that human beings have different values and interest and the divergence of these often leads to miscommunication, misunderstanding and conflicts among stakeholders concerning the pollution by current or proposed activities. Environmental conflict management refers to the various forms of direct contact between the parties involved in conflict in order to reach an agreement on the environmental conflict issues (Bingham, 1986). Such agreements may cover the following aspects (Asselt and Wubben, 1998):

- *Technological aspects* – help to point out the presence of a feasible technology to solve or prevent the pollution problem in question and the context in which it is considered.
- *Legal aspects* – involve the interpretation of the relevant pollution related environmental standards by the parties to the conflict in terms of their definition, the type of standard, and who are the users and how the standards are used.
- *Financial aspects* – focus on how financial liabilities are assigned to the parties involved in the conflict.
- *Social aspects* – e.g. the codes of behaviour such as power and socialisation pertaining to the parties involved in the conflict as well as the governance structure of the parties.

Based on the work of Glasbergen (1995), I identify a classical approach and an alternative approach as the two fundamental approaches to environmental conflict management.

Classical approach – The classical approach to environmental conflict management is based on notion of self-interest and arbitration. In the classical approach, environmental conflicts are resolved under three main institutional procedures (Asselt and Wubben, 1998):

- In administrative procedures, bureaucrats take decisions regarding some kind of environmental conflict because of the power and authority invested

in them. In some cases, administrative structures share or delegate power to people who will be affected by the decision. The whole process is routine.
- With the political approach, decision-makers are elected and are not specialists in resource and environmental management but receive advice from experts to aid them in dealing with competing values and interests in conflicts. In the political approach, public participatory approaches are adopted in order to include the public in decision-making and also to hear from the public about their needs, aspirations and preferences.
- The judicial approach involves the use of litigation and courts to resolve environmental conflicts. Decisions taken in this approach are followed by the enforcement of sanctions. The judicial approach places much emphasis on facts, precedents, procedures, guidelines and arguments.

A major drawback to the classical approach is that participants do not work together but rather antagonistically in an attempt to each influence the decision-makers.

Alternative approach – The alternative approach, sometimes referred to as a mutual gain approach, is based on using organised direct contact of the opposing parties, in order to share ideas about the potential benefits of resolving conflicts through mutual agreement. The approach acknowledges the interest and concern of parties involved in managing the conflict through joint fact-finding to arrive at a common ground. In addition, it focuses on building long term relationships between parties through face-to-face interaction and consultations before decisions are taken. And finally, it attempts to focus parties on what they really need in stead of on their adopted positions. The following are three main types of alternative approaches to environmental conflict management (Asselt and Wubben, 1998):
- *Public consultation* is used to allow parties involved in environmental conflicts to meet and share experience and information and also ensure that many perspectives are considered and the conflict management is open to the public to ensure that parties are satisfied with decisions taken and plans adopted.
- *Negotiation* is a forum on which the parties involved in an environmental conflict meet and discuss relevant matters directly with each other with the aim of coming to an agreement. The parties involved in the conflict negotiate among themselves without the help of external assistance
- *Mediation and arbitration* is similar to negotiations but in this case, there is a neutral third party. With mediation, the third party has no power to influence decisions taken but acts as a facilitator who develops or suggests strategies for parties to reach an agreement. The third party in the case of arbitration has power to make a decision, which may or may not be binding.

Relevance of conflict resolution tools in developing countries

First of all for developing countries, the institutional potential for conflict resolution should be built into the basic structure and culture of pollution management. This is because often, developing countries are 'under-institutionalized' to the extent that conflict resolution structures cannot be found outside or constructed on the spot when the (often urgent) need arises. In other words, pollution management strategies should always include some platform (commission, council, committee) and some rules and routines that can pick up the task as soon as necessary.

The literature mentions many factors that contribute to the success of conflict resolution. Examples are the quality of the third party and the establishment a monitoring agreement. For developing countries, the following four conditions seem particularly important:

- *Neutrality of the convenor:* It is important that whoever calls the conflict resolution process into action is perceived by parties as impartial as to the results. What is frequently lacking in emerging conflicts in developing countries is someone whom the parties trust – or, at least, do not mistrust – who can act as a bridge to help them begin a dialogue.
- *Financing:* Sufficient funds are needed to cover not only the costs of the process and of the mediator, but also to assist the parties in bargaining effectively for their interests. The source of these funds, or the means by which they are managed, need to be separate from the parties to the dispute, so as to avoid the appearance of bias.
- *Longevity of the process:* Consensus building processes require more time to complete than top-down solutions. This poses risks to the success of the process related to depletion of financing, loss of patience on the part of participants, and – in environmentally-sensitive issues – changes in the status of the resources at risk (i.e. further depletion).
- *Identification and representation of key stakeholders:* A key element of the design of dispute resolution processes is ensuring that the interests of all the key stakeholders (those who are affected by the dispute, and those capable of blocking an agreement) are represented in some way that is mutually acceptable to the parties.

These criteria may sometimes be in conflict with each other. It is often seductive, for instance, to leave out some 'difficult' stakeholders in order to speed up the process, but these may then later appear to be even more strongly opposed to the solution – if only due to the feeling aroused by the exclusion.

Conflict resolution is not currently applied in pollution management in Tema. However, good potential exists for application of the alternative approach to conflict resolution. For instance, identification of instabilities among actors by seeking to identify areas of potential conflict between the industries that are polluting

the Chemu lagoon and people making their livelihood from the lagoon and alerting relevant parties such as Tema Municipal Assembly and EPA Office in Tema. Through this, the Municipal Assembly and the EPA office could initiate a dialogue between potential adversaries to establish pollution management regimes that defuse causes of conflict.

6.2 Overall features of pollution management strategies

Any pollution prevention strategy is constructed out of a selective combination of the policy options discussed in the preceding section. The present section focuses on the other end of the design of a strategy, i.e. not the separate potential building blocks but the overall features, the 'basic style' of the strategy one could say, which may be, for instance, community-based or technocratic. Much debate is going on with respect to these basic features of environmental planning and management. It should become less top-down, less technocratic, more community-based, more adaptive, more focused on resilience, and so on (e.g. Mitchell, 2002). In my vision, a single combined style fits best for developing countries. This style may be summarized as 'participatory adaptive co-management'. I will first treat these three features separately.

6.2.1 Co-management approach

Co-management involves the sharing of vision, power and responsibility over a particular resource or action between government and local actors. A co-management approach considers both local and supra-local interests and visions in the management of pollution problems with roles in pollution management shared among actors based on the recognition that each actor or group of actors has a positive role to play in the management process.

In pollution management, co-management should involve government and industries as key actors, sharing responsibility over pollution prevention and abatement. In such a way, pollution management strategies designed should be built on negotiation between government, industries and social groups with conflicting interests that normally have unpredictable outcomes. The negotiations should be used as a platform to create suitable conditions for social learning and decision-making since it is about power and arguments. This would help define concrete tasks to facilitate an integrative decision making process. This is critical, since actors with conflicting interests must be mutually interdependent and agree to solve a pollution problem. The actors should see the clear benefits for negotiation based on self-interest or see the need to work together. For example with industrial actors, collective action such as the construction of a joint plant to treat pollutants and the bubble concept of emission permits should be explored and promoted. In

most cases, NGO's and communities should be involved in the process as well, e.g. because they represent possible victims, valuable knowledge or potential co-implementers of the strategy, e.g. in waste recycling or environmental monitoring.

The balance of sharing power and responsibilities between government levels and industry may vary according to the pollution case at hand. The degree of political complexity and environmental complexity of the pollution management task at hand will in a way influence the extent to which each of the stakeholders should be involved, for instance. A pollution problem that is large-scale and has high environmental and political complexity may require a relatively strong central state element in the co-management approach. On the other hand, a pollution problem that has a low environmental complexity and low political complexity may allow for a much stronger local emphasis, with the central state only in a facilitating role.

Co-management principles and experiences have mainly been gathered in the field of fisheries and other natural resources (e.g. Pinkerton, 1989 and Ostrom, 1999), but based in this work, the following conditions for co-management appear to apply also for pollution management:

- There should be clarity on boundaries such as who are the actors, what substances are at stake and where geographic responsibility end.
- The actors should be organised in two main parties, one party representing a broad group of actors (industries) while the other party represents the state and other-state owned institutions at the local level. Among each other, parties should as much as possible settle their differences outside of the key arena, so that they both can speak with one voice.
- Additional actors such as scientific institutions, local communities and NGOs could be included in the process for specific reasons and in specific roles, but without formal negotiation power.
- Point of departure should be a common problem perception and vision on a desirable development goal. This will help to create commitment, and avoid conflict and misunderstandings in the definition and sharing of environmental management roles and responsibilities between the parties.
- As stated in the preceding section, a structure and rules for conflict resolution should be built into the design and implementation of co-management. Ideally, conflict prevention and resolution expertise should be present on a permanent basis.

For a place such as Tema, for instance, co-management could involve the establishment of a mixed pollution management board made up of government institutions (Municipal Assembly, Environmental Protection Agency Office) and industries to develop a shared vision, shared responsibilities power and clear division of tasks for the management of the pollution problem facing the Chemu lagoon.

6.2.2 Participation

The principle of co-management has already brought on board the central actors of pollution management (the government, environmental protection agency and the industry). The principle of participation then brings in all the stakeholders, especially civil society, on a less day-to-day basis.

As discussed in section 2.4, stakeholders are all morally considerable entities (human and natural) that may affect or may be affected by the problem or policy under consideration, or may legitimately claim to represent these entities or their interests (e.g. an industry representing employees and consumers, a conservation NGO representing intrinsic values of nature, an environmental NGO representing future generation, a religious leader representing the spiritual well-being of people). More often than not, a difficulty in designing a participatory process lies not so much in the identification of these (many) stakeholders as in the question of how to turn these many into meaningful participants in the co-management process. Not everyone can or wishes to be involved in all levels of intensity but on the other hand, the group of actual participants should be manageable and be morally balanced (i.e. without undue exclusion or over-inclusion). The literature neglects this issue and I can therefore only advice here to use he general rules of caution, e.g. to be balanced, transparent, impartial and flexible when conflicts arise. The only specific rule appears to be that, following Kessler (2003), special care should be taken to have 'absent stakeholders' such as nature, future generations, children and the illiterate poor represented in the process. Often, the general government obligation to take care of these stakeholders needs to be strengthened by NGO groups.

Participation of stakeholders should entail their involvement in both the early stages (problem identification etc,) and late stages (strategy design, monitoring etc.) of pollution management. That way, the participation process can be organized to result in the articulation and wide sharing of values and knowledge.

There should be transparency with respect to financial resources, existing policies and decisions, legal requirements and norms, and the roles of the participants themselves. If actors participate in a co-management process between government and industries, for instance, it should be clear what their role is vis-à-vis these two central parties. All actors should always have free and easy access to information, however. A final condition for meaningful participation in co-management is that actors should be supported on scientific and technical issues. One example is what may be best practices for effluent purification. Another example is what might be the equity risks of efficiency-oriented solutions such as an overall 'bubble' on emissions. A third example is the translation of people's worries and values into concrete proposals for monitoring, e.g. a proposal to monitor specific

substances at specific places, or a proposal to design a new aggregate indicator out of already monitored data.

In Tema, for instance, characteristic stakeholders would include the concerned citizens of Tema and the fishermen and the people who use water from the lagoon for urban farming. Specific monitoring could include, for instance, water and soil focusing on health risks of the latter groups.

6.2.3 Adaptive management

Contrary to classical, 'blue-print' planning, adaptive management focuses on the flexibility of strategies to move on with time and new information. It tends to focus, therefore, on intensive monitoring and rapid adaptation on interventions. These interventions then tend to be rapid and frequent but relatively small each. In order to prevent that accumulation of such adaptations would result in undesired final situations, adaptive management should be guided by a long-term vision (Kessler, 2003).

Another characteristic of adaptive management is its focus on the upkeep of the resilience of ecosystems, meaning that also the ecosystems themselves should maintain their adaptive capacities. This is the ecological bedrock of adaptive management, giving it a focus on the maintenance of ecological processes rather than static biodiversity protection.

The idea of resilience also sounds through in the recommendation of adaptive management that management should be based on resilient institutional networks rather than on static and monofunctional organisations. In that sense, pollution management as a co-production of government and industries (see preceding section), though seemingly more difficult to execute on the short term, links up much better with adaptive management than do purely state-based approaches.

In adaptive management, interventions are not only evaluated for their primary value of environmental problem abatement but also seen as experiments to learn from through the monitoring programme. There is a tension here, however, with respect to the social acceptability of the policy. Frequent policy changes may be quite logical policy responses for the professionals who work on the environmental issues on a daily basis, but may require intense communication to stakeholders who have just understood the old policy and are now confronted with a new one. In other words, ways to implement adaptive management and ways to implement participation need to be closely considered in relationship with each other.

Pollution management, working as it does with industries as its major target group, feels a particularly hard edge of this dilemma. Industries need long-term

certainties to organise their responses to policy measures. They cannot live with, say, technology prescriptions in one year and tradable quota in the next. Even within the same type of policy instrument, industrial decisions are severely hampered by, say, variability of levies or changes in prescribed technologies. Not only economics but also psychology plays a role here. The lowering of an environmental standard, for instance, however logical this might be for an adaptive policy maker, for an industry may mean that one year you are praised because you comply, only to be branded as an environmental villain next year, even though your emissions have remained the same.

In order to retain legitimacy in society, therefore, adaptive pollution management requires intense communication and probably also a certain restraint against becoming 'too adaptive', in particular with respect to elements that society responds strongly to. For industries, such elements, as said, may especially involve financial uncertainties and managerial psychologies.

There are no theories or examples yet of adaptive management specifically for pollution issues in developing countries. Its principles, however – such as its emphasis on resilient institutional networks rather than fixed policy prescriptions – link up well with many other ideas explored in this dissertation, such as transdisciplinarity, precautionary principle, organizational learning, natural capitals and ecological functions. Adaptive pollution management may therefore be recommended as a key feature of pollution management strategies based on OPiC.

6.2.4 Combining the features

Co-management is the principle that describes the relationship between the two key actors, government and industries, of pollution management. Participation then structures the roles of the other actors, especially civil society and communities, in the design and implementation of pollution management. The principle of adaptive management, finally, adds the time dimension, focusing as it does on notions such as flexible response and long-tem vision. As we have seen, the three principles confine each other to a certain degree; a focus on two key actors (co-management) limits the role of other participants to a certain degree, and the degree to which adaptive management can be adaptive indeed is limited, to some extent, by the needs to involve industry (co-management) and non-professionals (participation). These limitations are not prohibitive however, and many other ideas within the approaches strengthen and other. In other words, pollution management strategies can be, and possibly also should be, *participatory adaptive co-management.*

Participatory adaptive co-management requires that pollution management tasks be designed for different classes of stakeholders who perform various functions.

In this respect, important actors appear to be (*i*) national public institutions, (*ii*) district and regional public institutions, (*iii*) the private sector, and (*iv*) civil society. The involvement of the four categories of stakeholders in pollution management largely depends on the pollution management goal. Table 6.1 presents an overview.

Table 6.1 ■ Showing proposed pollution management functions to different institutions

Sector	Proposed pollution management function
National	■ Establish national legislation and justice regarding pollution management and also create co-ordination and policy coherence between sectors and regions. ■ Develop a national legislative framework, regulations and quality standards, control, prevention and enforcement mechanisms. ■ Carrying out strategic planning at sectoral and national levels, jointly with major actors. ■ Providing expertise and training for the other sectors. ■ Co-manage pollution prevention and abatement especially in large-scale cases, including environmental monitoring. ■ Support lower-level activities such as monitoring and planning.
Municipal/ district	■ Establish regional and district legislation and justice regarding pollution management and also create co-ordination and policy coherence between sectors and regions. ■ Develop regional and district legislative framework, regulations and quality standards, control, prevention and enforcement mechanisms based on national guidelines. ■ Carrying out regional and district planning at project and community levels. ■ Co-manage pollution prevention and abatement especially in smaller-scale cases, including environmental monitoring. ■ Support private and civil society participation and monitoring.
Private (Major pollution actors)	■ Carry out industry related research and provide environmental expertise and also develop environmentally sound technologies. ■ Co-manage pollution prevention and abatement, including in-firm monitoring.
Civil society	■ Advocacy, lobbying, awareness raising, carrying out environmental education and getting pollution management issues on the political agenda. ■ Carry out community-level environmental research and monitoring and provide early warning signals.

As indicated in the Table, the main function of the public sector is to develop and put in place, the necessary national policy measures while the regional and district public offices develop local policies using the national polices as guidelines. Despite the fact that the public sector and the civil society would be involved in the formulation of both national and regional or district level policies, the public should carry related research, provide environmental experts and help in environmental auditing and monitoring activities. Civil society should implement community environmental activities and conduct community level environmental research and monitoring activities in other to provide early warning signals.

Connections between the various actors are a key element of participatory adaptive co-management. A platform for the internalisation and capacity building of all parties and forces to create a momentum that will help solve pollution problems should be created. This would help parties to develop a joint vision that will cover ecological, social and economic dimensions and partnerships based on win-win options for pollution management.

6.3 Design, evaluation, implementation and monitoring

Using a synergy of different tools is a good way to solve most pollution problems in developing countries. A useful mix of market-based tools, regulatory tools, communication tools and conflict resolution tools would help in the development of a well coordinated, focused and sequential solution to pollution problems. These tools are especially relevant in the later phases of the 'policy' or 'planning cycle'. In this cycle, Levei and Weiss (1998) distinguish (*i*) the preparatory phase (*ii*) the planning and selection phase (*iii*) implementation and enforcement phase and (*iv*) monitoring of outcomes for achieved pollution targets. In the OPiC framework, these phases coincide with: (*i*) problem analysis and explanation and the identification of solution options (chapters 4 and 5), (*ii*) choice of basic strategy (previous sections in chapter 6, (*iii*) design of solution; evaluation and selection of solution, and (*iv*) implementation, monitoring and adaptive re-design of the solution, respectively. The present section deals with the stages *iii* and *iv*.

6.3.1 The design process

As De Groot (1992) asserts, design is the selection and combination of options to form the higher system level of one or more solutions. The whole process is fed and guided by facts and values, identified in the problem analysis, problem explanation and search for opportunities. Translated to the present study, any pollution strategy is a selective combination of the opportunities identified on the basis of the problem analysis and explanation (chapter 4) and the creative search (chapter 5), giving rise to options summarized in section 6.1. Therefore, many of the creative methods discussed in chapter 5 also apply to the design stage. This is important because it is very rare that a single or separate option can be declared a proposed solution but rather a combination of options into a strategy.

In some cases, the problem analysis and explanation may have been carried out in a non-co-management and non-participatory style. If so, these issues have to be revisited and possibly revised, such that they become co-owned and shared by all stakeholders.

The design process should usually be guided by some overlying criteria and principles. Basic ones are efficiency, sustainability but other may be used too, depending on the case at hand. Examples are:

- A focus on priority substances, with others taken up alongside as much as possible and chosen problems and opportunities into socio-economic and ecological context.
- A special care to prevent conflict, for example responding to old grudges and avoiding making old mistakes.
- A special focus on resilience, adaptability and keeping options open, as part of the adaptive approach.
- Focus on the local implementability of the strategy, for example by industries and communities.
- Considering the responsiveness of the public sector, recognition and anchoring of social and political diversity by strengthening social actions and available social forces and economic initiatives of civil society and the private sector.

In some cases (for example, under circumstances of high physical or political complexity) it is wise to first design a number of draft plans. All of these draft plans will be 'full strategies' in the sense that they all are selective combination of options, only guided by different weights on the various criteria. The formal evaluation of the alternatives then becomes of great relevance for decision-making. In other cases it may be possible to keep the perspectives of the co-managers in the design process so close together that a single design may be the result. Even then, some kind of evaluation will be important to bring the design successfully through the decision-making structures. That is the subject of the next section.

6.3.2 Evaluation

Evaluation is usually carried out through CBA or MCA procedures (see section 4.5). All of these comprise a trading-off of various aspects of the effects of a proposed solution against each other. For instance, a higher cost may be compensated by a higher pollution abatement benefit, or higher damage in the present may be compensated by higher benefits in the future, or the reverse. The optimal solution then is the one with the best overall result (example, the highest NPV in CBA). This is the focus on efficiency. As explained by De Groot (1992), this lack of attention to the *distribution* of costs and benefits can create substantial damage to entities that are already bad off or vulnerable. For instance:

- Impacts on future generations are 'discounted away' by the discount rate used (for various good reasons) in CBA.
- If the poor become worse off but the benefits for the rich are higher than that, the net balance is positive and a plan will be approved through the efficiency criterion.

