SYSTEMS/ OPERATIONAL RESEARCH AND SUSTAINABLE

DEVELOPMENT: TOWARDS A NEW AGENDA[1]

Gerald Midgley[2] and Martin Reynolds[3]

ABSTRACT

Operational research (OR) and environmental planning for sustainable development share three characteristics: first, both have *wide boundaries* in terms of clientele, range of methodological approaches used, and attention to multiple (and often conflicting) values; second, both traditions have an interest in fostering *interdisciplinarity*; third, both traditions are concerned with the *implementation*, as well as the *design*, of planning strategies. In a literature review and interviews with stakeholders associated with both traditions, three generic issues were found to recur: *complexity and uncertainty* (regarding the unpredictability of natural and social phenomena); *multiple and often conflicting values* (of those involved in environmental planning); and *political effects* (on those not involved in planning processes, including non-human nature). This paper reveals a pattern of how these generic issues are perceived in the public, business and

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[2] Institute for Environmental Science and Research (ESR) Ltd., New Zealand
[3] Systems Department, The Open University, Milton Keynes, UK. (Please use Reynolds for correspondence)

voluntary sectors, and explains how, through a series of workshops and a mini-conference, three interrelated agendas for future action by systems/OR practitioners took shape.

INTRODUCTION

Since its inception during the Second World War, Operational research (OR) has a long tradition of mobilising different types of expert support to focus on particular problems associated with particular (albeit originally 'militaristic') objectives. Since the 1950s, OR has been deployed, along with closely associated systems research, as an interdisciplinary approach to address industrial, organisational management and local community issues. It is also clear that a great deal of work undertaken to support environmental planning - from modelling the Earth as a whole system, thereby making a case for limiting economic growth (Meadows *et al*, 1972; Meadows *et al*, 1992) to more recent applications of Multicriteria Mapping in support of risk management in the production of genetically modified foods (Stirling and Mayer, 1999) - can be described in OR terms. Although much of this work has been innovative and often influential, it is rarely identified as being OR. More generally, the label 'OR' appears to have a low profile in the discourse about appropriate methodologies and methods (Bloemhof-Ruwaard *et al*, 1995; Daniel et al, 1997). Our own literature search reveals that, for every paper on environmental planning and management that is explicit about using OR methods, there are at least five making claims to methodological innovation that are using the same or similar methods without any reference to OR (Midgley and Reynolds, 2001).

Meanwhile, the imperatives of environmental management have changed considerably, particularly in the last decade. Most obvious is the wider remit of concern relating to

'sustainable development', which requires people to address in an integrated manner the 'economic', the 'social' as well as the 'environmental' dimensions to development. In our view, and also in the view of the vast majority of the participants in our research, OR has the potential to become a broad-based, dynamic, applied practice of central relevance to environmental planning for sustainable development for both government and industry. Significantly, moreover, it can also support the growing demands of environmental activists in the 'third (voluntary) sector'.

This was further borne out at the 2002 International Sustainable Development Research (ISDR) Conference in Manchester (ERP Environment, 2002).[4] Many of the fifty-three papers presented at this conference addressed methodological developments which could be directly related to OR initiatives. These range from 'hard' OR techniques such as 'analysis of variance' in a comparative study of the Dutch drinking water industry (Dalhuisen and Nijkamp, 2002), through to 'soft' techniques such as 'systemic sustainability analysis' used for generating sustainable indicators (Bell and Morse, 2002), to more 'critical' tools such as 'critical systems heuristics' in modelling stakeholder participation for more meaningful corporate social responsibility (Vos, 2002).

The conference proceedings further illustrated a need for an agenda for the use of OR in environmental planning and management for sustainable development that makes the actual and potential contribution of OR more visible, and which sets out the changes needed in OR practice if this potential is to be realised.

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[4] This paper is a development of the paper we presented at this conference (Reynolds and Midgley, 2002)

In 1999, the UK-based Operational Research Society provided support to a systemic intervention project, based in the Centre for Systems Studies at the University of Hull, designed to create an agenda for the future role of OR in environmental planning and management. Our final report has recently been published in the form of a book entitled *Operational Research and Environmental Management: A New Agenda* (Midgley and Reynolds, 2001).[5] This paper summarises our approach and findings.

WHAT IS OR?

Operational research might be described as having three essential characteristics.[6]

1. OR has a *systems orientation*. The core tools used in OR are centred on modelling, which itself is concerned with fundamental questions regarding boundaries. Systems thinking and systems practice has co-evolved with OR in a mutual appreciation of the relationship between 'parts' and 'wholes' with attention towards holistic thinking.