These risks can not be fundamentally repaired within CBA or MCA tools. A very low or zero discount rate designed to protect future generations within CBA, for instance, would result approval of all projects with huge investments now but a perpetual stream of small benefits later (e.g. any dam in a river). Therefore, analogous to the Safe Minimum Standard approach, an 'equity test' is introduced in OPiC. This is to ensure that vulnerable parties do not become worse off due to the pollution management strategy. Logically, the equity test is to be applied before CBA or any other efficiency-oriented evaluation method is applied (see figure 6.1).

Furthermore, classic evaluation tools do not pay heed to the key principle of adaptive management, which is the avoidance of lock-ins and the upkeep of social and ecological resilience. Therefore, OPiC comprises a separate 'adaptability test'.

The three assessments should be carried out as follows.

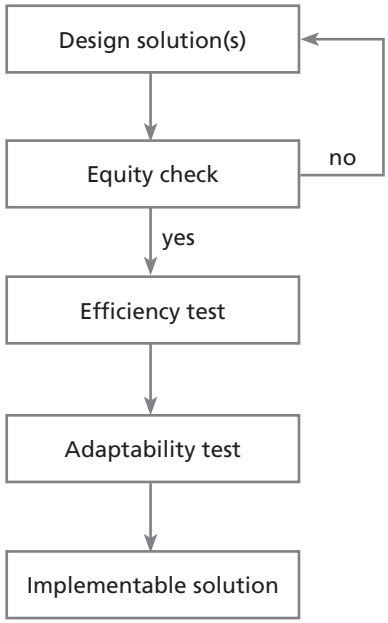


Figure 6.1 ■ Evaluation of designed solution

Equity filter

To carry out the equity assessment, actors should jointly and creatively formulate new ideas and at the same time with focus on the concrete pollution situation. After the potential implementable options have been identified, the equity aspect of the strategies should be addressed before an efficiency assessment is carried out. The equity assessment focuses on everything and everybody that should be

protected against being traded off in the efficiency assessment. It therefore entails the following questions:

- Do future generations not become worse off? In other words, is sustainability truly ensured?
- Do the poor or other vulnerable groups (women, children) not become worse off? This concerns their health, basic livelihood needs, cultural means to participate in society etc.
- Does biodiversity, especially endangered species, not become worse off?

Any strategy failing this test has to be redesigned, e.g. by applying other physical measures or by including real compensations. If the strategy passes the equity test, it can be put into the hands of CBA or other efficiency tests. These tools are then relieved of the duty to incorporate the equity criterion; they can be applied in any sound and traditional manner that suits the case at hand.

Efficiency assessment

Efficiency assessment should then be undertaken with the environment again playing a role. This is because the environment is not only about future generations and nature conservation (part of the equity test) but also the efficient allocation of environmental functions.

The efficiency assessment could be done by creating a matrix using environmental, economic and social-cultural final variables (see Section 4.1). Depending on the context and the task, the final variables can be further subdivided to identify specific subcomponents of these variables that best express the relevant normative aspects of the case at hand. These then may be the basis for a CBA or MCA approach (see Section 4.5).

Adaptability test

The adaptability test is important in the evaluation of designed solutions because it will show how applicable the solution is any environment, especially due to the rapid changes in technology, organisation structure, human perception and needs. Here, adaptability means how the designed solution can accommodate environmental and social change and how flexible the solution is. Taken from the principles of adaptive management, six questions here appear key:

- Does the strategy comprise an intensive and rapid-returns monitoring schedule?
- Are options kept open to adapt the actions if monitoring or changing circumstances demand?
- Does the strategy allow that decisions can be taken at the lowest possible authority level?
- Does the strategy satisfy the precautionary principle?
- Have the actors developed a collaborative learning structure and process?

6.3.3 Implementation of the chosen solution

Implementation is a major problem facing pollution management in developing countries. Mitchell (2002) identifies intractability, lack of clarity of goals, and commitment of those responsible for implementation as some of the problems hindering the implementation of solutions to pollution problems.

In order to consider the effectiveness of an implementation plan, the following should be used (Mitchell, 2002):

- Attention should focus on the contextual dimensions such as historical, economic and institutional and the state of biophysical resources.
- The policy or programme to be implemented should receive political commitment, statute, financial and administrative support.
- Pollution management functions of actors should be clear. Those that can be performed as a stand-alone and those that can be integrated, and those that deal with policy issues and project issues should be made clear.
- Processes and mechanisms should be put in place to address mismatches, overlaps and underlaps that will arise in implementing the management function and structures designed as part of the solution.

From my own experience I may add:

- Local people whose health, environment and livelihood are affected by the pollution problem should be involved in the implementation of the solution and monitoring of the implementation plan.
- Resources should be secured for the full implementation of the chosen solution. This is very important avoid the 'killing' of practical and sustainable solutions just after initially due to lack of resources.
- The implementation plan should be divided in phases of implementation. Each phase should be considered as a sub-project with clearly defined initiation and completion indicators. It is imperative that the phases be linked together.

In Tema, for instance, the implementation of a pollution management strategy for Chemu lagoon has to involve the people fishing from the lagoon, the industries pollution the lagoon, NGOs, Tema Municipal Assembly, the EPA Office in Tema and other interested stakeholders. Contribution of each actor and stakeholder in the plan should be clear, milestones set and resources secured for all activities.

OPiC has been designed such that many of these bottlenecks are solved in and along the way from the problem analysis onwards. Goals, for instance, are part and parcel of the final variables and will return in the form of the design criteria during the design phase. Context receives much explicit attention in the framework, too. Moreover, the basic ideas of OPiC are so close to common sense that all actors may easily participate in all its stages. This is not to say, of course, that OPiC

can solve all implementation problems. If funds are withdrawn, for instance, or major co-managing partners go bankrupt, or actors are not prepared to work together to solve a pollution problem, no framework will ever work in the end.

6.3.4 Monitoring and adaptive feedback

Monitoring is essential for adaptive management because as noted in section 6.2.3, it tends to focus on intensive monitoring and rapid adaptation on interventions. Monitoring gives actors the opportunity to learn from unexpected outcomes (Shindler et al., 1999). For this to happen, the expected outcome of a monitoring process should be clearly identified and documented. This would make it easy to differentiate between expected outcomes and what actually happens and determine whether the implementation of the designed solution has been a success or not.

I agree with Shindler et al. (1999) that monitoring poses challenges with regards to public involvement. The effectiveness of public involvement in monitoring and evaluation can be assessed against the following criteria:

- All affected parties should be involved in the monitoring and evaluation so as to achieve broad representation.
- Commitment and good leadership of key agencies to public participation. There should be personal and interactive involvement instead of impersonal forms of communication such as briefs.
- Different participatory tools should be used in monitoring and evaluation. This will allow for flexibility in the monitoring and evaluation process. This would help pay special attention to local situations and needs, the target of the solution and effectiveness of the monitoring and evaluation process.

In spite of the that people-based monitoring has the potential to signal problems and raise education level of the various actors involved, it is applied only rarely. Many potentials do exist, however, taking into account prevailing conditions in the context which it is applied. For example popular participation of people in the monitoring of environmental management in the coastal Ghana revealed conflicts and lead to negotiations between District Assemblies and the District Environmental Management Committees (made up of one person from the Regional Environmental Protection Agency, five assembly members, two representatives of environmental NGOs and one representative each from department of Parks and Gardens, Town and Country Planning, District Education Office, District Health Office, Ghana Water Company and National Council on Women and Development) with differing agendas and differing access to power (Porter and Young, 1998)

Environmental auditing and state-of-the-environment reporting are two formal incidental types of approaches that are critical to monitoring and evaluation.

These approaches have been discussed in detail in Chapter 5. Both approaches should preferably be elements in an overall monitoring design. Environmental audits then should comprise the degree to which an implemented solution has effectively addressed the environmental problems identified. State of the environment reports may function as comprehensive overviews of monitoring results, with themes arranged by decision-making level (national, municipal etc.), sectors (forest, agriculture, water, soil), or issues (climatic change, waste management), and aggregate indicators expressing these themes as closely as possible (see section 6.1.4). No matter which of the approaches discussed adopted, it is important that monitoring is done to document environmental condition and establish baseline trends and cumulative effects, to educate the people about environmental conditions as well as to provide information for decision making (Mitchell, 2002). Thus, monitoring should be carried out as an ongoing process, combined by adaptive review of pollution management targets and indicators for both external and internal issues.

Especially for developing countries, monitoring methods should be cheap and easy to use. For one thing, this calls for a reflection on the use of 'low-tech', directly sensory methods such as using the smell, the taste, the looks and colour to determine levels of pollution in absolute or relative terms. A well-designed monitoring programme makes use of such methods as much as scientifically justifiable. The same holds, in fact, for the other end of the spectrum of monitoring tools, namely the many high-tech chemical field kits that have become available recently. Both ways, the monitoring avoids the use of long routes through 'mid-tech' laboratories that are often unreliable. Often, costs of monitoring will be reduced (and public sense of ownership enhanced) by training local people in monitoring methods and using either their feet or high-tech mobile linkages to get the data in without delays.

Exemplifying this for the situation in Ghana, the following are some actions that non-professional actors could do in monitoring:

- The public could undertake voluntary sampling of water, air and soil to determine the level of pollution in the media. In Tema for instance, this could be done by fishers bringing in fish from daily catch or sampling water from Chemu on the way to work or during leisure hours.
- Stakeholders could monitor smell, identify the colour and transparency of water and air and the identification of sources and (roughly) levels of noise. For instance in Tema, actors and people living and working around the Chemu lagoon could monitor the colour of the water in the lagoon during to year to know when the water is very smelly, very turbid and not transparent, and report to the Environmental Protection Agency office.
- Not only the environment itself needs to be monitored but also emissions and the behaviour of polluters in general. Informal public sampling of such ele-

ments and the reporting of good performance, neglect and anomalies may help much to keep polluters on the right track. An anonymous alarm channel will reinforce this function. For example in Tema, community members could form a brigade to sample air emissions near the industrial facilities, participate in collecting, analyzing, and deploying environmental information and also participate in pollution-related policy dialogues.

In order to ensure the possibility of rapid responses, a reporting system should be established for all responsible actors. In order to strengthen motivations to act, the monitoring results need to be communicated to the public sector and civil society as well.

Responses to monitoring may be conceived at all levels of depth. Sometimes, only some rectification of mistakes or faults may be required. In other instances, processes or products may have to be adapted. It may also be necessary, however, to put institutional learning to work and initiate deeper cycles of adaptive management, e.g. for the re-design of the strategy or even a full OPiC cycle of new problem analysis, problem explanation and discovery of opportunities.

7 Overview of the OPiC Framework

In this chapter, I present an overview of the OPiC framework developed. I start out with the conditions necessary for the use of OPiC. This is then followed by summaries from the previous chapters, as components of the OPiC framework, organized under three main headings: (1) problem analysis and explanation, (2) opportunity analysis or option identification and (3) the design, evaluation, implementation and monitoring of a pollution management strategy. At the end the chapter, it is highlighted how the framework could be used not only for the design of solution to pollution problems but also various environmental and natural resources issues. Figure 7.1 gives the visual overview of the framework.

7.1 Conditions for the use of OPiC

To ensure the successful use of OPiC in the management of pollution problems in developing countries, it is important that the following conditions are met as much as possible.

1 Even though OPiC may well be used as an element in conflict resolution, for instance to give all actors a common footing in systematic analysis and to focus actors on what they really need in stead of their prefixed positions, OPiC in itself is not a conflict resolution tool. This implies that fruitful use of OPiC as a stand-alone instrument requires a basic willingness of actors to work together. If not present, OPiC should become only one tool under a conflict resolution umbrella.

2 OPiC may work well even on a weak data and modelling basis, as often the case in developing countries. This then requires, however, that actors trust each other's data and interpretations to a sufficient degree, in order to avoid endless bickering over poorly known facts. Small data gathering exercises may well be integrated in an OPiC process but if data gaps are not bridgeable by trust or small explorations, the OPiC process should be reconceptualized and changed into an (OPiC-led) data search.

3 Although OPiC is structured in main 'blocks' of problem analysis and explanation, options search and strategy design and implementation, practical planning processes are seldom run an such a 'linear' sequence. Efficient planning may start out with a preliminary exploration, then start up with a demon-

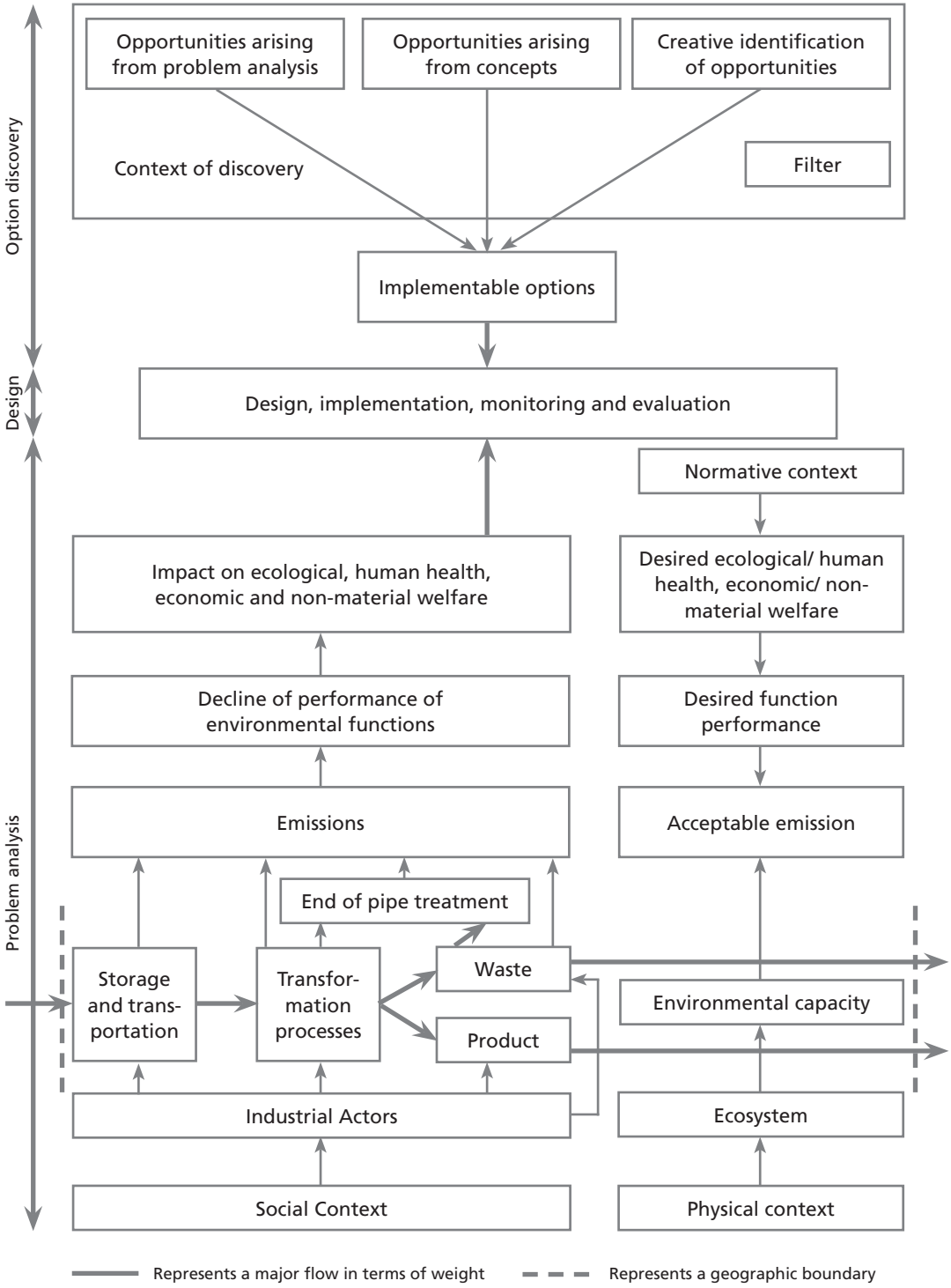


Figure 7.1 ■ An overview of the Opportunity and Problem in Context framework

stration project as a kind of pre-implementation, then move towards a formal social analysis and options search, then re-study the problem analysis in a participatory manner and so on, or follow many other cyclical sequences. OPiC may guide all these separate steps but it does not contain rules for the overall process. Practical use of OPiC therefore requires the presence of an agent with enough expertise to facilitate the OPiC process as a whole.

4 Through the design of solutions, application of OPiC is likely to result in proposals of institutional (legal and/or organisational) change. Such proposals have a future only, however, if they can build on a sufficient basis of core institutions and good governance. In strongly disrupted or corrupted contexts, OPiC applications may amount to good academic exercises but the key problems are likely in need to be solved first.

5 The focus of OPiC is primarily *causal*. Almost all arrows in the overview picture of Figure 7.1 are causal arrows. This is a great strength because insights in (physical and social) causal chains are essential to design solutions that really work. The causal focus presents a limitation too, however, especially in the spatial sense. OPiC is strong in telling why things happen, but not in where they do. Spatial questions are sometimes trivial or unimportant, e.g. when we already know where our industries are or when we are not interested in the address of a government agency. In other cases, spatial questions are resolved by the models that we may apply within an OPiC application, e.g. a model of pollution diffusion. In other cases however, a geographic component may have to be added to OPiC, e.g. using a geographic information system (GIS).

7.2 Problem analysis and explanation

In Figure 7.1, the lower part depicts the structure of the environmental problem in its causal contexts. Specifying this structure with the facts and values of the problem at hand constitutes the problem analysis and explanation.

Problem analysis: specifying the problem structure

The centre of the problem structure is constituted by the chains of fact/value discrepancies depicted in the Figure by the 'flash' arrows.

On the left lie the facts of the problem situation (actual facts in the case of existing facilities, and predicted facts in the case of proposed activities). These facts form the effect chains that start out from human activities (often: emissions), result in changes in the environment and end with the impacts on the 'final variables' such as human health, development and biodiversity. Describing the effect chain is usually called impact analysis. Environmental dose-effect relationships, environmental models and EIA tools in general may be applied in the impact analysis.

On the other side of the flash arrows lie the chains of norm that set the acceptable or desired levels of the facts on the other side, speaking in the same terms. Hence: human health standards, desired levels of economic growth, desired biodiversity, and from there down to desired levels of environmental state such as acceptable ambient concentrations, and from there on further down to desired human activities. The latter are often called environmental capacity, and describing the whole logical chain of values (standards, norms) can be called norms derivation. Policy objectives, legal standards and regulations may be used to fill key elements of the norms chains, but others may require the application of scientific models to derive lower-level norms from overlying values. These models are basically the same as in the impact study, but applied in reversed causality (e.g. not from predicted emission to predicted ambient concentration but from desired ambient concentration to desired emission). The analysis of the structure and severity of the problem should consider the political and ethical legitimacy of the standard setter and the standard setting process as it does on the scientific grounding of the pollution problem facts.

The flash arrows themselves symbolize the discrepancies between facts and values (the 'Is' and the 'Ought') that are the core of the environmental problem.

Getting a full grip on the environmental problem amounts to describing this whole 'problem block' to a degree of accuracy, certainty and balance that fits the needs of the stakeholders and general professional ethics. The routes through which this is achieved may be highly iterative, however, depending on the case at hand. Environmental functions may well be used as an organizing concept for complex cases, and evaluation methods such as Total Environmental Value, CBA and MCA may be used to (partially) quantify the fact/value discrepancies in these or final variable terms.

Problem analysis may be carried out in a participatory manner, tapping local knowledge but also incorporating local value perspectives. It no agreements or compromises on facts or values may be reached between participants, more than one partially different problem analyses may have to be accepted. More on the problem analysis is in section 4.2.

The activity analysis

The human activities causing the environmental problem are identified in the preceding problem analysis. They are sometimes simple enough to not require further analysis. Often, however, it serves to take a more detailed look at the structure of these activities. One approach is to try and decompose the activity in a multiplicative structure of, for instance, number of actors multiplied by activity per actor (the I=PAT structure, *cf.* De Groot, 1998). Especially in pollution cases, however, analyzing material flows in a LCA thinking type of structure will often

help much to later identify effective points of leverage for solutions. LCA thinking also offers tools to connect emissions to these material flows. The fat horizontal arrows in Figure 7.1 indicate the material flows.

As Figure 7.1 indicates, the LCA thinking type activity analysis may be confined to a specified region, e.g. because the commissioning agency has a responsibility only for that one region. This then implies that processes such as raw material mining or waste emissions, if taking place outside the region's boundary, are left out of the analysis. The emissions generated by activities taking place within the region may be accounted for without considering these boundaries, however, e.g. when the heath of people outside the region is threatened by pollution generated within the region. More on activity analysis is in section 4.3 and 4.4

The normative context

The normative context of environmental problems is entered when critically reflective questions are asked concerning aspects of the final variables that are usually taken for granted. Examples are questions on the need or distribution of economic growth, or on the way that biodiversity objectives are grounded philosophically, or on the elitist character of frameworks such as OPiC. Questions such as these, theoretical and irritating as they might be at first encounter, may help much to better adapt, ground and explain environmental science and policies. More on the normative context is in section 4.1

The ecological context

One result of the problem analysis is the assessment, however roughly, of the environmental capacity, which is the maximum intensity of the human activity the environment can handle without too adverse effects on the final variables (or reversely, the minimum intensity of a human activity that supports the environment). Going into the ecological context is to search, often in step by step manner, for the factors and underlying structures and processes that determine why the environment has that specific capacity and the degree to which self-renewal may take place after disturbance. This would help determine the potential of the ecosystem to regenerate, the degradation situation of the ecosystem, and to identify areas for effective investment that will protect the environment and the need for protective measures. More on ecological context is in section 4.1 and 4.3.

The social context

Knowledge of the social context of the environmental problem is often of great practical importance, because it helps define policy target groups and many options for policy intervention. The analysis of social context starts out from the actions that directly affect the environment. Examples are manufacturing activities that pollute the environment, or waste recycling activities that reduce emissions, or dredging of polluted sediments that restore environmental capacity. These ac-

tions are identified in the problem analysis and are called primary (or proximate) actions, and are caused (*i.e.* decided upon) by the primary (or proximate) actors.

The core element of the further analysis is the assumption that actors make their decisions on the basis of what they can do (called their implementable options) and what they want to do (called their motivations). These are in their turn influenced by actions of other actors. For instance, a prohibition reduces the options available to primary actors and a levy reduces the motivations of primary actors for the activity carried out. The prohibitions, levies etc. are called secondary actions, carried out by secondary actors. These in turn have their own options and motivations for these actions, which in turn are influenced by other (tertiary) actors. The causal structures thus defined are called the *actors field*. An actors field runs from the primary action outward and may involve government agencies, banks, NGOs, politicians etc. that all influence the primary action.

Each actor identified in the actors field may be subject of a deeper analysis of how the actor in fact makes his decisions (the 'actor model', e.g. rational choice or a broader theory of moral domains) and how the actor's options and motivations are embedded in structural and cultural features of society. This 'deeper analysis' proceeds by first decomposing the actor's implementable options into potential options and the actors 'autonomy' (consisting of positive capacity or capitals and bounded by external restrictions such as taboos), and decomposing the actor's motivations into 'objectified motivations' (expressed in terms of money, time etc.) the (cultural, psychological) interpretations of these objectified motivations. It may then be analysed how these elements are embedded in the actor's culture, the micro-structures the actor is member of and the macro-structures of the actor's society (markets, tax structure etc.).

The process of this analysis has been called 'progressive contextualisation' by Vayda (1983) and the structure of the analysis has been called Action-in-Context by De Groot (1992). The analysis can be done as a desk study but also involve interviews and participatory methods. More on the social context is in section 4.6.

7.3 Opportunity discovery and realisation

Options arising from the problem analysis and explanation

Essentially, all causal connections identified in the problem analysis and explanation offer a potential point of leverage for problem alleviation or prevention. From the problem analysis arise the technical options of diversion of polluted flows, improving of environmental capacity to handle pollution, end-of-pipe technologies and so on. The activity analysis generates insight into the life-cycle phases that may best be targeted and the manufacturing processes that might be improved for

most efficient impacts. From the problem explanation, finally arise the social and economic options that help realise the technical ones, such as

- Focusing on actors' potential options: knowledge provision and extension
- Focusing on actors' autonomy: strengthening actors' capacity to implement positive actions they might be motivated for (e.g. through credit schemes) and reduce the capacity of negative actions (e.g. through prohibitions)
- Focusing on the actors' objectified motivations: levies, subsidies, deposit-refund schemes, changes in institutional contexts, extended producer responsibility (EPR), etc.
- Focusing on the actors' interpretations: environmental communication, prestige of non-pollution etc.

Identification of these options may be carried out by the analyst alone, but also through joint enquiry with stakeholders, and NGO and public participation. More on all these options for pollution policies is in section 5.1

Options arising from industrial concepts

Apart from the problem analysis and explanation, concepts developed in industrial ecology and allied disciplines may serve as a source to identify opportunities for problem prevention and abatement. Cleaner Production is a tradition focusing on waste reduction through the analysis of industrial processes and the reasons (in methods, people, machines and materials) why these are run the way they are. Options arising from this type of analysis characteristically concern waste-reducing process improvements. The more recent school of thought of Industrial Ecology uses tools such as Material Flows Analysis (MFA) to draw up an integrated view of the interaction between industries and society. Characteristic options arising from Industrial Ecology are 'eco-industrial' development that links various industries and communities to reach greater overall material efficiency, and 'dematerialisation' which is to reach the same added value with less material use. Developing countries provide ample opportunities to apply these types of analyses and options. MFA may be applied in a semi-quantitative manner, for instance, to support regional pollution management. More on options arising from industrial concepts is in Section 5.2.

Options arising from creativity

Traditional ecological knowledge, comprising factual environmental knowledge, knowledge on traditional environmental management systems, social institutions and cosmologies, may be tapped to identify alternative options for pollution management, e.g. through participatory local appraisal, focus groups or advisory committees. Creative capacities can also be found internally within pollution management teams. Available methods to enhance this source of options focus, for instance, on the reflective breaking of routines and on brainstorm techniques.

Also dreams may be taken as opportunities for creative options identification. More on creativity is in Section 5.3.

Context of discovery

The fruitfulness of all three sources of identification of options for pollution management depends much on the presence of an enabling context of discovery. Regular environmental data gathering routines, e.g. connected to environmental accounting or ecological accounting, can form an important element in this context. Apart from these formal tools, people form the second pillar under effective options identification. Self-efficacy is the key notion here. It is defined as a person's judgement of his/her own capability to organise and execute courses of action. Self-efficacy has a special relevance for developing countries because people in pollution management often feel inferior to Western experts or are locked up in authoritarian management systems that reward the passive execution of tasks. Self-efficacy can be enhanced by way of persuasion, training, support groups and role modelling. Thirdly, learning (individual and organisational) is the key process in the context that enables effective options identification. For pollution management, learning should be anchored in the actors' own experiences and be organised as a dynamic group process. More on the context of discovery is in Section 5.4. Section 5.5 draws the conclusions of the whole chapter.

7.4 Design and evaluation of solutions

Design is the selective combination of options (opportunities) to form the higher system level of a plan, *i.e.* a pollution management strategy. Physical and social options have been identified as elaborated in the preceding section. The social options are often categorized under the rubrics of market-based, regulatory and communicative policy instruments, and conflict resolution. Market-based instruments comprise charges and taxes, tradable permits, subsidies and performance bonds, eco-labelling and direct payments for environmental services. Regulatory instruments comprise environmental standards, international regulations such as conventions, and voluntary agreements. Communicative instruments comprise environmental reporting and environmental education. Conflict resolution approaches entail elements such as public consultation, negotiation, mediation and arbitration. More on all these is in Section 6.1, where also the applicability on developing countries is discussed.

Environmental strategies display certain overall styles of operation. They may, for instance, be community-based or technocratic. A conscious choice of basic style is important for the design of any effective plan. For pollution management strategies in developing countries, three aspects of overall style seem especially important. They are co-management, participation and adaptive management.

Co-management involves the sharing of visions, power and responsibilities between government and industries. Participation connects stakeholders and the wider public to the planning and implementation process of pollution management. Adaptive management, contrary to blueprint approaches, implies intensive monitoring and rapid responses to change, guided by a long-term vision. A combination of these overall styles would appear to be appropriate for developing countries. Sections 6.2 and 6.3.1 give more detail.

Evaluation of a designed solution

After designing a solution based on the preceding insights, a two-tier evaluation should be undertaken. The first step is an equity filter. The second step is composed of an efficiency assessment and adaptability test.

Equity filter

Equity is the protection of values that are not or only very poorly included in cost-benefit analysis or other efficiency-oriented instruments. The filter is composed of the following questions:

- Do future generations not become worse off? In other words, is sustainability truly ensured?
- Do the poor or other vulnerable groups (women, children) not become worse off? This especially concerns their basic needs such as health, livelihoods and means to participate in society.
- Does biodiversity, especially endangered species, not become worse off?

The designed strategy should have positive answers for the above questions (i.e. pass the test) for it to pass on to the efficiency assessment and adaptability test. If the designed strategy fails the equity filter, it has to be redesigned.

Efficiency assessment

Efficiency is the degree to which the desired outcomes are achieved at a lowest possible cost. If a designed solution has passed the equity filter, the efficiency assessment is freed from obligations that it can only poorly fulfil. The use of a discount rate in cost-benefit analysis, for instance, is not problematic any more because the interests of future generations, which are discounted away in the efficiency assessment, have been secured in the equity filter already. The prime instrument for efficiency assessment is cost-benefit analysis (CBA). CBA proceeds by first selecting the methods by which as much as possible of the final variables (policy aims) can be expressed in monetary terms, then apply these methods and then integrate the resulting data, using a discount rate, to calculate the Net Present Value (NPV) or some other overall efficiency indicator of the designed solution. In most cases in developing countries, contingent valuation methods such as willingness-to-pay (WTP) would appear to be the best standard method for monetarization of final variables.

Adaptability test
Designed solutions may be equitable and efficient and yet too inflexible to respond to future change. Adaptive management requires a specific test to address the adaptability aspect of the designed strategy. The following questions appear to be key in this respect:

- Is the designed solution free of path-dependent traps and does it leave options open for future adaptations?
- Does the strategy comprise an intensive and rapid-returns monitoring schedule and an institutional structure that enables quick responses to monitoring results, e.g. response capacity at the lowest possible scale?
- Have the actors within the context developed a culture and structure for collaborative learning for pollution management?

More on evaluation is in Section 6.3.2.

Implementation and monitoring of a chosen solution
The OPiC process ends with the design and evaluation of a pollution management strategy. A few words on implementation and monitoring, however, may be found in Sections 6.3.3.and 6.3.4.

7.5 Applicability of OPiC

Section 7.1 has discussed some of the limitations of OPiC, focusing as it did on the conditions that should be met as much as possible for OPiC to be applied effectively. In the present section, the focus is the other end of the limitations/applicability dimension.

The OPiC framework development for environmental management is generic and its applicability is not greatly dependent on scale and context. It can be used for small and large scale, simple and complex problems. The focus in this dissertation has been on pollution issues in developing countries, in order to ensure that the resulting framework is certainly of great relevance for that type of problems in that type of countries. The conceptual basis and theories applied in the resulting framework have continued to be generic enough however to make it likely that, with some adaptations, the framework will also be of value in other contexts, e.g. in developed countries or questions of natural resource management. With that, OPiC will be of value as well for mixed situations where pollution abatement, biodiversity protection, poverty alleviation etc. all play an interconnected role, as in integrated regional analysis. In such situations, much of OPiC's basic tenets (such as final variables, functions of the environment, norms derivation, Action-in-Context methodology) may be maintained.

The following may be added to this general assertion.

OPiC is obviously applicable to existing pollution problems. This is its use for pollution abatement. OPiC may just as well be used, however, to potential problems. The question then is: if this process would be installed here, what would happen? Or: if this industry would be established here, what would happen? The OPiC process that enrols from such questions is OPiC's use for pollution prevention. Usually, real-world situations comprise both elements of pollution abatement and pollution prevention. OPiC is able to handle these mixed situations in a single application. This enables actors to find synergy between the two aspects, example using physical and social structures necessary for pollution abatement also for pollution prevention, or the reverse. (For example, using the knowledge and opportunities that arrive with the establishment of a new industry also the abatement of pollution by existing industries.)

OPiC may be used not only for *action* purposes as it is worded at present (*i.e.* how to do the problem analysis, how to do the design of solutions etc.), but also for *analytical* purposes, that is, using OPiC in order to study how and to what degree rational planning processes have taken place. For instance, what final variables were used? What actors were identified? How were options discovered? What type of management was chosen? That way, we use OPiC as a tool to understand and assess existing planning and policy strategies.

The basic concepts of OPiC are fundamentally simple. This implies that the same OPiC structure may be used at any degree of sophistication: qualitative or quantitative, participatory or expert-based, narrative or computerized. Care should always be taken, however, to spend budgets such that a balanced level of sophistication is reached over the OPiC 'map'. It does not make much sense, for instance, to spend much money on an impact model if in fact the values against which the outcomes should be assessed are very poorly known. Or, to take another example, to spend much money on problem analysis when the social causes of the problem are so poorly understood that there would only be a poor basis to design effective policies.

As said already in Section 7.1, any OPiC application should use the framework with flexibility. The framework is presented in this study in large blocks. This does not imply, however, that in actual use, a full problem analysis would be needed before a problem explanation, and a full explanation is needed before options can be identified, and so on. Efficient planning is more cyclical. The OPiC user is fully free to jump from phase to phase, for example first take stock of options, then do a more systematic problem analysis and explanation, then do a more systematic options discovery, then form a co-management group, then revisit the problem

analysis with this group, and so on. Extremely put, OPiC should be used as a menu, not as a cookbook.

Like any other framework, OPiC is not something to be applied rigidly as if it were a mathematical formula with only one way of doing it. Users will often have to adapt the framework to address the issue and context under consideration. The way to do so is to go down to the more basic principles and theories that underlie the framework as formulated, and then go back up again to specify 'one's own OPiC' . That is why throughout the present study and in the earlier chapters in particular, much emphasis has been put on these underlying principles.

References

Adams, B. (1993). *Sustainable Development and the Greening of Development Theory*. In: Schuurman, F.J. (ed). Beyond the Impasse. New Directions in Development Theory. Zed Books, London, pp. 207-222

Aguilar, B. and Semanchin, T.J. (2001). The implication of ecological economics theories of value to Cost Benefit Analysis: Importance of alternative valuation for developing nations with special emphasis on Central America. In: Puttaswamaiah, K. (eds) *Cost Benefit Analysis: Environmental and Ecological Perspective,* Transaction, pp. 367-342.

Ainsworth, S. and Loizou, A.T. (2003). The effects of self-explaining when learning with text or diagrams. *Cognitive Science*, 27, 669-689.

Alam, K. (2005). Valuing the environment in developing countries: Problems and potentials.

Alcamo, J., Shaw, R. and Hordijk. L. (1990). *The RAINS model of acidification. Science and strategies in Europe*. Dordrecht (the Netherlands), Kluwer Academic Publishers.

Allen, D. (1997). *Pollution Prevention for Chemical Processes*. New York: Wiley Interscience.

Allen, P.M. (1994). *Evolution, Sustainability, and Industrial Metabolism in Industrial Metabolism: Restructuring for a Change*. Ayres, R.U. and Simonis, U.E. (eds). Tokyo: United Nations University Press.

Allen, W.J., Bosch, O.J.H., Kilvington, M.J. and Oliver, J. (2001). Benefits of collaborative learning for environmental management: Applying the Integrated Systems for Knowledge Management approach to support animal pest control. *Environmental Management* 27: 215-223.

Alteir, W.J. (1993). A process for creativity. *Research and Development Innovator,* 2 (1).

Amoako, K.Y. and Ali, A.A.G. (1998). *Financing Development in Africa: Some Exploratory Results.* Paper presented at the Planary Session of the African Economic Research Consortium (AERC) Workshop. Nairobi: AERC.

Amin, S. (1992). Can Environmental Problems be subject to economic calculations? *World Development*, 20 (4), 523-530.

Amabile, T.M. (1999). How to Kill Creativity. Breakthrough Thinking. *Harvard Business Review.*

Ametekpor, J.K. (1994). *Ghana Coastal Wetlands Management Project: Environmental Reconnaissance Studies on Soils, Landuse and Land Degradation*. Department of Game and Wildlife, Government of Ghana. GW/A.285/SF.2/29.

Anderson, M.S. and Sprenger, R. (2000). *Market based instruments for environmental management: politics and institutions*. Eward Elgar.

Appiah-Opoku, S. and Mulamoottil,G. (1997). Indigenous Institutions and Environmental Assessment: The Ghana Case. *Environmental Management,* 21 (2), 159-171

Appiah-Opoku, S. and Mulamoottil, G. (1997). Indigenous Institutions and Environmental Assessment: The Case of Ghana. *Environmental Management,* 21 (2), 159-171.

Ardila, S., Quiroga and Vaughan, W.J. (1998). A review of the Use of Contingent Valuation Methods in Project Analysis at the IDB, Inter-American Development Bank. Washington DC.

Argyris, C. and Schon, D.A. (1996). Organisational learning II: Theory, method, and practice. Reading, MA: Addison-Wesley.

Atkinson, J. and Cowe, M. (2006). Interdisciplinary Research: Diverse Approaches in Science, Technology, Health and Society. Wiley Publication.

Atkinson, R.L., Atkinson, R.C., Smith, E.E. and Bem, D.J. (1993). Introduction to psychology (11th edition). Fort Worth, Texas, Harcourt Brace Jovanovich.

Ayittey, G.B.N. (1991). *Indigenous African Institutions*. Transnational Publishers, Ardsley-on-Hudson, New York.

Ayres, R.U. and Leynseele, T.V. (1997). *Eco-efficiency, Double Dividend and the Sustainable firm*. Fontanebleau: INSEAD.

Ayres, R.U. (1994). *Information, Entropy and Progress: Anew evolutionary Paradigm.* New York: American Institute of Physics.

Ayres, R.U. and Simonis, U.E. (1994). *Industrial Metabolism: Restructuring for Sustainable Development*. United Nations University Press.

Ayres, R.U. (1988). *'Self–organization in Biology and Economics'.* International Institute for Applied Systems Analysis, Luxemburg.

Ayres, R.U.(1998). *'Industrial Metabolism: Work in Progress'*. In: Van den Bergh, J.C.J.M. and Hofkes, M.W. (eds), Theory versus Implementation of Sustainable Development Modelling. Dordrecht: Kluwer Academic Publishers.

Azapagic, A. (1999). Life cycle assessment and its application to process selection, design and optimization. *Chemical Engineering Journal,* 73, 1-21.

Azzone, G., Manzini, R. and Noci, G. (1996). Evolutionary trend in environmental reporting. *Business Strategy and the Environmen*t, 5, 219-230.

Babiuch.W.M. and Frhar B.C. (1994). Stakeholder analysis methodologies resource book. National Renewable Energy Laboratory, USA. Report Number: NREL/TP-461-5857

Bartell, S.M. (1997). Ecological Risk Assessment: progressing through experience or stalling in debate*. Environmental Management*, 21 (6).

Bandura, A. (1986). *Social Foundation of Thought and Action: A Social-Cognitive View*. Englewood Cliffs, NJ: prentice Hall.

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. New York: W.H. Freeman and Company.

Bannet, C.J. and Howlett, M. (1992). The lessons of learning: reconciling theories of policy learning and policy change. *Policy Sciences*, 25, 275-294.

Bardhan, P. and Mookherjee, D. (2000). *Corruption and Decentralisation of Infrastructure Delivery in Developing countries*.

Bartone, C., Bernstein, J., Leitmann, J. and Eigen, J. (1994). Towards Environmental Strategies for Cities: Policy Considerations for Urban Environmental Management in Developing Countries. World Bank, Washington, DC.

Belenky, M.F., Clinchy, B.M., Goldberger, N.R. and Tarule, J.M. (1986). *Women's ways of knowing: The development of self, voice and mind*. New York, Basic Books.

Berloznik (1997). *Anticipating the environmental Effects of Technology.* Paris. UNEP/IETC/IE.

Benowitz, S. (1995). Wave of the future: Interdisciplinary collaborations. *The Scientist*, 9 (130), 1.

Bergquist. G. (1998). Post –Decision Assessment. In: Nath, B., Hens, L., Compton, P. and Devuyst, D. (ed). P*ollution management in Practice. Vol. 1: Instruments for the Environment*.