2. OR is *interdisciplinary*. The military roots of OR reflect the imperative towards bringing together experts from different disciplines in order to address specific problems. Industrial and public sector OR departments reflect a continuation of this

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[5] Copies of the report might sought from the OR Society website www.orsoc.org.uk
[6] These characteristics are a development of those presented by Nigel Cummings (from the UK-based OR Society), 2001, *A History of OR in 2000 Words* OR Newsletter, 364, pp.20-23

tradition. Whilst initially orientated towards mathematics present-day OR incorporates a wide range of disciplinary backgrounds.

3. OR is explicitly *purposeful*. Another way of viewing OR as distinct from traditional disciplines is that it is problem-determined activity rather than an expert-determined activity. OR is almost by definition action-oriented research. Rather than merely providing a set of tools for helping to predict the future, OR is involved explicitly with shaping or designing the future.

APPROACH TOWARDS DESIGNING A NEW AGENDA

Critical Systems Thinking (CST), as represented in the work of Midgley (1996, 2000), provided the guiding methodological framework for our intervention. Midgley lists the key CST principles as:

1. *Improvement* - defined temporarily and locally, but in a widely informed manner, taking issues of power (which may affect the definition) into account;
2. *Boundary critique* - regularly questioning and exploring value and boundary judgements, both with respect to the methodological approach adopted and the substantive subject matter being investigated; and
3. *Methodological pluralism* - learning from other methodologies and drawing in methods from those methodologies.

Participants in this study did not only define improvement in terms of environmental protection, but also the more proactive improvement of approaches to environmental and associated social development. Boundary critique proved crucial, as what counts as an environmental issue was a thorny and recurring question addressed in locally meaningful ways throughout the project. Also, participants generated many insights into the ways in which OR methods can either marginalise or empower stakeholders in environmental management projects. Finally, the practice of methodological pluralism enabled us to ensure that our methods remained flexible and responsive to the great variety of situations we faced. The methods we used were drawn from Qualitative Applied Social Science (e.g., Silverman, 2000), Interactive Planning (Ackoff, 1981), Soft Systems Methodology (Checkland, 1981; Checkland and Scholes, 1990) and Critical Systems Heuristics (Ulrich, 1983).

In this relatively short article we have chosen not to provide any further details of the enactment of the CST principles. For more information about CST, see Flood and Romm (1996), Jackson (2000) and Midgley (2000).

The study ran through four phases, as follows:

Phase 1: Groundwork and stakeholder analysis

A multi-agency steering group was established, and a review of the literature on OR and environmental planning was undertaken. A stakeholder analysis was then initiated, drawing upon both the literature and the views of our steering group. Four stakeholder groups were identified: *professional experts* (operational researchers) associated with

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environmental planning; and users of professional expertise including agencies of *government*, *business*, and the *voluntary sector* (each operating at local, national, and international levels of planning).

Phase 2: Interviews

Two cycles of semi-structured interviews were undertaken: one with stakeholders identified in phase 1, and a second with significant others suggested by those interviewed in the first cycle. 50 respondents agreed to be interviewed in 46 interview sessions. A sectoral breakdown of agencies reveals 11 government, 13 business, 13 voluntary sector, and 11 academic. Phase 2 culminated in the production of an interim report offering feedback to respondents and providing a stimulus to launch phase 3.

Phase 3: Workshops and mini-conference

Two one-day workshops (in London and Sheffield) took place. Interested parties were invited to explore how better expert support could be provided, based on the outputs of Phase 2. The workshops were designed to establish ideal 'mission statements' associated with possible future agendas, and to explore the parameters in which such statements might be realised.

Phase 4: Reporting

Three working documents were produced during the course of the study: an interim report, a workshops report and a mini-conference report. These, along with presentations made to a number of different regional, national and international fora, were designed to elicit feedback to support the learning process.

FINDINGS

The traditions of OR and environmental planning share some common concerns. First, both have *wide boundaries* in terms of clientele, the range of methodological approaches used, and attention to multiple (and often conflicting) values. Second, both traditions have an interest in fostering purposeful *interdisciplinarity*. Third, both OR and environmental planning are concerned with the *implementation* of, as well as the *design* of, planning strategies.