Berkes, F. (1993). Traditional ecological knowledge in perspective. In: Inglis (ed). Traditional ecological knowledge: concepts and cases. Ottawa: International Programme on Traditional Ecological Knowledge, and International Development Research Centre, pp. 1-10.

Berkes, F. and Folke, C. (1998). Linking social and ecological systems for resilience and sustainability. In: Berkes and Folke (ed). *Linking social and ecological systems: management practices and social mechanism for building resilience*. Cambridge University Press, pp. 1-25.

Berkes, F. (1999). *Sacred ecology: traditional ecological knowledge and resource management*. Philadelphia: Taylor & Francis.

Berkes, F., Colding, J. and Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Application,* 10 (5), 1251-1262.

Bielacxyc, K., Pirolli, P.L. and Brown, A.L. (1995). Training in self-explanation and self-regulation strategies: investigating the effects of knowledge acquisition activities on problem solving. *Cognition and Instruction*, 13 (2), 221-252.

Blackman, A. and Harrington. W. (1999). *The Use of Economic Incentives in Developing Countries: Lessons from International Experience with Industrial Air pollution*.

Boateng, J.Y. (2003). Enhancing Business-Community Relations. Cooperate Responsibility Movement Case Study – Ghana. www.revitalizationinstitute.org/csrm/case_study.htm.

Bockstael, N.E., McConnell, K.E. and Strand, I.E. Jr. (1991). Recreation. In: Braden, J. and Kolstad, C.D. (eds). *Measuring the Demand for Environmental Quality*. North Holland, Amsterdam.

Bouman, M., Heijungs, R., Van der Voet, E., Van den Bergh, J. and Huppes, G. (2000). Material flows and economic models: an analytical comparison of SFA, LCA, and partial equilibrium models. *Ecological Economics*, 32, 195-216.

Bookchin. M. (2003) Social Ecology? *Communalism: International Journal for a Rational Society*, 4.

Bourner, T. and Weinstein, K. (1996). Just another talking shop? Some of the pitfalls in action learning. Employee Counselling Today. *The Journal of Workplace Learning* 8 (6).

Borgerhoff Mulder, M. and Coppolillo, P. (2005). *Conservation; Linking ecology, economics and culture*. Princeton: Princeton University Press.

Borkey, P. and Leveque, F. (2000). Voluntary Approaches for environmental protection in the European Union – A Survey. *European Environmental Management* 10, 35-54.

Braidotti, R., Charkiewicz, E., Hausler, S. and Wieringa, S. (1994). *Women, the environment and Sustainable Development*. London: Zed Books.

Bringezu, S., Fischer-Kowalski, M., Kleijn, R. and Palm, V. (1997). *Regional national material flow accounting: From paradigm to practice of sustainability*. Proceedings of the Conaccount workshop, 21-23 January 1997, Leiden, The Netherlands.

Bringham, G. (1986). *Resolving Environmental Disputes: A decade of Experience*, Washington, DC: The Conservation Foundation.

Bromme, R. (2000). Beyond one's own perspective. In: Weingart, P. and Stehr, N. (eds). *Practising Interdisciplinarity*. Toronto: University of Toronto Press, pp. 115-133.

Brunner, P.H. and Rechberger, H. (2003). *Practical Handbook of Material Flow Analysis. Advanced Methods in Resource and Waste Management*. Lewis Publishers.

Brugha, R. and Varvasovszky, Z. (2000). Stakeholder analysis: a review. *Health Policy and Planning*, 15 (3), 239-246.

Burgelman, R.A and Sayles, L.R. (1986). *Inside Cooperate Innovation*, The Free Press, New York.

Buggie, F.D. (1997). *New Product Development Strategies.* AMACOM, New York, 1981.

Cameron, J. and Abouchar, J. (1991). The Precautionary Principle: a fundamental principle of law and policy for the protection of the global environment. *Boston College International and Comparative law review,* 14, 1-27.

Caiden, G.E. and Naomi, C. (1994). Administrative Corruption (1977) revisited, *Philippine Journal of Public Administration*, 38 (1), 1-17.

Canton, E.J.F., De Groot, H.LF. and Nahuis, R. (1999). *Vested interest and resistance to technology adoption*. Research memorandum 9913. Erasmus University Rotterdam.

Checkland, P. B. (1988). Information systems and systems thinking: time to unite? *International Journal of Information Management,* 8, 239-248

Checkland, P.B. and Scholes., J. (1990). *Soft systems methodology in action*. John Wiley & Sons, Chichester, p. 329.

Checkland, P. (1993). *Systems Thinking, Systems Practice*. Chichester: John Wiley and Sons.

Cheakland, P. and Scholes, J. (1990). *Soft system methodology in action.* England, Chichester: John Wiley.

Chen, Y. and McRae. G.J. (2003). *Technology Choices in the presence of uncertainties*.

Chien, E. (1991). *Working Towards Environmental Quality in the 21st Century, Environmental Protection Administration*. Government of Republic of China.

Cleveland, C.J. and Ruth, M. (1998). Indicators of dematerialization and the materials intensity of use. *Journal of Industrial Ecolology*, 2 (3), 15-50

Clark, R. (2000). Making Environmental Impact Assessment Count in Decision-making. In: Partidario, M.R. and Clark, R. (eds). *Perspective on Strategic Environmental Assessment*. CRC-Lewis. Boca Raton, pp. 15-27.

Clausen, J. (1996). Environmental reporting and the EMAS Statement in Germany. *Ecomanagement and Auditing*, 3, 37-41.

Clayton, A. and Radcliffe, N. (1996). *Sustainability, A Systems Approach*, Earthscan Publications, London.

Chambers, R. (1994). Participatory rural appraisal (PRA): Challenges, potentials and paradigms. *World Development,* 22, 1437-54.

Coleman, J.S. (1990). *Foundations of social theory*. Cambridge, MA: Harvard University Press.

Constanza, R. and Cornell, L. (1992). The 4P approach to dealing with scientific uncertainty. *Environment,* 34, 12-20.

Constanza, R. (1991). *Ecological economics: The science and management of sustainability.* Columbia University Press, New York.

Cook, P. and Kirkpatrick, C. (1988). Privatisation in Less Developed Countries: An overview. In: Cook, P. and Kirkpatrick, C. (eds). *Privatisation in Less Developed Countries*. London: Harvester Wheatsheaf, pp. 3-44

Cosbey, A. (1998). International Trade and its environmental integrity. In: Nath, B. Hens, L., Compton, P. and Devuyst, D. (ed). *Pollution management in Practice. Vol. 1: Instruments for the environmen*t.

Couger (1995). *Creative Problem Solving and opportunity finding*. International Thomson Publishing Company Council of Europe (1994). *Definition and Limits of the Principle of Subsidiarity, Local and Regional Authorities in Europe*, 55, 12.

CSA (Canadian Standards Association) (1994). Life Cycle Assessment, Environmental Technology CSA Guideline Z760-94. Toronto, Canada.

Cooper, D.E. and Palmer, J.A. (1992). *The Environment in Question: Ethics and Global Issues*. London: Routledge.

Cory, K.A. (1999), Discovering hidden analogies in an online humanities database. *Library Trend*s, 48 (1), 245-59.

Conway, G.R. and McCracken, J.A. (1990). Rapid rural appraisal and agro ecosystem analysis. In: Altieri, M.A. and Hect, S.B. (eds). Agroecology and Small Farm Development. Boca Raton, CRC Press, pp. 221-35.

Constanza, R. and Daly, H.E. (1992). Natural capital and sustainable development. *Conservation Biology*, 6, 37-46.

Cooper, J.R. (1998). A Multidimensional Approach to the Adoption of Innovation. *Management Decision*, 36 (8), 493-502.

Cremer, J., Estache, A. and Seabright. P. (1994). *The Decentralisation of public services: Lessons from Theory of the Firm*. Policy Research Working paper 1345, World Bank, Washington DC.

Crippen, K.J. and Earl, B.L. (2004). Considering the efficacy of web-based worked examples in introductory Chemistry. *Journal of Computers in Mathematics and Science Teaching*, 21 (2), 183-201.

Cumming, S. (1995). Centralization and decentralisation: The never ending story of separation and betrayal. *Scandinavian Journal of Management*, 11 (2), 103-117.

Cusins, P. (1996). Action learning revisited. *The Journal of workplace Learning*, 8 (6).

Coway and McCracken.???

Daft, R. and Weick, K. (1984). Toward a model of organizations as interpretation systems. *Academy of Management Review*, 9 (2), 284-295.

Daly, H. (1996). *Beyond Growth: the economics of sustainable development*. Beacon Poress, Boston.

Daly, H.E. (1990). Towards some operational principles of sustainable. *Ecological Economics*, 2, 1-6

Dalal Clayton, D.B. and Sadler, B. (1998). *Strategic environmental assessment and developing countries*. London: IIED.

Davis, G.A. (1992). *Creativity is Forever*. 3rd edition, Kendall/Hunt Publishers, Dubuque. Iowa.

Davis, G. (1998). *Environmental Labelling. Issues, Policies and Practices Worldwide*. US EPA 743-R-98-009 (prepared by Abt Associates Inc. and Davis, G.).

Davis, G. (1998). Is There a Broad Principle of EPR? In: Jonsson, K. and Lindhqvist, T. (eds). *Extended Producer Responsibility as a Policy Instrument-what is the Knowledge in the Scientific Community*? AFR-Report 212. Stockholm: Swedish Environmental Protection Agency, pp. 29-36.

De Bruyn, S.M. and Opschoor, J.B. (1997). **Developments in the throughput-income relationship: theoretical and empirical observations.** *Ecological Eonomics,* 20, 255-268.

De Groot, W.T. (1992). *Environmental Science Theory*. Elsevier Science Publishers, Amsterdam.

De Groot, W.T. (1998). Problem-in-Context: A framework for the analysis, explanation and solution of Environmental issues. In: Nath, B. Hens, L., Compton, P. and Devuyst, D. (eds). *Environmental Management in Practice. Vol. 1: Instruments for Environmental Management*.

De Groot, W.T. and Kamminga E.M. (1995). *Forest, People, Government*. CML reports 120, CML, Leiden University, Leiden.

De Mey, M. (2000). **Name article?????** In: Weingart, P. and Stehr, N. (eds). *Practising Interdisciplinarity*. Toronto: University of Toronto Press, pp. 154-244.

Den Hond. F. (2000). Industrial ecology: a review. *Regional Environmental Change,* 1 (2).

Desambre, E.R. (1998). *International Environmental Policy*. **In: Nath, B. Hens, L., Compton, P. and Devuyst, D. (eds).** *Environmental Management in Practice. Vol. 1: Instruments for Environmental Management*.

Desvousges, W. and Smith, V.K. (1988). Focus groups and risk communications; The 'science' of listening to data. *Risk Analysis,* 8, 479-484.

Dethlefsen, V. (1993). The Precautionary Principle: Towards Anticipatory Environmental Management. In: Jackson, T., (ed). *Clean Production Strategies*. New York: Lewis Publishers.

De Tilly, S. (2004). Waste Generation and Related Policies: Broad Trends over the Last Ten Years. In: OECD, *Addressing the Economics of Waste*. Paris: OECD.

De Weedt, H. (1998). Environmental Auditing and environmental Management systems. In: Nath, B. Hens, L., Compton, P. and Devuyst, D. (eds). *Environmental Management in Practice. Vol. 1: Instruments for Environmental Management*.

Didnck, A.P. and Sinclair, A.J. (1997). The concept of critical environmental assessment (EA) education. *Canadian Geographer,* 41, 294-307.

Dickson, B. (2000). The Ethicist Conception of environmental problems. *Environmental Values,* 9, 127-52.

Dickson. B. (2000). The Ethist Conception of Environmental Problems. *Environmental Values*, 9 (2).

Dixon, J.A., Scura, L.F., Carpenter, R.A. and Sherman, P.B. (1998). *Economic Analysis of Environmental Impacts*. Earthscsn Publication Ltd, London.

DuBose, J., Frost, J.D., Chamaeau, J.A. and Vanegas, J.A. (1995). Sustainable development and Technology. In: Elms, D. and Wilkinsin, D. (eds). *The Environmental Educated Engineer*. Canterbury: Centre for Advanced Engineering.

Duchin, F. and Steenge, A.E. (1998). *Input-Output Analysis, Technology and the Environment.* In: Van den Bergh, J.C.J.M. (ed). *Handbook of Environmental and Resource Economics*. Edward lgar, Cheltenham.

Dunn, K. (1995). Fundamentals of Environmental Auditing Toronto 9th Annual Toronto Environmental Conference and Trade show.

Dutton J.E. and Jackson, S.E. (1987). Categorizing Strategic Issues: Links to Organisational Action. *Academy of Management Review*, 12 (1), 76-90.

Easton, D. (1991). Divided knowledge across disciplines, across cultures. The division, integration, and transfer of knowledge. *Bulletin of the American Academy of Arts and Science*, 64 (4), 12.

Edward-Jones, G., Davies, B. and Hussain, S. (2000). *Ecological Economical: An Introduction*. Blackwell Science.

El-Mosley, H. (1997). *The Discovery of Local Raw Materials: New Opportunities for Developing Countries*. In: UNEP Industry and Environment. January-June.

Endter-Wada, J., Blahna, D., Krannich, R. and Brunson, M. (1998). A framework for understanding social science contributions to ecosystem management. *Ecological Application*, 8 (3), 891-904.

Erkuman, S. (1997). Industry ecology: history view. *J. Cleaner Prod.,* 5 (1-2):, 1-10.

Faber, M., Manstetteen, R. and Proops, J. (1992). Toward an open future ignorance, novelty, and evolution, in Ecosystem Health: New Goals for Environmental Management. In: Costanza, R., Norton, B., and Haskell, B. (eds). Island Press, Washington, DC.

Faber, M. and Proops, J.L.R. (1991). *Evolution in Biology, Physics and Economics: A Conceptual Change*. Present Status and Future Prospects. Manchester: Harwood Academic Publishers, pp. 58-87.

Fadyomi, T.O. (1996). Brian Drian and Brain Gain in Africa: Causes, Dimensions and consequences. In: Adepoju, A. and Hammer, T. (eds). *International Migration to and from Africa: Dimensions, Challenges and Prospect*s. Dakar: PHRDA.

Field, B.C. (1997). *Environmental Economics*, 2nd edition. McGre-Hill.

Fiksel, J.R. (1996). *Design for environment: Creating eco efficient product and processes*. New York: McGraw-Hill.

Fiol, C.M. and Lyles, M.A. (1985). Organisational learning . *Academy of Management Review*, 10 (4), 803-813.

Fischhoff, B. (1991). Value elicitation: Is there anything there*? American Psychologist,* 46, 835-847.

Fischer-Kowalski, M. and Hullter, W. (1999). Scoiety's Metabolism. The Intellectual History of Material Flow Analysis, Part II, 1970-1998. *Journal of Industrial Ecology,* 2 (4), 107-136.

Flinterman, J.F., Teclemariam-Mesbah, R., Broerse, J.E.W. and Bunders, J.F.G. (2001). Transdisciplinarity: The New Challenge for Biomedical Research. *Bulletin of Science, Technology and Society*, 21 (4), 253-266.

Frank, P, Rubik, F. and Bartolomeo. M. (2000). *Life cycle assessment in industry and business: Adoption patterns application and implications*. Berlin: New York; Springer.

Gadgil, M., Berkes, F. and Folkes, C. (1993). Indigenous knowledge for biodiversity conservation. *Ambio,* 22, 151-156.

Gee, D. (1997) Economic Reforms in Europe: Opportunities and Obstacles. In: O'Riodan, T. (ed). *Ecotaxation*. London: Earthscan Publication.

Geiser, K. (1997). Cleaner Production: What's next? In: Meima, R. *Cleaner Production – The Search for New Horizon*. International seminar, Trolleholm Castle, June 15-17. Lund: International Institute for Industrial Environmental Economics, Lund University, pp. 27-29.

Georgoiu, S., Whittington, D., Pearce, D. and Moran, D. (1997). *Economic Values and the Environment in the Developing World*. Cheltenham: Edward Elagr.

Ghosh. B. (1996). Economic Migration and the Sending countries. In: Van den Broeck, J. (ed). *The Economics of Labour Migration*. Antwerp: University of Anterp.

Gibbons, M. and Nowotny, H. (2001). The Potential of Transdisciplinarity. In: Kelin, J.T., Grossen-Mansuy, W., Haberli, R., Bill, A., Scholz, W. and Welti, M. (eds). *Transdisciplinarity: Joint Problem Solving among Science, Technology and Society*. Basel: Birkhouser Verlag, pp. 67-80.

Glasbergen, P. (1995). *Managing Environmental Conflicts. Networks Management as an Alternative.* Dordrecht: The Netherlands: Kluwer Academic Press.

Glasson, J., Therivel, R. and Chadwick, A. (1999). *Introduction to environmental assessment*, 2nd edition. The Natural and Built Environmental Series. Routledge.

Goodland, R. (1995). The Concept of Environmental Sustainability. Annual Review of *Ecological Systems,* 26, 1-24.

Gopalakrisham, S. and Demanpour, F. (1997). A Review of Innovation Research in Economics, Sociology and Technology Management, *Omega*, *International Journal of Management Science,* 25 (1), 15-28.

Goodland, R. and Tillman, F. (1995). Strategic environmental assessment. In: Goodland, R., Mercier, J,R. and Muntemba, S. (ed). *Environmental Assessment in Africa*. Proceedings of the Durban World Bank workshop, June 25, 1995. The World Bank.

Graedel, T.E. and Allenby, B.R. (1995). *Industrial ecology*. Prentice Hall, Englewood Cliff.

Gregory, R., Lichtenstien, S. and Slovic, P. (1993). Valuing environmental resources: A constructive approach. *Journal of Risk and Uncertainty*.

Gregory, R. (1998) *Identifying Environmental Values*. In: Tools to Aid Environmental Decision making.

Guimaraes, P.A and Funtowicz, S. (2006). Knowledge Representation and Mediation for Transdisciplinary Framework: Tools to inform debates, dialogues and deliberations. *International Journal of Transdisciplinary Research*, 1 (1), 34-50.

Guinee, J.B. (2002). *Handbook on Life cycle assessment: Operational Guide to the 1SO Standards.* Dordrecht/London: Kluwer Academic.

Hammond, A.L., Adriaanse, A., Rodenburg, E. Bryant, D. and Woodward, R. (1995). *Environmental Indicators: A Systematic Approach to Measuring and Reporting.* On Environmental Policy Performance in the Context of sustainable development.

Hanley, N., MacMillan, D., Wright, R.E. (1998) Contingent valuation versus choice experiments: estimating the benefits of Environmentally Sensitve Areas in Scotland. *Journal of Agricultural Economics,* 49, 1-15.

Hanley, N. and Spash, C. (1993). *Cost-Benefit Analysis and the Environment*. Edward Elgar, Aldershot.

Hansen, P. E. and Jørgensen, S.E. (1991). *Introduction to Environmental Management*. Developments in Environmental Modelling 18. Elsevier.

Harpaz, Y. (1996). *Putnam's on the relations between language and the world*. www.yehouda.com.

Haught, J.F. (1996). Christianity and Ecology. In: Holmberg, J. (ed). *Policies for a small planet*. London. Earthscan Publication

Harremoes, P. (1998). Can Risk analysis be applied in connection with the precautionary principle. In: *The Precautionary principle*. Extract and summary from the Danish Environmental Protection Agency's Conference on the precautionary principle. Eigtveds Pakhus, Copenhagen 29 May, pp. 30-35. Danish Environmental Protection Agency, Copenhagen. (Environmental New 35)

Harremoes, P. and Madsen, H. (1999). Fiction and reality in the modelling world-Balance between simplicity and complexity, calibration and identifiably, verification and falsification. *Water Science and Technology*, 39 (9), 1-8.

Harremoes, P. (2001). *Ethical aspects of Scientific Incertitude in Environmental Analysis and decision-making*. 7th European Roundtable on Cleaner Production, May 2-4, 2001, Lund, Sweden.

Heijungs, R. (1997). *Economic Drama and the Environmental Stage-Formal Derivation of Algorithmic Tools for Environmental Analysis and Decision-Support from a unified Epistemological Principle*. Leiden, the Netherlands Centre of Environmental Science.

Hens, L. and Boon, K. (1999). Institutional, Legal and Economic Instruments in Ghana's Environmental Policy. *Environmental Management,* 24 (3), 337-351.