Because of the extraordinarily wide range of substantive issues that are considered to have an environmental dimension, we chose, in this research, to focus our attention on the *generic* properties of environmental issues. We argue that, if OR practitioners are able to show that they can deal with these generic properties, as perceived from different stakeholder groups, then they will be in a good position to make an effective and sustained contribution to environmental planning and management. They will also be in a good position to raise the profile of OR for the future.

Complementarity between OR and generic issues of environmental planning

Three generic issues were found to recur in both the environmental management literature (see Midgley and Reynolds, 2001, for extensive references) and the interview data generated in our study:

1. *Complexity and uncertainty* (regarding the unpredictability of natural and social phenomena);

2. *Multiple and often conflicting values* (of those involved in environmental planning); and

3. *Political effects* (on those not involved in planning processes, including non-human nature).

OR practitioners have typically (but not exclusively) addressed complexity by attempting to make analyses as *comprehensive* as possible through the use of systems thinking. Issues of uncertainty, on the other hand, tend to be addressed through the promotion of *transparency*, typically through processes of modelling and by the selection of indicators (for example, in optimisation studies). There has been a useful focus on *revealing* (rather than solving) problems, and the value of OR modelling as a contribution to *learning* about the management of environmental issues has been stressed. Many OR methods that have been designed to handle complexity and uncertainty are quantitative in nature, and with good reason: they have the enduring value of offering transparency to otherwise obscure or ill-defined phenomena. However, there has been debate about the limitations of such methods in the face of some environmental issues which are *so* complex that they resist quantification. In addition, there is a concern that OR methods might be used to promote technical answers to what are basically ethical or moral questions. Our own answer to these criticisms is that it all depends how quantitative methods are used. We should obviously resist trying to quantify the unquantifiable, and we should think of these methods as a support to learning (rather than as a means for uncovering 'the' truth). Most importantly, however, we should remember that quantitative methods should not *replace*

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debate about values - but once this debate is engaged more purposefully, and a way forward identified, they can provide vital support for further clarifying issues and monitoring performance.

This takes us onto the second recurring, generic theme in environmental management: multiple (and often conflicting) values. One approach to handling these is to aggregate all the (internal and external) costs of implementing a plan to see whether or not these outweigh the benefits (again, costed financially). Of course, this means making a judgement on costs which others may disagree with. Therefore, multiple values are essentially handled by the imposition of one value system translated into costings, thereby allowing optimisation to take place (at least, optimisation from one point of view). There have been many criticisms of these kinds of approaches, but until relatively recently there have been few alternative methods available. However, once the suite of Multi-Criteria Decision Analysis (MCDA) approaches was introduced into the environmental management literature by OR practitioners (including, for example, multicriteria analysis, multicriterion decision techniques, multicriteria mapping, multicriteria evaluation, multi-objective goal planning, multicriteria power generation dispatch etc.) all this changed. MCDA allows multiple purposes to be considered in planning so that win-win scenarios can be constructed. These techniques have been subject to less criticism than earlier ones based on optimisation, but there has still been some scepticism surrounding the quantification of values and, most importantly in the context of environmental planning, it has been realised that MCDA is not value-neutral: it tends to disadvantage environmentalists who, unlike business and public sector managers, are not always willing to accept trade-offs. Finally, we should mention another OR response to the need

to handle multiple, conflicting values: problem-structuring methods. These are mostly qualitative, and support people in debating values and modelling action plans. However, their emphasis on dialogue leaves them open to accusations that they cannot account for the effects of hidden coercion in relationships between stakeholders. Also, in our view, we should be sceptical about claims that, in most circumstances, problem structuring methods should *replace* the more traditional, quantitative OR techniques: rather, we argue that they should both be seen as useful for different purposes.

The third and final recurring generic theme in environmental management is a recognition of the need to account for the political effects of planning on people and non-human nature. In the OR literature, the 'divide' between planners and the communities they serve has been recognised for many years, and some useful theoretical and practical approaches have been developed to support planners in sweeping in the concerns of the affected (a central tenet of some of the work in Critical Systems Thinking). While there are many examples of OR practitioners proposing methodological developments to achieve this, we raised a question about whether or not people's interests in dealing with the political effects of environmental planning should be formalised into an explicit sub-discipline of OR (equivalent in status to the now well-established Community OR): this may promote awareness of the issue of political effects, or it may marginalise it.