Hen, L. and Vojtisek, M. (1998). *The Establishment of health and environmental standards*. In: Nath, B., Hens, L., Compton, P. and Devuyst, D. (ed). *Pollution management in Practice. Vol. 1: Instruments for the environment*, pp. 108-123

Henry van, A. and Wubben. E. (1998). *Environmental Conflict Management*. In: Nath, B., Hens, L., Compton, P. and Devuyst, D. (ed). *Pollution management in Practice. Vol. 1: Instruments for the environment.*

Heijings, R. and Gunee, J.B. (1995). On the usefulness of life cycle assessment of packaging. *Environmental Management,* 19, 665-668.

Heiskanen, E. (2000). Managers' interpretation of LCA: enlightment and responsibilities of confusion and denial. *Business Strategy and Environment,* 94, 239-254.

Heiskanen, E. (2000). *Translation of an environmental technique. Institutionalisation of the cycle approach in business, policy and research networks*. Helsinki: Acta Universitatis Oeconomicae Helsingiensis.

Heiskanen, E. (2002). The institutional logic of life cycle thinking. *Journal of Cleaner Production*, 10 (5), 427-437.

Hirschorn, J.S. (1997). Why the Pollution Prevention Revolution Failed and Why it Ultimately will Succeed. *Pollution Prevention Review*.

Hope, K.R. (2000) Corruption and Development in Africa. In: Hope Snr, K.R. and Chikulo, B.C. (eds). *Corruption and Development in Africa: Lessons from Country Case Studies*. Macmillan and St Martin's Press.

Holmberg, J. (ed) (1994). *Polices for a small Planet*. London: Earthscan Publication.

Holland, J. (1995). *Hidden order. How adaptation builds complexity*. Reading: Addison Wesley.

Howell, F. (1994). Action Learning and action research management education and development. *The Learning Organisation*, 1 (2), 15-22.

Huber, R., Ruitenbeek, J. and Seroa de Motta, R. (1998). *Market Based Instruments for Environmental policymaking in Latin America and Caribbean: Lessons from Eleven Countries.*

Huisingh, D. (1989). *Cleaner Technology Through Process Modifications, Material Substitution and ecological Based Ethical Values*. In: UNEP industry and Environment, January-March, 1989, Paris: UNEP.

Hunt, J. (1994). *The Social Construction of Precaution*. In: O'Roirdan, T. and Campbell, J. (eds). *Interpreting the precautionary principle*. London: Earthscan.

Huntington, H.P. (2000). Using traditional ecological knowledge in science: methods and applications. *Ecological Application,* 10 (5), 1270-1274.

International Chamber of Commerce (ICC) (1989). *Environmental Auditing*. Report No. 468. Paris: ICC.

International Bank for Reconstruction and Development (IBRD) (2000). Decentralisation: Rethinking Government, *World Development Report 1999/2000*. New York: Oxford University Press, p. 107.

Jacobs, M. (1994). The limit to Neoclassim: Towards an Institutional Environmental Economics. In: Redclift, M. and Benton, T. (eds). *Social Theory and the Global Environment*. London: Routlege.

Jackson,C. (1994). Gender analysis and environmentalisms. In: Redclift, M. and Benton, T. (eds). *Social Theory and the Global Environment*. London: Routlege.

Jansen, M. (1995). *Influences Upon Sustainable Product development in the Developing World*. Amsterdam: UNEP-WG-SPD.

Jansen, M. (1995). *Influences upon Sustainable Product Development in the Developing World*. Amsterdam: UNEP-WG-SPD

Jackson, T. (ed) (1993). *Clean Production Strategies*. New York: Lewis Publishers.

Jian Qin, F., Lancaster, W. and Allen, B. (1996). Research types and levels of collaboration in interdisciplinary research in the sciences. *Journal of the American Society of Information Science,* 48 (10), 893-916.

Johnson, M. (1992). *Lore: Capturing Traditional Environmental Knowledge*. Ottawa: Dene Cultural Institute.

Johnston, M. (1998). Fighting systemic corruption: social foundations for Institutional Reform. *The European Journal of Development Research*, 10 (1), 85-104.

Johnson, P.J. (1998). *Hazard, Exposure and Ecological Risk assessment*. In: Nath, B., Hens, L., Compton, P. and Devuyst, D. (ed). *Pollution management in Practice. Vol. 1: Instruments for the environment*.

Johnson, P. J. and Duinker, P.N. (1993). *Beyond dispute: Collaborative Approaches to Resolving Natural Resources and Environmental Conflict*s. Thunder Bay, Ontario: Lakehead University, School of Forestry.

Jordan., A. and Jeppesen, T. (2000). EU Environmental Policy: Adapting to the Principle of Subsidiarity? *European Environment,* 64-74.

Kathawala, Y. and Lingaraj, B.P. (1990). Organisational Structure Considerations in the Next Decade: Implication for Operations Management. *International Journal of Operations and Production management,* pp. 53-60.

Keeney, R. and Raiffa, H. (1976). *Decisions with multiple objectives, preferences and value tradeoffs.* New York: John Wiley and Sons.

Kessler, J.J. (1997). *Strategic Environmental Analysis, a framework for planning and integration of environmental care in development polices and intervention*. AIDEnvironment and SNV.

Kessler, J.J. (1999). Strategic Environmental Analysis Tool Box. The Hague: AIDEnvironment and SNV (Netherlands Development Organisation).

Kessler, J.J. (2003). Working towards SEAN-ERA: A framework and principles for integrating environmental sustainability into planning. PhD thesis. Wageningen: Wageningen University and Research Centre, Department of Environmental Sciences.

Khan, M. (1996). A typology of corrupt transaction in developing countries. *IDS Bulletin,* 8 (5).

Khosla, A. (1995). *Foreword. In A Sustainable World*. T.C. In: Tryzna (ed). Sacramento: IUCN.

Kjaerheim, G. (2005). Cleaner production and sustainability. *Journal of Cleaner Production*, 13 (4), 329-339.

Klein, J.T. (1990). *Interdisciplinarity: History, theory, and practice*. Detroit: Wayne State University Press.

Klein, J.T., Grossen-Mansuy, W., Haberli, R., Bill, A., Scholz,W. and Welti, M. (eds) (2001). *Transdisciplinarity: Joint Problem Solving among Science, Technology and Society*. Basel: Birkhouser Verlag, pp. 67-80.

Kilvington, M. and Allen, W. (2001). *A participatory evaluation process to strengthen the effectiveness of industry teams in achieving resource use efficiency: The Zero programme of Christchurch City Council*. Landcare Research Contract Report.

Klitgaard, R. (1997). Cleaning up and Invigorating the Civil Service. *Public Administration and Development*, 17, 487-509.

Koo, L.C. (1999). Learning Action Learning. *Journal of Workplace Learning*, 11.3.

Kohn, J. (1999). System Hierarchy, Change and Sustainability. In: **Kohn, J, Gowdy, J., Hinterberger. F. and van der Straaten, J. (eds).** *Sustainability in Question*.

Kolb, D. (1984). *Experiential learning; Experience as a source of learning and development*. Prentice-Hall: Englewood

Kolk, A. (1999). Evaluating Corporate Environmental Reporting. *Business Strategy and the Environment*, 8, 225-237.

Kolk, A. (2000). *Environmental Management*. Prentice Hall: Financial Times.

Kroepelien, K.F. (2000). Extended Producer Responsibility – New Legal Structures for Improved Ecological Self-Organisation in Europe? *RECIEL, Review of European Community and International Law*, 2 (2), 165-177.

Kruger, Jr., Norris, F. and Dickson, P.R. (1994) How Believing Ourselves Increases Risk Taking: Percieved Self-efficacy and Opportunity Recongition. *Decision Sceinces*, 25 (3), 385-400.

Kuhn, T.S. (1970). *The structure of scientific Revolution*, 2nd edition. Chicago: University of Chicago Press.

Kuhre, W.L. (1997). *ISO 14020s, Environmental Labelling-marketing*. Prentice Hall PTR, Upeer Saddle River NJ, USA.

Laackey, R.L. (1997). Ecological Risk Assessment: Use, abuse and alternatives. *Environmental Management,* 21 (6).

Lambsdroff Johann, G. (1999). Corruption in international research-a review.

Landau and Eagle. 'On the concept of Decentralisation.

Landell-Mills, P. and Serageldin, I. (1995). Governance and the External Factor. In: Rashid, S., Lee, N. and George, C. *Environmental Assessment in Developing and Transitional Countries. Principles, Methods and Practice*.

Laszlo, E. (ed) (1991). *The New Evolutionary Paradigm*. New York: Gordon and Breach Science Publishers.

Lawn, P.A. (1999). On Georgescu-Roegen's contribution to ecological economics. *Ecological Economics*, 29 (1), 5.

Lawn, P.A. (1998). In defence of the strong sustainability approach to national income accounting, *Environmental Tax Accounting*, 3 (1), 29.

Laylard, R. and Glaister, S. (eds) (1994). Cost-Benefit Analysis. Cambridge: Cambridge University Press.

Leal Filho, W. (1998). *Environmental education and communication. Complementary tools for environmental management*. In: Nath, B., Hens, L., Compton, P. and Devuyst, D. (ed). *Pollution management in Practice. Vol. 1: Instruments for the environment*.

Leal Filho, W. (1996). Integrating environmental education and environmental management. *Environmental management and health,* 2, 80-82.

Leonard, J.H. (1989). *Environment and the poor: development strategies for a common agenda*. New Brunswick: Transaction Books.

Levitt, B. and March, J.G. (1988). organisational learning . *Annual Review of Sociology*, 14, 319-340.

Leroy, P. (1997). *Interdisciplinarity Within Dutch Environmental Science(s). Proceedings of the Conference on Science for Sustainability: Integrating Natural and Social Sciences.* Roskilde: Roskilde University.

Lietch, C.M. and Harrision, R.T. (1999). A Process for an entrepreneurship education and development. *International Journal of Entrepreneurial Behaviour and Research.* 5.3.

Liette, V., Lise, L., Colette, A., Dominique, R., Daniel, M. and Therese, A. (1997). Advisory Committee: A powerful tool for helping decision makers in environmental issues. *Pollution management*, 21 (3), 359-365.

Lifset, R. (1998). Why industrial ecology? *Journal Industrial Ecology*, 1 (4), 1-2

Lindhurst, R.A., Bourdeau, P. and Tardiff, R.G. (1995). *Methods to assess the effect of chemicals on the Ecosystem*, Chichester, UK: Wiley and Sons.

Lindhqvist, T. (2000). *Extended Producer Responsibility in Cleaner Production: Policy principles to promote environmental improvements of product systems*, doctoral dissertation, Lund: Lund University Sweden, International Institute for Industrial Environmental Economics.

Lindhqvist, T. (1998). *What is Extended Producers Responsibility?* In: Jonsson, K. and Lindhqvist, T. (eds). *Extended Producers Responsibility as a Policy Instrument- What is the Knowledge in the Scientific Community*. Lund: IIIEE.

Lindhqvist, T. and Lifset, R. (1997). What's in a Name: Producer or Product Responsibility from theory to practice? *Journal of Industrial Ecology*, 7 (2), 6-7.

Lindhqvist, T.(1992*). Extended Producer Responsibility as a Strategy to Promote Cleaner Products* (1-5). Lund: Lund University, Department of Industrial Environmental Economics.

Litman, T. (2001). Transport Cost Analysis: Application in Developed and Developing Countries. In: Puttaswamaiah, K. (eds). *Cost Benefit Analysis: Environmental and Ecological Perspective.* Transaction, pp. 115-138.

Lipietz, A. (1995). *Green hopes. The future of political ecology*. Polity Press.

Luke, F. (1995). *Development management in Africa. Towards Dynamism, empowerment and Entrepreneurship*.

Luken, R., Johnson, F. and Kibler, V. (1992). Benefits and costs of pulp and paper effluent controls under the Clean Water Act. *Water Resources Research,* 28, 665-674.

Lumley. S. (2001). Cost Benefit Analysis and the Natural Environment. In: Puttaswamaiah, K. (eds) *Cost Benefit Analysis: Environmental and Ecological Perspective,* Transaction, pp. 95-114.

Lorig, K. and Gonzalez, V. (1992). The integration of theory with practice: a twelve-year case study. *Health Education Quarterly,* 19, 355-368.

Lowe, E. (1997). Creating by-product resource exchanges: strategies for eco-industrial parks. *Journal Cleaner Production*, 5 (1-2): 57-65.

Macdonell and Holoubek (2001). Methods and tools for assessment and management of environmental risk. In: Linkov, I., Palma-Oliveira, J. (ed). *Assessment and management of environmental risks. Cost-efficient methods and applications.*

Margerum, R.D. (1999) Integrated environmental management; the foundations for successful practice. *Environmental management* 24 (2): 151-166.

Marilyn, J.A. and Dennis, F.B. (2004). *Breaking Out of the Box: Interdisciplinary Collaboration and Faculty Work*. Information Age Publishing.

Mawhood, P. (1983). Decentralisation: The Concept and the Practice. In: Mawhood, P. (ed). *Local Government in the Third World.* Chichester: Wiley, pp. 1-24.

Mawhood, P. (1987). Decentralisation and the Third World in the 1980s. *Planning and Adminstration*, 14 (i), 10-22.

McGill, I. and Beaty, L (1992). *Action Learning. A practitioner's guide*. London: Kogan Page.

McGill, I. and Beaty, L. (1995). *Action Learning: A guide for professional management and educational development*. London: Kogan Page.

Mee, L. (1995). Scientific Methods and the Precautionary Principle. In: Freestone, D. and Hey, E. (eds). *The Precautionary Principle and International Law*. Boston: Klewer Law International.

Medellin-Milan, P. (2005). Two approaches for pollution prevention in the chemical engineering curriculum at UASLP. *Journal of Cleaner Production*, 14 (2006).

Meittinen, P. and Hamalainen, R.P. (1997). How to benefit from decision analysis in environmental life cycle assessment. *European Journal of Operational Research,* 102, 279-294.

Metzger, H. and Zare, R.N. (1999). Interdisciplinary research: from belief to reality. *Science*, 283, 642.

Miley, W.M., Conway, R. and Anderson, R.G. (1997). Muliattribute Utility analysis as a framework for public participation in siting a hazardous waste management facility. *Pollution management*, 21 (6), 831-839.

Ministry of Finance (2002). *2002 Financial Budget for Ghana*. Ghana.

Mitchell, B. (2000). *Resource and Environmental management*, 2nd edition. Prentice Hall.

Mitchell, B. (2002). *Resource and Environmental Management*, 2nd edition. Prentice Hall.

Mitcham, C. (1995). The Concept of Sustainable Development: its Origins and Ambivalence. *Technology in Society*, 17 (3), 311-326.

Modak, P. and Biswas, A.K. (1999). *Conducting environmental impact assessment in developing countries*. United Nations University Press.

Modelski, G. (1996). Evolutionary paradigm for global politics. *Int. Stud. Quart.,* 40 (3), 321-342.

Modelski , G. and Poznanski, K. (1996). Evolutionary paradigm in the social sciences. *Int. Stud. Quart*., 40 (30), 315-319.

Mohan, G. (1999). Not so distant, not so strange: the personal and the political in participatory research. *Ethics, Place and Environment,* 2, 40-54.

Morgan, D. (1998). *Focus Groups as Qualitative Research*. Newbury Park, CA: Saga.

Morgenstern, R. (1997). *Economic analysis of EPA: Assessing regulatory Impact*. Washington, D.C: Resources for the future.

Morris, P and Therivel, R. (eds) (2003). *Methods of Environmental Assessment*, 2nd edition. Spon Press, UK.

Navrud, S. and Mungatana (1994). Environmental valuation in developing countries. *Ecological Economics*, 11 (2), 135-151.

Netherwood, A. (1996) Pollution management systems. In: Welford, R. (ed). *Corporate Environmental Management. Systems and Strategies*. London: Earthscan Publications Ltd, pp. 35-59.

Netherlands Scientific Council for Government Policy (NSCGP) (1992). *Environmental policy strategy, instruments and enforcement. Summary of the 41st Report*. Report to the Government, The Hague.

Nelson, J.G. (1995). Sustainable development, conservation strategies, and heritage. In: Mitchell, B. (ed). *Resource and Environmental Management in Canada. Addressing conflict and Uncertainty*. Toronto: Oxford University Press, pp. 384-405.

Nelson, R.R. (1995). Recent Evolutionary theorizing about economic change. *Journal of Economic Literature*, 33, 48-90.

Nicolescu, B. (1987). *Moral Project*. International Centre for Transdisciplinary Studies and Research, nicol.club.fr/ciret/English/project.htm.

Nicolescu, B. (1999). *The Transdisciplinary evolution of learning*. Paper presented at the symposium on Overcoming the Underdevelopment of Learning at the Annual Meeting of the American Education Research Association, Montreal, Canada, April 19-23. Online. Avaliable: www.learndev.org/ (9 April 2005).

Nicolescu, B. (2005). Towards Transdisciplinary education. *The Journal of Transdisciplinary Research in Southern Africa*, 1 (1), 5-16.

Nierynck, E. (1998). Life Cycle Assessment. In: Nath, B., Hens, L., Compton, P. and Devuyst, D. (ed). *Pollution management in Practice. Vol. 1: Instruments for the environment*.

Norgaard, R. (1988). Sustainable Development and co-evolutionary view. *Futures*, 606.

Nohria, N. and Gulati, R. (1996). Is Slack Good or Bad for Innovation? *The Academy of Management Journal*, 39 (1), 1245-1264.

NSCGP (1995). Sustained Risks. A Lasting Phenomenon.

Nystrom, H. (1979). *Creativity and Innovation*. New York: John Wiley and Sons.

O'Connor, D. (1991). *Policy and Entrepreneurial Response to the Montreal Protocol: Some Evidence from the Dynamic Asian Economies*. Technical Paper No. 51. Paris: OECD Development Centre.

O'Connor, D. (1994). *Managing the Environment with Rapid Industrialisation: Lessons from the East Asian Experience*. Paris: OECD Development Centre Study.

OECD (1994a). *Applying Economic Instruments to Environmental Policies in OECD and Dynamic Non-Member Economies.* Paris: OECD Documents.

OECD (1994b). *Managing the Environment: The Role of Economic Instruments*. Paris.

OECD (1995). *Report on Trade and Environment to the OECD Council at Ministerial Level.* Paris.

OECD (1996). *Implementation Strategies for Environmental Taxes*. Paris.

OECD (1975). *The Polluter Pays Principle: Definition, Analysis, Implementation*. Paris: Organization for Economic Co-operation and Development.

OECD (2000). Working Group on the State of the Environment 30th Meeting. Special Session on Material Flow Accounting. History and Overview. Paris: Organisation for Economic Cooperation and Development.

Olowu. D. (1995). *Decentralization for Democratic Governance in African States in the 1990s and Beyond: A proposal.* Paper presented at the African Association of Public Administration and Management (AAPAM), expert Consultation Meeting in Nairobi, Kenya.

Ometto, A.R., Guelere Filho, A. and Souza, M.P. (2006). *Implementation of life cycle thinking in Brazil's Environmental Policy*.

Osei-Hwedie, B. and Osei-Hwedie. K. (1999). The Political, Economic and Cultural Bases of Corruption in Africa. In: Hope Snr, K.R. and Chikulo, B.C. (eds). *Corruption and Development in Africa: Lessons from Country Case Studies*. Macmillan and St Martin's Press.

Oscar, J. and Blanchfield, W.C. (1995). *The Evolution of Economic Thoughts*. New York: Harcourt Brace Jovanovich Inc.

Osrtom, E. (1990). Governing the commons: the evolution of institutions for collective actions. Cambridge: Cambridge Uuniversity Press.

Ostrom, E. (1999). *Self-governance and forest resources*. Centre for International Foretry Research, Occasional Paper No. 20. Bogor: CIFOR.

Ostrom, E. (2000). *Understanding the complex linkage between attributes of gods and the effectiveness of property right regimes*. Paper presented at the conference on 'Common Goods and Governance Across Multiple ARENAS' at the Max Planck Project Group on Common Goods: Law, politics, and Economics: Bonn, June 30-July 1.

Oyugi, W.O. (1990). *Decentralised Development Planning and Management: An assessment.* In: Adamolekun, L. et al. (ed). *Decentralization Policies and Scio-Economic Development in Sub-Saharan Africa*. Washington, DC: Economic Development Institute (EDI), World Bank.

Palmer, C.L. (2002). *Work at the Boundaries of Science; Information and the Interdisciplinary Research Process*. Springer.

Padmore, T., Schuetze, H. and Gibson, H. (1998). Modelling Systems of Innovation: An Enterprise-Centered View. *Research Policy*, 26 (6), 605-624.

Pan, T. (1994). The Use of Economic Instruments in Environmental Protection: The Experience of Taiwan. In: *Applying Economic Instruments To Environmental Policies in OECD and Dynamic Non-Member Economies*, OECD Documents. Paris.

Parson. E. and Clark, W. (1995). Sustainable Development as social learning: Theoretical Perspectives and Practical Challenges for the Design of a Research Programme. In: Gunderson, L., Holling, C. and Stephen, S. (eds). *Barriers and Bridges to the Renewal of Ecosystems and institutions*. New York: Columbia University Press.

Pearce, D. (1998). Economics, equity and sustainable development. *Futures*, 20, 598-605.

Pearce, D. and Atkinson, G. (1993). Measuring sustainable development. *The Bulletin. Quarterly Review of progress towards sustainable development*, 20.

Pearce, D. and Alkinson, G. (1993). Capital theory and the measurement of sustainable development: an indicator of weak sustainability. *Ecological Economics*, 8, 103.

Pearce, D., Pearce, C. and Palmer, C. (2001*). Valuing the Environment in Developing Countries*. Cheltenham: Edward Elgar.

Pepper. D. (1993). *Eco-socialism*. London: Routlege.

Pezzey, J. (1989). *Economic analysis of sustainable growth and sustainable development*. World Bank Environmental Working Paper No. 15, Washington, D.C.

Pedler, M. (1991). *Action Learning in practice*. Gower Limited: England.

Perrings, C. (1991). Reserved Rationality and the Precautionary principle: Technological Change, Time, and Uncertainity in Environmental decision making. In: Costanza, R. (ed.). *Ecological Economics: The Science and management of sustainability.* New York: Colombia press, pp. 153-66.

Persoon, G.A. and Van Est, D.M.E. (2003). *Co-Management of Natural Resources: The Concept and aspects of Implementation.* In: Persoon, G.A., Van Est, D.M.E and Sajise, P.E. (eds). *Co-management of Natural Resources in Asia. A comparative perpective*.

Persoon, G.A. and Van Est, D. (1999). Co-management of natural resources: the concepts and aspects of implementation. In: Bernardo, E. and Snelder. D. (eds). *Co-managing the environment*. CVPED, the Philippines.

Plumwood, V. (1993). *Feminism and the Mastery of nature*. London: Routledge.

Pimbert, M.P. and Pretty, J.N. (1997). Parks, people and professionals: putting participation into protected are management. In: Ghimire, K.B. and Pimbert, M.P. (eds). *Social change and conservation. Environmental Politics and impacts of parks and protected areas*. London: Earthscan.

Pinkerton, E. (1989). Attaining better fisheries management through co-management prospects, problems and prepositions. In: Pinkerton, E. (ed). *Co-operative Management of Local Fisheries: New Directions in Improved Management and Community Development*. Vancouver: Universiy of Britihs Colombia Press, pp. 3-33.

Phantumvanit, D. Q. L. and O'Connor, D. (1994). *Applying Polluter Pays-Principle: Time for Action*. Prepared for the 1994 Annual Conference.

Polimeni, J.M. (1999). *A New Vision of the World Transdisciplinary*. International Centre for Transdisciplinary Studies and Research. nicol.club.fr/ciret/English/visionen.htm.

Polimeni, J.M. (2001). *Manifesto of Transdisciplinarity*. Translated from French by Karen-Claire Voss. New York: State of New York Press.

Polimeni, J.M. (2006). Transdisciplinary Research: Moving Forward. *International Journal of Transdisciplinary Research*, 1 (1), 1-3.

Porter, M.E. (1998). Clusters and the New Economics of Competition. *Harvard Business Review,* 77-92.

Power, M. and McCarty, L.S. (1996). Probabilistic risk assessment: betting on its future. *Human Ecol. Risk Assess.,* 2, 30-34.

Pomeroy, R.S., Katon, B.M. and Harkes, I. (1996). Conditions affecting the success of fisheries co-management: Lessons from Asia. *Marine Policy,* 25, 197-208.

Porter, G. and Young, E. (1998). Decentralised environmental Management and popular participation in Coastal Ghana. *Journal for International Development*, 10, 515-526.

Porter, M.E. and Van der Linde, C. (1995). Towards a New Conception of the Environment-Competitiveness Relationship. *Journal of Economic Perspectives,* 9, 97-118.

Posey, D. (ed) (2001). *Cultural and spiritual values of biodiversity: a complementary contribution to the global biodiversity assessment*. London: Intermediate Technology Publication.

Rannis, G. and Stewart, F. (1993). *Government Decentralisation and Participation*. Geneva: UNDP.

Rapport, D.J., Constanza, R. and McMicheal, A.J. (1998) Assessing Ecosystem Health. *Tree* 13 (10).

Rapport, D.J. (1997). Is Economic Development compatible with Ecosystem Health? *Ecosystem Health* 3 (2) .

Reagan, A.J. (1993). *Decentralisation – A comparative Overview of Concepts, Aims, Processes, Outcomes, Actors and Trends.* Paper presented at the conference on Decentralization organised by the Department of Political Science, Makerere University, Kampala, Uganda.

Redclift, M. (1992). The meaning of sustainable development. *Geoforum*, 23 (3), 395-405.

Redclift, M. and Benton, T. (1994). *In Social Theory and the Global Environment*. London: Routlege.

Revans, R.W. (1987). *International Perspective on action learning*. Manchester Training Handbook, V.9 IDM Publication Manchester.

Reynolds, J. and Busby, J. (1996). *Guide to information management in the context of the convention on biological diversity*. Nairobi: UNEP.

Rietbergen-McCracken, J. and Abaza, H. (2000). *Economic instruments for environmental management: a worldwide compendium of case studies*. UNEP: Earthscan Publications.

Ring, I. (1997). Evolutionary Strategies in Environmental Policies. *Ecological Economics,* 23, 237-249

Robinson, M. (2001). It works, but it is action learning? *Education and Training*, 43 (2).

Roberts, H. and Robinson, G. (1998). *ISO 14001 EMS Implementation handbook*. Oxford: Butterworth-Heineman.

Rondinelli, D.A. (1993). *Development Projects as Policy Experiments: An Adaptive Approach to Development Adminstration,* 2nd edition. London: Routledge.

Rosenman, M.F. (1988). Serendipity and scientific discovery. *Journal of Creative Behaviour*, 22, 132-138.

Rose-Ackerman, S. (1999). *Corruption and Government: Causes, Consequences and Reform* Cambridge: Cambridge University Press.

Rotmans, J. and Van Asset, M. (2002). Integrated Assessment: current practices and challenges for the future. In: Abaza, H. and Baranzini, A. (eds). *Implementing Sustainable Development – Integrated Assessment and Participatory Decision-Making Processes*. Cheltenham, UK: Edward Elgar.

Rickhardson, P.M. (1996). Developments in Danish Environment Reporting, *Business and the Environmen,* 5, 269-272.

Riordan, T.O and Campbell, J. (1994). I*nterpreting the precautionary principle*. London: Earthscan.

Riordan, T.O. and Campbell, J. (eds) (1994). *Interpreting the Precautionary Principle*. London: Earthscan Publication.

Riordan, T.O. and Jordan, A. (1995). **The precautionary principles in contemporary environmental politics**. *Environmental Values,* 4, 191-212.

RIVM (2001). *Dutch Environmental Compendium*. National Institute of Public and Environment, RIVM.

Ross, L. and Nisbett, R.E. (1991). *The person and the situation: perspectives of social psychology*. Philadelphia, Temple University Press.

Rourke, D.O., Connelly, L. and Koshland, C.P. (1996). Industrial ecology: a critical review. *International Journal of Environmental Pollution,* 6 (2-3), 89-112

Ruiz, J.A.C. (2000). *Decision Support tools for environmentally conscious chemical process design in CHEE*. MIT.

Russell, C.S. (2001). *Applying Economic to the Environment*. New York: Oxford University Press.

Sadler, B. (ed) (1996). *International study on the effectiveness of environmental assessment*. Canadian Environmental Assessment Agency and IAIA.

Sadler, B. and Verheem (1996). *Strategic Environmental Assessment. Status, challenges, and future directions*. The Hague: Ministry of Housing spatial planning and the environment, publication no. 54.

Salter, L. and Hearn, A. (1997). *Outside the Lines; Issues in Interdisciplinary Research. A pragmatic guide to the issues and problems involve in conducting interdisciplinary research*. McGill Queen's University Press, 216.

Sarkis. J. (1999). Evaluating environmentally conscious business practices. *European Journal of Operational Research*.

Samalulu, O., Magunda, M., Majaliwa, M., Ssali, H., Tenywa, M. and Abisiga, N. (2004). An integrated approach to sustainable utilization of land resources for a better environment. *Uganda Journal of Agricultural Science,* 9, 294-302.

Schaltegger, S. (1998). *Accounting for Eco-efficiency*. In: Nath, B., Hens, L., Compton, P. and Devuyst, D. (ed). *Pollution management in Practice. Vol. 1: Instruments for the environment*.

Schlager, E. and Ostrom, E. (1992). Property-rights Regimes and Natural Resoruces: A Conceptual Analysis. *Land Economics*, 68 (3), 249-262.

Schmidheiny, S. (1992). *Changing Course: A Global Business Perspective on Business and Environment*. Massachuset: The MIT Press.

Schitovky, T. (1992). *The Joyless Economy: The psychology of human beings*. New York: Oxford University Press, revised edition.

Senge, P.M. (1990). *The Fifth Discipline-the Art and Practice of the Learning Organisation*. New York: Doubleday

Shaltegger, S., Muller, K. and Hindrichsen, H. (1996). *Corporate Environmental Accounting*. Chichester: John Wiley & Sons.

Shih-Liang, C. and Shu-Li, H. (2004). A systems approach for the development of a sustainable community—the application of the sensitivity model (SM). *Journal if Environmental Management,* 72 (3), 133-147.

Shrivastava, P. (1983). A typology of organisational learning systems. *Journal of Management Studies*, 20 (1), 7-28.

Smith, P.A.C. (1998). Action Learning: Praxiology of variant. *Industrial and Commercial Training*, 30 (7).

Simonis, U.E. (1994). Industrial restructuring in Industrial Countries. In: Ayres, R.U. and Simonis, U.E. (eds). *Industrial metabolism: Restructuring for a Change*. Tokyo: United Nations University Press.

Sirkin, T. and Houten, M. (1993). *Presource Cascading and the Cascade chain: Tools for Appropriate and sustainable product development*. Onderzoeksreeks No. 71, Interfaculty Department of Environmental Sciences. University of Amsterdam.

Smith, B.C. (1985). *Decentralisation: The Territorial Dimension of the State.* London: George Allen & Unwin.

Solomon, B. and Goitom, G. (1998). *Second and third level manpower demand projections from 1994-2000*. In proceedings of the Seventh Annual Conference on the Ethiopian Economy. Addis Ababa: Ethiopian Economic Association.

Soolsbery, W. (1995). Voluntary Approaches for energy-related CO2 abatement. *The OECD Observer,* 196.

Stankey, G.H., McCool, S.F. and Stokes, G.L. (1999). *Limits of acceptable change. A new framework for managing the Bob Marshall Wilderness Complex*.

Stapenhurst, F. and Langseth, P. (1997). The Role of the Public Administration in Fighting Corruption, *International Journal of Public Sector Management*, 10 (5), 311-330.

Stara, J.F. (1984). *Selected approaches to risk Assessment for Multiple chemical Exposure*. Cincinnati, O. 45268: USEPA – 600/9-84-014a.

Stavins, R. (2000). *Experience with market-based Environmental Policy Instruments, Resources for the future*. Discussion Paper 00-09, Resources for the future, Washington D.C.

Storey, M. (1996). *Policies and Measures for common Action- Demand Side Efficiency: Voluntary Approach Agreement with Industry*. Paris: OECD.

Stien, H. (1998). *Globalisation, Adjustment and the Structural Transformation of African Economies*. Chicago: Roosevelt University.

Sterner, T. (1996). Environmental Tax Reform: Theory, Industrialized Country Experience and Relevance in LDCs. In: Lundahl, M., Ndulu, B.J., Stijkel, A. and Reijnders, L. (1995). Implementation of the Precautionary Principle in Standards for workplace. *Occupational and Environmental Medicine,* 52, 304-312.

Sudley, J. (1998). *Dominant Knowledge System and Local Knowledge. Mtn-Forum On-line Library Document*. www.mtnforum.org/resources/library/stud98a2.htm.

Szeftel, M. (1998). Misunderstanding African Politics: Corruption and the Governance Agenda. *Review of African Political Economy*, 76, 221-240.

Tang, H.K. (1999). An Inventory of Organisational Innovativeness, *Technovation*, 19 (1), 41-51.

Taylor, C.N., Bryan, C.H. and Goodrich, C.G. (1995): *Social assessment: Theory, process and techniques*, 2nd edition. Christchurch: Taylor Baines and associates.

Theobald, R. (1990). *Corruption, Development and Underdevelopment.* London: Macmillan.

Therivel, R., Wilson, E., Thompson, S., Henry, D. and Pritchard, D. (1994). *Strategic Environmental Assessment*. London: Earthscan.

Tojo, N. (2004). *Extended Producer Responsibility as a driver for design change – Utopia or Reality*. Doctoral Dissertation, International Institute for Industrial Environmental Economics. Lund: Lund University Sweden.

Thomas, S. (2003). *Policy instruments for environmental and natural resource management*. Swedish International Development Cooperation Agency.

Tomlinson, P. and Atkinson, S.R. (1987). Environmental audits: proposed terminology. *Environmental monitoring and assessment,* 8, 187-198.

Transparency International Working Paper, Berlin. www.transperancy.de.

Tryzna, T.C. (1995). A Sustainable World. Sacramento: IUCN.

Tukker, A. (2000). Life cycle assessment as a tool in environmental impact assessment. *Environmental Impact Assessment Review,* 20, 435-456.

United States Environmental Protection Agency (1997). *Guidance on cumulative Risk Assessment.* Part 1: Planning and scope. United States Environmental Protection Agency, Science policy.

United Nations Environmental Programme – Industry and environment (1994). Company Environmental Reporting, Technical Report No. 24. UNEP.

UNIDO (1999). UNEP/UNIDO *Definition of cleaner production*. www.unido.org/doc/online.html.

US EPA (1998). *Waste Minimization Opportunity Assessment Manual.*

Usher, P.J. (2000). Traditional Ecological Knowledge in Environmental Assessment and Management. *Arctic,* 53 (2), 183-193.

Uphoff, N. (1998). *Community-based natural resource management: Connecting micro and macro process, and people with their environment*. Washington: International Workshop on CBNRM.

Vanclay, F. (1999). *Social impact assessment*. In: Petts. J. (ed). *International handbook of environmental impact assessment*, Vol. 1. Oxford: Blackwell Science, pp. 301-326.

Van der Voet, E. (1996). *Substance from Cradle to Grave, Optima Druk*. Molenaarsgraaf, the Netherlands.

Van Weenen, H. (1997). *Sustainable Product Development: Opportunities for Developing countries*. UNEP Industry and Environment.

Van der Straaten, J. (2001). Challenges and pitfalls of Cost Benefit Analysis in Environmental issues. In: Puttaswamaiah, K. (eds). *Cost Benefit Analysis: Environmental and Ecological Perspective.* Transaction, pp. 323-346.

Van der Vorst, R. (1997). *Clean Technology and Its Impact on Engineering Education*. PhD thesis. Uxbrigde: Brunel University.

Van Berkel, R., Williams, E. and Lafleur M. (1997). Development of an industrial ecology toolbox for the introduction of industrial ecology in enterprises – I. *Journal of Cleaner production,* 5 (1-2), 11-25.

Van Weenen, H. (1997). *Design for sustainable development*. Dublin: European Foundation.

Van Weenen, H. (1997). *Sustainable Product development: Opportunities for Developing countries*. UNEP Industry and Environment. Paris: UNEP.

Vayda, A. (1983). Progressive contextualization: methods for research in human ecology. *Human Ecology,* 11, 265-281.

Vayda, A. (1986). Holism and individualism in ecological anthropology. *Reviews in Anthropology*, 13 (4), 295-281

Verbruggen, A. (1998). *Economic instruments for Environmental management*. In: Nath, B., Hens, L., Compton, P. and Devuyst, D. (eds). *Pollution management in Practice. Vol. 1: Instruments for the environment*.

WECD. (1987). *Our Common Future*. London: Oxford University Press.

Wenzel, H. (1998). *Environmental Assessment of Products*. London/New York: Chapman and Hall.

Werlin, H.H. (1994) Revisiting Corruption: With a New Definition. *International Review of Administrative Sciences*, 60, 547-558.

WECD. (1987). *Our Common Future. London*: Oxford University Press.

Weiss, J. (2002) *Full Speed Ahead: Become Driven by Change and Take the Ride for your Life!* Bloomfield, MI: Bloomfield Press.

Weintraub, S. (1995). Cultivate Your Dreams for Find New Solutions. *Research and Development Innovator*, 4 (10), 179.

Welford, R., Young, W. and Ytterhus, B. (1998). Towards sustianble production and consumption: literature review and conceptual framework for the service sector. *Eco-Management and Auditing,* 51, 38-56.

Werlin, H.H. (1994). Revisiting Corruption: With a New Definition. *International Review of Administrative Sciences*, 60, 547-558.

White, M.A, and Wagner, B. (1996). Ecobalance: a tool for environmental financial management. *Pollution Prevention,* 13, 31-44

White, A.L, Stonghton, M. and Feng. L. (1999). *Servicizing: The quiet transformation to extended producer responsibility*. Boston: Tellus Institute.

Whittington, D. (1998). Administering contingent valuation surveys in developing countries. *World Development*, 26, 21-30.

Whittington, D.(2002). Improving the performance of contingent valuation surveys in developing countries. *Environmental and Resource Economics*, 22, 323-367.

Wilke, M. and Wallace, H. (1990). *Subsidiarity: Approaches to Power Sharing in the EC*. RIIA Discussion Paper 27. London: Royal Institute of International Affairs.

Williams, A. (1999). *Creativity, Invention & Innovation: A guide to building your business future*. Australia: Allen and Unwin.

Wilson, B. (1990). *System: concepts, methodologies and applications*, 2nd edition. Chichester: John Wiley & Sons, p. 391

Wilke, M and Wallace, H. (1990). *Subsidiarity: Approaches to Power Sharing in the EC*. RIIA Discussion Paper 27. London: Royal Institute of International Affairs.

Winpenny, J.T. (1991). *Values of the Environment*. London: HMSO.

Winpenny, J.T. (1998) Application of Economic instruments for Environmental management. In: Nath, B., Hens, L., Compton, P. and Devuyst, D. (eds). *Pollution management in Practice. Vol. 1: Instruments for the environment*.

World Bank (1992). *Development and environment*. World development report. Baltimore: John Hopkins.

World Bank (1996). Sharing Experiences – Examples of Participatory Approaches. Environmentally Sustainable Development. In: The World Bank Participation Sourcebook, pp. 103-109.

World Bank (1999). *World Bank Report*. London: Oxford University Press

World Bank (1998). *Pollution prevention and Abatement Handbook. Toward Cleaner production*.

Wynne, B. (1992). Uncertainty and Environmental Learning: Preconceiving Science and Policy in the Preventive Paradigm. *Global Environmental Change*, 111-127.

Young, O.R. (1995). The Problem of Scale in Human/Environment Relationships. In: Keohane, R.O. and Ostrom, E. (eds). *Local Commons and Global Interdependence*. London: Sage, pp. 27-45.

Zhu, X. and Dale, A.P. (2000). *Identifying Opportunities for Decision Support systems in Support of Regional Resource Use Planning*: *An Approach Through Soft Systems Methodology*.

Summary
OPiC: a framework for environmental management in developing countries

Chapter 7 of this study overviews the OPiC framework in a formal manner. The present summary provides a more narrative and chapter-by-chapter account.

Research questions and methodology

This thesis focuses on the development of a framework for environmental management, with a focus on pollution management, in developing countries. Most frameworks for environmental management are geared towards partial problem analysis and (rarely) problem explanation with little integration and no attention to positive opportunities that exist in the context of the problem. One hypothesis for the present study is that in almost any context, such opportunities do exist, and that these may enhance the efficacy of environmental policies.

The second hypothesis on which this study is based is that environmental management frameworks express underlying paradigms such as system approaches, causal chain approaches or evolutionary approaches, and that it therefore serves to go into these relatively fundamental issues in order to arrive at a more comprehensive framework that is not only multi-disciplinary but also grounded in a balanced view on these on these foundations.

The research questions which resulted from these hypotheses and explored in this thesis include:

1 How can the major scientific approaches, theories, principles and concepts be used as building blocks for the development of an Opportunity and Problem in Context (OPiC) framework for environmental management?
2 What are the major tools and approaches that can be used in pollution problem analysis and explanation, and how may these become part of a comprehensive OPiC framework?
3 What are the major tools and approaches that can be used to discover and realise opportunities, and how may these become part of a comprehensive OPiC framework?
4 How may a solution to an environmental problem be designed that integrates the options identified through problem-based and opportunity-based approaches to jointly serve comprehensive objectives such as sustainability and efficiency?

These questions have been focused on developing countries, with Ghana as example. These countries present special demands to a framework in terms of data availability, participatory potential and often a relatively weak state.

As detailed in Chapter 1, the dissertation has evolved through a series of studies conducted by the author in the period 2001 -2006. The explorations started as a wandering process with little expectation of leading to the desired outcomes. During the enquiry process, the why and how of the different steps taken in the study were slowly made transparent. The scientific and practical quality of the results have been under constant attention, using a variety of methods such as literature analysis, interviews with practitioners and focus groups, critical thought experiments and discussions with supervisors.

Research findings

The main findings of the study are provided as answers to the four research questions.

1 *How can the major scientific approaches, theories, principles and concepts be used as building blocks for the development of an Opportunity and Problem in Context (OPiC) framework for environmental management?*

The answer to this question is presented in Chapter 2 of the study where the conceptual basis and building blocks for the development of the framework are presented. I examine disciplinary approaches which include the monodisciplinary, multidisciplinary, interdisciplinary, transdisciplinary and holistic approaches to environmental management, and identify pillars for the development of a conceptual framework for opportunity-and-problem-in-context analysis. It is argued that despite the shortcomings of disciplinary and interdisciplinary approaches to environmental challenges, they have made major contributions in terms of expanding our knowledge base and some pollution problems can be solved simply by taking an interdisciplinary approach. However, a transdisciplinary approach helps to overcome the shortcomings of the disciplinary domains and the detailed complexity of the interdisciplinary approach in environmental management.

Environmental functions, the causal chain approach, the systems approach, the adaptive management of complex systems and the material flow analysis of systems are among the relevant first-order offspring (applications) from the disciplinary approaches. It is argued that their combination offers the broadest applicable approach to environment problems. A causal chain approach offers great flexibility in tracing the relationships between structures of society, actions of actors, changes in the environment and onwards to effects on stakeholders. A system approach al-

lows for dealing with the identification, analysis and control of these variables of a specific system phase based on the notion of a set of relationship between state variables capturing all relevant information about the state of the system, and others as flow or rate variables which include input, throughput and output. The adoption of adaptive management stimulates self-regulation of institutions to reach defined management goals through careful and limited guidance using existing diversity and complexity so as to adapt and be resilient during the management process. The use of material flow analysis will allow for the reduction of primary resource use through improved resource efficiency on a life cycle basis.

The concepts of governance decentralisation, subsidiarity, co-management, integrated environmental management, organisational learning and corruption abatement are identified as social building blocks for the OPiC framework. It is argued that decentralization by allocation of responsibilities across institutions and agencies will ensure effectiveness of policies related to environmental management in developing countries. The most important underlying condition for successful decentralization is serious commitment from the central state. It is also noted that not all pollution problems should be managed in a decentralised fashion because of the difference in complexity of the problem and the variation in factors in the context. While there is the need for devolution of authority in pollution management to the lowest possible level connected to the physical scale of the pollution problem, at the same time central governments should retain rights to instruct the lower-level governments when needed. The decision to decentralise pollution management should be made in the light of the spatial distribution of the problem and the actual strength and weaknesses of public and private sector organisations at different levels. Building blocks identified for the framework are the application of: co-management approaches where the state and community negotiate to agree on shared responsibility for a range of pollution management functions, and integrated environmental management where all interested actors are involved to agree on a common vision, strategy and roles and responsibilities. In all this, accountability and transparency are of utmost importance, as well as multilevel learning, habits of inquiry and shared understanding.

Also in Chapter 2, the concept of sustainable development is examined in an attempt to operationalise the concept in pollution management, with special attention to its precursors, the varied conceptualizations held in the scientific community, natural capital as a condition for sustainable development and the issue of its complementarity or substitutability. In view of the complementarity between natural and man made capital, achieving sustainability through environmental management requires that human beings maintain the ecosphere's source and sink functions and sustain the national capital entering the production process. Moreover, human beings should protect the ecosphere's rich biodiversity in order to limit any irreversible damage inflicted on the ecosphere's functions. Strong

sustainability approaches, with their non-negotiable well-defined norms, values and standards, should be used for environmental functions provided by natural capital that are not or most likely not substitutable, whilst weak sustainability approaches, with their market-based and economic tools, may be applied for natural capital that requires major human management inputs. This requires a two-tiered approach to the evaluation of plans and policies, with one tier focusing of equity issues (including sustainability and other interests of future generations) and market-based cost-benefit analysis in the second tier. Finally, context analysis and macro-level analysis are identified as the key aspects of a realistic planning process.

Throughout this study, examples are given from developing countries. Chapter 3 presents this 'context of application' of the framework, taking into account the answers to research question 1. It starts with a review of constraints in developing countries that call for an adapted approach to pollution management. Mismatch between sectors, socio-cultural constraints, financial resource constraints and institutional constraints are identified as key issues hampering sustainable pollution management in developing countries. Resource valorisation, sectoral synergy and sectoral policy reforms are identified as principles for dealing with the special circumstances in developing countries. Since most examples and illustrations in the study are on Ghana, the second part of this chapter presents general description of the socio-economic background of Ghana and its current development strategies. The section also gives an overview of the pollution problems in Ghana and examines the national environmental policy and assesses pollution management tools used in Ghana. A review of Tema, a port city in Ghana with pollution problems, is presented. The review outlines the general background of Tema, its pollution problems and industrial activities.

2 *What are the major tools and approaches that can be used in pollution problem analysis and explanation, and how may these become part of a comprehensive OPiC framework?*

Answers to these questions are presented in Chapter 4 of the study where the Problem-in-Context (OiC) framework, environmental assessment (EIA) tools, functions of the environment, Life Cycle Assessment (LCA), economic assessment (TEV; CBA) and Action-in-Context (AiC) are identified as tools to guide environmental problem analysis and explanation. The tools are reviewed and where possible their application in Ghana is illustrated to generate insights for the development of OPiC framework.

These tools have been chosen for the development of OPiC because of the following reasons:

- PiC's problem analysis is taken as a template for the problem analysis because it encompasses all other tools, is conceptually clear and close to daily life reasoning. It covers the facts and norms that jointly define what a problem is, and the full causal chains between human activities and impacts in terms of policy objectives.
- The functions concept is taken up in the framework because classifications of ecological functions such as 'CPSH+PR' have a good structuring power in complex and multi-sectoral analyses and are cheap to use. Moreover, they provide a systematic basis to establish Total Economic Value.
- Life cycle thinking approach is used to expand the 'activity' element of the problem analysis because it makes explicit that different pollution flows are connected to different stages of the life cycle of products. Moreover, it connects the analysis with the emission and impact models produced by the global LCA community.
- Tools and models from the conceptual structure of EIA may play a useful role in the analysis of effect chains and the derivation of environmental standards for higher-level norms. Moreover, the principles of strategic EIA will help to mainstream the environment in policymaking.
- Economic tools such s total economic value (TEV) assessment or cost-benefit analysis (CBA) should be used with awareness of their sometimes arbitrary character and limitations (e.g. see under evaluation, below), but then may form a powerful tool to communicate the value of the environment with policy makers.
- Action-in-Context is made explicit in the framework because it is able to give truly causal explanations of environmental problems by focusing on the actors behind the problem-generating activities. Moreover, it and can be applied in flexible, informal ways and links up quite concretely with options for policy interventions.

The structure that results from the integration of these tools is summarized in Chapter 7 (e.g. Figure 7.1). Key elements are effect chains and norm chains that run parallel to each other but with reversed causality ('impact assessment' versus 'norms derivation') between the polluting activities and the 'final variables' that express policy objectives of health, biodiversity, welfare and culture. The polluting activities are decomposed in a cradle-to-grave manner that may be regionally constrained. Norms in terms of human activities (e.g. emission standards) are called environmental capacities. Discrepancies between effects and norms (facts and values) describe the seriousness of the problem, which may be expressed in monetary terms through the economic tools but may also be left in their own terms, e.g. environmental variables, emission variables, variables of performance of environmental functions or final variables. Specifying this structure for the

problem at hand is called the problem analysis. As a process, problem analysis may start anywhere in the structure and follow any sequence thereafter, but it is important to in the end cover all elements and causal linkages with a level of sophistication that is as balanced as possible. Problem analysis may well include local and traditional knowledge as well as local and traditional values, and may be carried out in any degree of stakeholder or public participation.

Environmental problems stand in a contextual structure that comprises the normative context, the ecological context and the social context. Each of these is connected to its own elements of the problem analysis. The normative context comprises the deeper justifications of why values in terms of the final variables (health, biodiversity, economic development etc.) are set as they are. The ecological context comprises the causes of why the environmental capacity of a certain place is what it is. Finally and most importantly in practice, the social context comprises the reasons why the problem-generating human activities are carried out the way they are. Going into these contexts marks the cross-over from problem analysis to problem explanation. It is often done most effectively in a step by step manner ('progressive contextualisation').

The social explanation of the environmental problem in OPiC is actor-based, with as its central element that for the explanation of an activity A, we first need to identify the decision-making social entity of the activity (*i.e.* the actor), then take stock of the options the actor may implement (A, B, C etc.) and the considerations the actor uses to make its decision (their 'motivations'). Starting this process from the directly problem-causing activity, we may identify actors causally behind these 'primary' ones by finding out what actors have an influence on either the options or the motivations of the primary actors. Simple examples of such influences are giving information on new options for pollution prevention, or the establishment of a levy on polluting activities. The 'secondary' actors responsible for such actions in turn have their own options and motivations, which are then influenced by tertiary actors, and so on. The causal structure thus identified around the polluting activity is called the actors field. Out of this field, selected actors may be further analyzed on how their options and motivations are connected to underlying societal structure and culture. This analysis adds the elements of the actors' knowledge, capitals, economic costs and benefits and the cultural interpretations thereof, self-image, micro-structure and macro-structure. Relevant for the design of solutions to the environmental problems, the actors field identifies potential target groups for policy interventions and the deeper analysis per actor identifies potential policy content (the 'policy instruments').

3 *What are the major tools and approaches that can be used to discover and realise opportunities, and how may these become part of a comprehensive OPiC framework?*

Answers to this question are presented in Chapter 5 of the study. The problem-analytical and explanatory tools from the preceding chapter but also normative concepts such as sustainable product development, cleaner production and industrial ecology, as well as creativity-enhancing approaches are identified as tools and approaches that could be used to discover and realise opportunities to solve environmental problems.

The problem analysis of the preceding chapter generates physical policy options which include options interrupting causal chains in the environment, options to reduce environmental burdens, options that integrate environmental restoration and management, and end-of-pipe solutions. The LCA-type of structure given to the 'activity' element in the problem analysis translates to policy options of waste management, extended producer responsibility, and environmental product improvement. From the problem explanation arise insights in potential target groups and options for policy content that include (1) options directed at the actors' capacities such as research for technological innovation, credit schemes and prestige enhancement, restrictive regulation and so on, (2) options directed at the actors' motivations such as financial internalization, social internalisation, environmental information and education and many others.

Based on normative concepts explored in the chapter, it is found that the revaluation of local raw materials and the upgrading of indigenous and existing processing technologies can provide new opportunities for the field of product development in developing countries. Pollution prevention strategies based on local industrial skills and capacities may enable industries and society to achieve improved production efficiency. The application of industrial ecological concepts in developing countries could take different forms and depths depending on the scope of the region, the nature of industrial activities in the region, and the desirable objectives to be achieved. Resource and material flow analyses could be used in a qualitative manner to establish trends that would provide a sound background for sustainable environmental management.

Traditional and local knowledge offer good opportunities to improve environmental management in developing countries. One example is to help establish the current use and cultural meanings of lands and resources by people that may be adversely affected. Traditional ecological knowledge may also play a vital role in the environmental assessment by providing different perspectives on the ecosystem and human-environment interrelations. Traditional ecological knowledge could also be used in the public review phase of environmental impact assessment

to contribute to understanding the cumulative effects of activities. Participatory local appraisal, focus groups and advisory committees can be used to tap traditional ecological knowledge for environmental management.

For developing countries especially, the enhancement of self-efficacy of actors has the potential to cause positive change. With improved self-confidence, actors can more successfully engage in a creative search for opportunities and support these opportunities in debates and media. Allied to this point, action learning should be used to guide creative identification of opportunities. Learning through early field trials of possible solutions is part of this strategy for learning in and by environmental and industrial organisations. The creative identification of opportunities will also be enhanced of organisations and individuals would pay more attention to the power of serendipity and dreams.

4 *How may a solution to an environmental problem be designed that integrates the options identified through problem-based and opportunity-based approaches to jointly serve comprehensive objectives such as sustainability and efficiency?*

Chapter 6 starts out with a round-up of the types of options identified in the preceding chapter and then moves on to discuss how these may be brought towards implementation by way of market-based tools, regulatory tools, environmental communication and education and conflict resolution tools. With respect to market-based tools, charges and taxes may be recommendable for water pollution, tradable permits for air pollution, deposit-refund system for solid waste management and eco-labels to promote the use of sustainable products. Regulatory tools and environmental education and communication tools should be used in combination with other tools. However, the effectiveness of tools will depend on the pollution problem in question and the legal, judicial and social context. The effectiveness of conflict resolution, for instance, will depend on the conflict at hand as well as the history of the relationship among the parties in the conflict, particularly their willingness to come together to find a long-lasting solution to the conflict. Often, a balanced and synergistic mixture of market-based, regulatory and communicative tools is most effective in the development of solutions to pollution problems.

Furthermore, Chapter 6 discusses the principles and applications of co-management, stakeholder participation and adaptive management as overall characteristics of pollution management strategies. Co-management involves government and local actors (e.g. industries) that negotiate over the sharing of visions and regulatory inputs. Participation entails the inputs of the wider circle of all stakeholders in the design, implementation and follow-up of pollution management plans. Adaptive management focuses on the time dimension, and especially on the flexible responses to monitored changes. These principles may serve to guide

the coherent integration of options and tools for solutions of pollution problems. The principles may be combined to form the notion of participatory and adaptive co-management, but this combination has its limitations, too.

The final sections of Chapter 6 focus on the methods of design, evaluation, implementation and monitoring of pollution management plans. Contrary to common approaches, the evaluation in OPiC implies a two-tiered process. Designed solutions first have to pass an equity filter that checks produced designs on the avoidance of harm to basic needs of the poor, to future generations and to biodiversity. Once passed this filter, designed solutions may enter a traditional efficiency test such as cost-benefit analysis, since the equity filter has already taken care of interests that are poorly expressed in CBA. The adaptability test, finally, involves elements such as the preservation of open options for the future and institutional learning.

Overviewing all preceding material, Chapter 7 summarizes the OPiC framework. It starts out with the conditions that needs to be fulfilled for effective use of OPiC and then focuses on the key elements of OPiC such as problem analysis and problem explanation, the options for solutions arising from these and from additional industrial concepts and creativity, the features of a conducive context of discovery and the principles of design and evaluation of pollution management strategies. Finally, the chapter discusses the range of applicability of the framework. Due to its generic character, OPiC can be used not only for pollution abatement but also in many mixed problem situations that also include issues of poverty abatement, natural resources, pollution prevention etc. on various scales. Although designed as an instrument for the design of action, OPiC may also be used as a framework for the analysis of planning processes. And although designed primarily for use in developing countries, OPiC may well be of use in industrialized countries s well. At the same time, however, OPiC is not something to be applied rigidly as if it were a mathematical formula with only one way of doing it. People have to adapt the framework to address the issue under consideration.

Samenvatting
OPiC: Een raamwerk voor milieu-management in ontwikkelingslanden

Een raamwerk voor milieumanagement is een conceptuele structuur, een model in de brede zin des woords, dat gemaakt is om milieumanagement te ondersteunen. Hoofdstuk 7 van dit proefschrift geeft een formeel overzicht van het hier ontwikkelde 'OPiC' raamwerk. Onderstaand volgt een meer narratieve en hoofdstukgewijze samenvatting van het proefschrift.

Onderzoeksvragen en onderzoeksaanpak

Dit proefschrift behandelt een raamwerk voor milieumanagement, met een nadruk op vervuilingsvraagstukken in de ontwikkelingslanden. De meeste raamwerken voor milieumanagement geven slechts gedeeltelijk inzicht in de aard van milieuproblemen. Ook bestaat er slechts zelden aandacht voor de verklaring van problemen of de kansen voor oplossing die verborgen liggen in de context van problemen. Een van de uitgangspunten voor de onderhavige studie is dat zulke kansen bijna altijd bestaan en kunnen bijdragen aan effectief milieubeleid. Het tweede uitgangspunt voor de studie is geweest dat raamwerken voor milieumanagement gebaseerd zijn op onderliggende paradigma's zoals de systeembenadering, ketenbenadering of evolutionaire benadering. Onderzoek naar deze grondslagen kan helpen om tot een meer omvattend raamwerk te komen dat niet alleen multidisciplinair is maar ook gebaseerd is op een evenwichtige keuzes.

De onderzoeksvragen die hieruit voortkwamen zijn:

1 Hoe kunnen belangrijke wetenschappelijke benaderingen, theorieën, principes en concepten gebruikt worden als grondslagen van een raamwerk voor milieumanagement dat zowel kansen als problemen in hun context omvat? ('Kans en probleem in context' – 'Opportunity and Problem in Context – 'OPiC')
2 Wat zijn de belangrijkste instrumenten en benaderingen die gebruikt kunnen worden voor de analyse en verklaring van vervuilingproblemen, en hoe kunnen die in een omvattend OPiC raamwerk worden opgenomen?
3 Wat zijn de belangrijkste instrumenten en benaderingen die gebruikt kunnen worden voor de ontdekking en realisatie van kansen voor oplossingen, en hoe kunnen die in een omvattend OPiC raamwerk worden opgenomen?
4 Hoe kan een oplossing voor milieuproblemen worden ontworpen op een wijze die een evenwichtige integratie is van de opties die gevonden zijn via beide bovenstaande denklijnen en die omvattende doelstellingen zoals duurzaamheid en efficiëntie zo goed mogelijk kan dienen?

Deze vragen zijn in dit proefschrift toegespitst op ontwikkelingslanden, met Ghana als voorbeeld. Deze landen stellen bijzondere voorwaarden aan een raamwerk, in termen van de beschikbaarheid van data, potentieel voor participatie en toepasbaarheid vanwege een relatief zwakke staat.

Zoals uiteengezet in Hoofdstuk 1 is dit proefschrift het resultaat van een aantal studies ondernomen gedurende 2001 tot 2006. De verkenningen begonnen als een zwerftocht met weinig beeld van het gewenste einddoel. Gedurende het werk werden doelen en stappen meer transparant. De wetenschappelijke en praktische kwaliteit van resultaten hebben steeds centraal gestaan, ondersteund door verschillende methoden zoals literatuurstudie, interviews met praktijkwerkers en focusgroepen, kritische denkexperimenten en discussies met collega's en supervisoren.

De onderzoeksresultaten worden onderstaand weergegeven in de vorm van antwoorden op de vier onderzoeksvragen.

1 *Hoe kunnen belangrijke wetenschappelijke benaderingen, theorieën, principes en concepten gebruikt worden als grondslagen van een raamwerk voor milieumanagement dat zowel kansen als problemen in hun context omvat?*

Deze vraag wordt behandeld in Hoofdstuk 2, waarin de conceptuele basis en bouwstenen voor het raamwerk worden gepresenteerd. De eerste invalshoek is het onderscheid tussen monodisciplinaire, multidisciplinaire, interdisciplinaire, transdisciplinaire and holistische benaderingen van milieumanagement. Ondanks hun tekortkomingen blijken de mono- en multidisciplinaire modellen belangrijke bijdragen te leveren, die voor de analyse, verklaring en oplossing van sommige milieuproblemen voldoende kunnen zijn indien zij in een interdisciplinair verband worden geplaatst. Transdisciplinaire, meer systeemgerichte benaderingen helpt echter om de gedetailleerde complexiteit van interdisciplinaire modellen te overstijgen.

De verschillende wetenschappelijke benaderingen hebben allemaal producten opgeleverd met een brede relevantie voor milieumanagement. Daaronder zijn bijvoorbeeld de functies van het milieu, de causale ketenbenadering, adaptief management en materiaalstroom-analyse. Een combinatie hiervan levert de breedst mogelijk toepasbaarheid voor de oplossing van milieuvraagstukken. De causale ketenbenadering, bijvoorbeeld, heeft een grote flexibiliteit in het traceren van de relaties tussen maatschappelijke structuren, het handelen van actoren, veranderingen in het milieu en effecten op stakeholders. Een systeembenadering maakt het mogelijk om deze variabelen coherent te kwantificeren en tot reductie van hulpbronnengebruik te komen, bijvoorbeeld met behulp van input-output sche-

ma's. Adaptief management tenslotte stimuleert de zelfregulatie en robuustheid van instituties binnen breed geformuleerde doelen.

In hetzelfde hoofdstuk worden de concepten van decentralisatie, subsidiariteit, co-management, integraal management, lerende organisaties en corruptiebestrijding besproken als maatschappelijke basis voor het OPiC raamwerk. Decentralisatie, bijvoorbeeld, bevordert effectiviteit van milieubeheer indien (1) de centrale overheid sterk gecommitteerd blijft aan de doelen en duidelijke instructies geeft, indien (2) de mate van decentralisatie wordt aangepast aan de fysieke schaal van het probleem en indien (3) de feitelijke capaciteit van lagere overheden en private partijen in de planning wordt betrokken. Co-management, waarin overheden en lokale partijen samen een visie ontwikkelen en beslissen over milieubeheer, past goed in een strategie van decentralisatie. Transparantie en het afleggen van rekenschap ('accountability') zijn bij dit alles, zeker in ontwikkelingslanden, centrale waarden.

Eveneens in Hoofdstuk 2 wordt het concept 'duurzame ontwikkeling' onderzocht teneinde dit te operationaliseren voor milieumanagement. Aandacht wordt besteed aan de voorlopers van het begrip, de verschillende opvattingen die er leven en de rol van natuurlijk kapitaal in duurzaamheid. In de visie dat natuurlijk kapitaal niet (genoeg) substitueerbaar is door mensgemaakt kapitaal wordt het behoud van natuurlijke functies en biodiversiteit een zelfstandig doel voor 'mensbehoud' nog los van de intrinsieke waarde van de natuur. Dit leidt tot een tweetraps aanpak voor de evaluatie van menselijk ingrijpen. De eerste stap ('equity') beoordeelt of het betrokken plan geen schade doet aan de natuur of de toekomstige generaties. De tweede stap ('efficiency') beoordeelt dan welke van de toelaatbare plannen de beste kosten-baten verhouding heeft.

OPiC richt zich, zoals gezegd, op toepasbaarheid in ontwikkelingslanden. Hoofdstuk 3 beschrijft deze 'toepasbaarheidscontext'. Het begint met de organisatorische, financiële en institutionele beperkingen waarmee milieumanagement in ontwikkelingslanden wordt geconfronteerd, en bespreekt principes om die op te lossen, zoals valorisatie van hulpbronnen en sectorale hervorming. Daarna richt de aandacht zich op Ghana als voorbeeldland. Aan de orde komen de ontwikkelingsproblematiek van het land, de vervuilingproblematiek en het beleid en instrumentarium die worden ingezet om die problematiek te verminderen. Het hoofdstuk eindigt met een weergave van de achtergrond, de actoren en de problemen in Tema, de industrie- en havenstad van Ghana.

2 *Wat zijn de belangrijkste instrumenten en benaderingen die gebruikt kunnen worden voor de analyse en verklaring van vervuilingproblemen, en hoe kunnen die in een omvattend OPiC raamwerk worden opgenomen?*

Hoofdstuk 4 presenteert de antwoorden op deze vragen. Het hoofdstuk bevat een kritische bespreking van benaderingen zoals zichtbaar in Probleem-in-Context (PiC) raamwerk, de functies van het milieu, milieu-effectrapportage (m.e.r.), levenscyclusanalyse (LCA), economische waardering (TEV, KBA) en Handeling-in-Context (AiC) als middelen ter ondersteuning van de analyse en verklaring van milieuproblemen. Zo veel mogelijk wordt dit getoetst aan en geïllustreerd met toepassing in Ghana.

Deze instrumenten worden als belangrijk beschouwd om de volgende redenen.

- PiC omvat alle andere causale raamwerken voor de analyse van milieuproblemen, inclusief de meespelende waarden en normen.
- De functies van het milieu geven een systematische classificatie van de relaties tussen milieu en mens, die goed te gebruiken is in brede, multi-sectorale analyses en voor het vaststellen van 'total economic value' (TEV).
- Levenscyclusanalyse kan goed worden gebruikt als systematische structuur binnen het ongedifferentieerde element 'milieuhandeling' in PiC. Dit verbindt de analyses met de kennis van de wereldwijde LCA gemeenschap.
- Instrumenten en modellen uit wereld van m.e.r. kunnen de analyse van causale ketens ondersteunen, zowel voor de voorspelling van effecten als voor de afleiding van milieunormen. Tevens kunnen de principes van strategische m.e.r. helpen om het milieu in te voegen in de algemene politieke besluitvorming.
- Economische instrumenten zoals TEV en kosten-baten analyse kunnen, indien we ons bewust blijven van hun beperkingen (zie onder bij evaluatie), een belangrijk instrument zijn voor waardebepaling en communicatie.
- Handeling-in-Context helpt bij het bereiken van werkelijk causale verklaringen van milieuproblemen, door de identificatie van causale sociale mechanismen en actoren achter de probleemgenererende activiteiten. Bovendien kan het raamwerk ook informeel worden toegepast en geeft het een goed zicht op opties voor beleidsinterventies.

De structuur die ontstaat door de samenvoeging van deze instrumenten is weergegeven in Hoofdstuk 7. Kernelementen hierin zijn causale effect- en normketens die onderling gespiegeld zijn maar met een omgekeerde causale richting (effectvoorspelling versus normafleiding) tussen de milieubelastende activiteiten en de 'eindvariabelen' die de finale doelen van milieubeleid uitdrukken, zoals duurzame gezondheid, welzijn, welvaart en behoud van biodiversiteit. De milieubelastende activiteit wordt in het raamwerk in termen van levenscyclus uiteengelegd, al of niet voorzien van en ruimtelijke inperking. Normen die spreken in termen van toelaatbaarheid van milieubelastende activiteiten worden milieucapaciteit

genoemd. Paarsgewijze discrepanties tussen effecten en normen geven de ernst van het probleem weer. Deze kunnen in monetaire termen worden beschreven mar ook in hun eigen termen gelaten, zoals emissievariabelen, milieuvariabelen, variabelen van functievervulling van het milieu of eindvariabelen. Specificatie van bovenstaande structuur heet de probleemanalyse. Als proces kan een milieuprobleemanalyse overal in de structuur beginnen en daarna een willekeurige route doorlopen, als aan het einde maar alle elementen en causale relaties worden gedekt in een min of meer gelijke mate van precisie en zekerheid. Probleemanalyse kan lokale kennis en waarden in zich opnemen, en worden uitgevoerd in iedere gewenste vorm en mate van publieke participatie.

Milieuproblemen staan in een causale context die bestaat uit een normatieve context, een ecologische context en een sociale context. Ieder van deze ontspringt uit een bepaald element van de probleemanalyse. De normatieve context bestaat uit de rechtvaardigingen waarom de normen van de eindvariabelen (gewenste gezondheid, gewenste economische groei, biodiversiteitnormen etc.) zijn wat ze zijn. De ecologische context bevat de oorzaken waardoor de milieucapaciteit op een bepaalde plaats is wat hij is. De sociale context heeft meestal met de grootse directe relevantie voor de praktijk. Deze context bevat de oorzaken waarom de milieubelastende activiteiten zijn wat ze zijn. Ingaan op deze contexten markeert de overgang van probleemanalyse naar probleemverklaring. Probleemverklaring kan meestal met meest effectief worden uitgevoerd in een stap voor stap proces, vertrekkend vanuit de betrokken elementen van de probleemanalyse ('voortschrijdende contextualisatie').

De sociale verklaring van milieuproblemen in OPiC blijft geheel op actorniveau, met sociale systemen op de achtergrond als bron van opties en overwegingen van actoren. Het centrale element in de verklaring is dat we voor de te verklaren handeling A eerst moeten zoeken wie de besluitvormende sociale entiteit (actor) is, dan moeten inventariseren welke hier relevante handelingsopties de actor heeft (A, B, C, …) en de overwegingen (motivaties) die de actor gebruikt voor zijn keuze. Als we dit proces beginnen vanuit de direct milieubeïnvloedende handeling, dan kunnen we achterhalen welke actoren causaal achter de direct milieubeïnvloedende ('primaire') actoren liggen. Dat zijn namelijk de actoren die invloed hebben op de opties of/en motivaties van de primaire actoren. Voorbeelden van zulke invloeden zijn het geven van informatie over nieuwe opties voor het voorkomen van vervuiling, of het leggen van een heffing op vervuiling. De 'secondaire') actoren die verantwoordelijk zijn voor deze invloeden worden via hun opties en motivaties voor het beïnvloedend handelen op hun beurt beïnvloed door tertiaire actoren, enzovoorts. De causale structuur die op deze wijze rond de primaire activiteit wordt ontdekt heet het actorenveld. De opties en motivaties van geselecteerde actoren uit dit veld kunnen nader worden verklaard door de causaal te verbinden met de hun onderliggende maatschappelijke structuur en

cultuur. Deze analyse maakt gebruik van concepten als kennis, kapitaal, kosten, baten en de interpretaties daarvan, zelfbeeld, microstructuur en macrostructuur.

3 *Wat zijn de belangrijkste instrumenten en benaderingen die gebruikt kunnen worden voor de ontdekking en realisatie van kansen voor oplossingen, en hoe kunnen die in een omvattend OPiC raamwerk worden opgenomen?*

Antwoorden op deze vragen zijn het onderwerp van Hoofdstuk 5. De probleemanalytische en –verklarende methoden van het vorige hoofdstuk vormen een der fundamenten voor het identificeren van kansen om milieuprobleem op te lossen, naast normatieve concepten zoals duurzame productontwikkeling en industriële ecologie en creativiteitsbevorderende methodieken.

De probleemanalyse behandeld in het vorige hoofdstuk levert fysieke oplossingsmogelijkheden, zoals het onderbreken van causale ketens in het milieu of tussen milieu en mens en het herstel van milieucapaciteit. De levenscyclusstructuur die gegeven is aan de milieuactiviteiten vertaalt zich tot opties voor afvalbeheer, sturing van grondstoffenverwerving en productverbetering. Uit de probleemverklaring komen de sociale instrumenten ('beleidsinstrumenten') voort om de fysieke opties te helpen realiseren. Het actorenveld geeft inzicht in de potentiële doelgroepen (doel-actoren) en de diepere analyse levert de potentiële inhoud van interventies. Dit zijn oplossingselementen gericht op de opties die actoren hebben, zoals het ontwikkelen en aanbieden van innovatieve technieken, kredietverlening en versterking van sociaal kapitaal, restrictieve wet- en regelgeving, enzovoorts, benevens opties die zich richten op de motivaties van actoren, zoals financiële internalisatie (heffingen e.d.), sociale internalisatie, milieu-educatie en vele andere.

Gebaseerd op de normatieve concepten die in het hoofdstuk worden verkend wordt geconcludeerd dat een herwaardering van lokale grondstoffen en het verder ontwikkelen van lokale kennis over procestechnologie kansen bieden voor productontwikkeling in ontwikkelingslanden. Locale vaardigheden kunnen industrieën helpen om een hogere efficiëntie te bereiken. De toepassing van concepten uit de industriële ecologie kan in ontwikkelingslanden vele vormen aannemen, afhankelijk van de regio, de industrie en de doelstellingen. De analyse van materiaalstromen kan reeds indien op een kwalitatieve manier toegepast van nut zijn voor duurzaam milieubeheer.

Traditionele en lokale kennis bieden vele mogelijkheden voor het versterken van milieumanagement in ontwikkelingslanden. Een voorbeeld is het vaststellen van de gebruiksfuncties en culturele betekenis van land en natuurlijke hulpbronnen van mensen die mogelijk getroffen worden door milieuvervuiling. Traditionele kennis kan ook een belangrijke rol spelen in milieu-effectstudies, door het verschaffen van alternatieve perspectieven op het ecosysteem en mens-milieurelaties.

En tenslotte kan deze kennis gebruikt worden om zicht te krijgen op de cumulatieve effecten van meerdere activiteiten na of naast elkaar. Participatief lokaal onderzoek (PRA), focusgroepen en adviescomités zijn vormen waarmee lokale kennis tot expressie kan worden gebracht.

Speciaal in ontwikkelingslanden kan de bevordering van het zelfstandig denk- en werkvermogen van actoren een grote betekenis hebben. Met toegenomen zelfstandigheid en zelfvertrouwen kunnen actoren meer succesvol betrokken zijn in het zoek naar creatieve oplossingen en het uitdragen daarvan in debat en media. Daaraan gekoppeld is het van belang dat vormen van actief leren worden toegepast in het zoeken naar kansen voor oplossingen. Het snel uitproberen van mogelijke aanpakken in het veld is deel van een dergelijke strategie. Ten slotte wordt de identificatie van kansen bevorderd door bewust om te gaan met serendipiditeit en dromen.

4 *Hoe kan een oplossing voor milieuproblemen worden ontworpen op een wijze die een evenwichtige integratie is van de opties die gevonden zijn via beide bovenstaande denklijnen en die omvattende doelstellingen zoals duurzaamheid en efficiëntie zo goed mogelijk kan dienen?*

Hoofdstuk 6 begint met een overzicht van de typen opties voor oplossingen die gevonden zijn in het voorgaande hoofdstuk en vervolgt dan met de vraag hoe deze opties tot implementatie kunnen worden gebracht door middel van marktgerichte en regulerende instrumenten, communicatie, educatie en conflictbeheersing. Binnen de groep van marktgerichte instrumenten zijn, globaal gesproken, heffingen geschikt voor watervervuiling, verhandelbare emissierechten voor luchtvervuiling, statiegeldsystemen voor afvalproblemen en eco-labels voor milieuvriendelijke producten. Regulerende instrumenten, communicatie en educatie kunnen het best worden ingezet in combinatie met andere instrumenten, al naar gelang de institutionele en sociale context. De effectiviteit van conflictbeheersing zal afhangen van het conflict zelf maar ook van de geschiedenis die de actoren met elkaar (willen) hebben. In vele gevallen zal een uitgebalanceerde combinatie van instrumenten het meest effectief zijn.

Verder behandelt Hoofdstuk 6 de principes en toepassingen van co-management, de participatie van belanghebbenden en adaptief management als algemene karakteristieken van strategieën voor milieubeheer. Co-management betrekt overheden en lokale actoren (bijv. industrieën) op elkaar in een gezamenlijk aanpak van milieuproblemen, door middel van onderhandelingen binnen een gedeelde visie. Participatie betrekt een grotere kring van belanghebbenden bij het ontwerp van de implementatie van plannen. Adaptief management richt zich vooral op de tijdsdimensie, in het bijzonder snelle en flexibele antwoorden op gemonitorde veranderingen. De drie karakteristieken kunnen worden gecombineerd tot 'par-

ticipatief adaptief co-management', maar niet zonder dat wederzijdse beperkingen optreden.

Het laatste deel van Hoofdstuk 6 behandelt onder andere de (ex ante) evaluatie van ontworpen oplossingen. In tegenstelling tot gangbare benaderingen is evaluatie in OPiC een driestaps proces. Ontworpen oplossingen worden eerst getoetst op rechtvaardigheid ('equity'), dat wil zeggen het vermijden van schade aan biodiversiteit, toekomstige generaties en de bevrediging van basisbehoeften van de armen. Ontworpen oplossingen die deze toets doorstaan mogen verder naar de gewone doelmatigheidtoetsing ('efficiency') zoals kosten-batenanalyse, omdat de eerste toets de belangen die niet in kosten-baten analyse kunnen worden opgenomen reeds heeft veiliggesteld. De aanpasbaarheidstest, tenslotte, bevat elementen zoals institutioneel leren en het openhouden van opties voor de toekomst.

Hoofdstuk 7 vat al het geleerde samen in een formeel overzicht van het OPiC raamwerk. Het begint met de voorwaarden die moeten zijn vervuld voor het succesvol toepassen van OPiC en richt zich daarna op de kernelementen van het raamwerk, zoals de probleem-analyse en -verklaring, de opties voor oplossingen die daaruit voortkomen, de opties die voortkomen uit additionele concepten en creativiteit, de kenmerken van een goede 'context of discovery' en de principes van ontwerp en evaluatie van strategieën voor milieubeheer. Als laatste behandelt het hoofdstuk de toepasbaarheid van OPiC. Het raamwerk kan worden gebruikt voor vervuilingsvraagstukken maar ook in vele meer gemengde probleemsituaties waarin ook elementen voorkomen van armoedebestrijding, beheer van natuurlijke hulpbronnen en dergelijke, op allerlei schaalniveaus. Hoewel ontworpen als een instrument voor het ondernemen van actie (planning, beleid) kan OPiC ook worden gebruikt als instrument voor de analyse van acties van anderen. En hoewel primair ontworpen met het oog op ontwikkelingslanden kan OPiC ook zijn diensten bewijzen in de ontwikkelde wereld. Tegelijkertijd blijft altijd gelden dat OPiC niet toegepast dient te worden als ware het een mathematische formule voor de enig juiste wijze van analyse en ontwerp. Iedere probleemsituatie vraagt om een doordenking van het raamwerk.

About the author

David Tsetse had his General Certificate of Education Ordinary level in 1989 and Advanced level Certificate in 1991 at Dormaa Secondary School in Ghana. He studied Geology at the University of Ghana and graduated with BSc (Hons) in 1996.

From 1996 to 1998 he worked as a Project Geologist with Johannesburg Consolidated Investment (JCI), an exploration company in Ghana and was responsible for over four million dollars worth of gold exploration activities in the Prestea areas of the greenstone belt in Ghana.

In 1998 he started a Master of Science in the Environmental Engineering degree programme at the Department of Environment and Resources at the Technical University of Denmark and graduated in 2000. His areas of specialisation are environmental engineering in developing countries, water supply and management, and Environmental Impact Assessment.

From 2000 to 2002, he worked as an environmental manager/consultant with the Coalition for Sustainable Development Initiatives, now Santa Consult Ltd, an environmental engineering and management firm in Ghana. During this period, he was an environmental consultant to multinational organizations such as Shell Ghana Ltd, Sahara Energy Ltd and Total Ghana Ltd, and government institutions such as the Department of Urban Roads, Ghana and the Ghana Highway Authority where he was involved in the Environmental Impact Assessment on a number of World Bank, IDA and African Development Bank funded projects in Ghana.

From 2002 to 2004 he worked as an environmental research scientist/consultant at the Science and Technology Policy Research Institute of the Council for Scientific and Industrial Research in Accra, Ghana. Here, he was involved in national and international policy analysis and providing inputs for policy formulation in the environmental and industrial sectors.

From October 2004 to July 2005 he was employed by the Catholic Agency for Overseas Development, a UK based non-governmental organisation as the Environmental Health Manager and seconded to the ACT/Caritas Darfur Emergency Response Programme in Sudan. Here he was responsible for the overall planning, management and implementation of about 5 million dollars water, sanitation and hygiene promotion activities funded by the European Commission for Humanitarian Aid

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He joined the United Nations Children Fund (UNICEF) as a Project Officer responsible for planning, monitoring and evaluation of water, environment and sanitation activities in North Darfur, Sudan. In June 2006, he moved to Addis Ababa, Ethiopia as UNICEF Emergency Water, Environment and Sanitation Officer responsible for the country-level coordination of UNICEF Horn of Africa emergency water and environmental sanitation activities in draught, flood and acute watery diarrhoea affected areas. Since January 2007, he has been the UNICEF Water, Environment and Sanitation Specialist and Sector Coordinator for West Darfur, Sudan.

He is happily married to Courage and they have four sons, Bernard, David, Emmanuel and Joel.