In reflecting on these generic issues, it seems to us that OR does indeed have a great deal to offer environmental planning and management. Hopefully, the identification of the three generic themes focuses attention both on where OR has already made a contribution, and where it needs to direct its attention in future. The problem is,

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complexity, multiple values and political effects rarely occur in isolation from one another: it is not possible to produce a simple methodological grid which allocates different methods to the different themes and expect this to answer all our problems. Most often, complexity is *complicated* by multiple values and different perceptions of political effects - in other words, in many situations faced by environmental planners, the three are tangled up together. This means that a huge challenge faces OR as a discipline: developing methodologies and methods that can deal with all three themes simultaneously. The results of our empirical research into the views of environmental managers in the public, business and third sectors reveals some interesting parameters of this challenge.

Stakeholder perceptions of generic issues

An examination of how the three generic issues are perceived in the different sectors (public, business and voluntary) revealed clear patterns, summarised in the following four points:

First, each sector can be shown to have concerns relating to each of the three issue categories (complexity and uncertainty; multiple, conflicting values; and political effects).

Second, for each sector there is considerable conflict between interpretations of how each issue category should be addressed. For example, in dealing with issues of

complexity and uncertainty, some businesses are seeking to adopt and promote a 'learning culture', taking heed of wider economic, social and environmental affairs in long-term planning. However, others still reduce the idea of 'sustainability' to short-term economic prosperity.

Third, issues of complexity and uncertainty dominate the public sector, with attention primarily focused on developing appropriate 'indicators'. Competing values are the main concern of business organisations, with attention being paid to minimising risks by improving stakeholder interaction. Political issues dominate the voluntary sector, with concerns about representing marginalised interests and widening the net of meaningful participation in planning processes. These might be termed the *primary* issue categories associated with each sector.

Fourth, for each sector the two *secondary* issue categories tend to cluster around the primary issue category. For example, in the public sector, conflicting values and issues of social exclusion tend to be dealt with *in relation* to the formation of indicators to deal with complex and uncertain realities.

The issues discussed above are generic and therefore arguably quite abstract. Substantive issues like transport, green belt policy, pollution, energy, waste, genetically modified organisms—and even wider concerns relating to sustainable development, global warming, world trade, population growth, the elimination of poverty, etc.—can be more specifically examined using the same parameters. That is, any environmental issue being addressed could potentially involve each of the three user groups (from the public,

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business and voluntary sectors), as well as some form of 'expert' function. Likewise, any substantive issue might be analysed in terms of all three generic issue types as discussed above.

Clearly, in the increasingly complex, interdisciplinary and politicised world of environmental planning, if we want to enhance expert support using OR, it will be vital to do more than just deal with the technical difficulties associated with modelling the natural world. This is not to say that the technical issues are trivial or unimportant (far from it), but it will also be necessary to address the more messy social worlds of values and ethics in which both OR support and environmental issues are embedded. A major challenge for OR practitioners will be to develop methodologies and methods that are capable of dealing with *all three* of the generic themes identified in this research (complexity and uncertainty, multiple values and political effects).

DEVELOPING THE AGENDA FOR OPERATIONAL RESEARCH

Through the workshops and mini-conference, three distinct (though strongly interrelated) agendas took shape:

1. *Develop OR* (with a focus on methodological issues);

2. *Promote Interaction* (with a focus on issues of interdisciplinarity, intersectoral co-operation, etc.); and

3. *Promote Public Participation* (with a focus on issues of accountability and social inclusion).

Each agenda was subject to a process of analysis and 'conceptual modelling' (Checkland, 1981; Checkland and Scholes, 1990) at the mini-conference. Participants asked themselves, what is the transformation being sought? Who are the intended beneficiaries? Who or what might be made a victim (and should something be done about this)? Who should act to implement the agenda? What worldview underlies the agenda? Who should those implementing the agenda be accountable to? And what environmental constraints will have to be taken as given? The answers to these questions led the group to define key activities needed to realise the stated purposes of the agendas.

For agenda 1 (*Develop OR*), the activities centred on establishing an on-going research project to relate methods with problem situations relevant to environmental management. The need for extensive testing of OR methods in case studies was stressed, as was the need to communicate the results of these tests to enhance the OR knowledge base for environmental management. Importantly, however, the idea of relating methods to problem contexts was not conceived as the production of a mechanical rulebook for OR practice. Rather, it was seen as involving the reconceptualisation of OR as a *reflective practice.* Amongst other things, this will involve questioning purposes (rather than taking them as given); focusing on the big picture; multi-sectoral thinking; including multiple agents in defining problems; drawing upon and mixing multiple methods; and embracing environmental issues alongside social ones (rather than taking either environmental or social issues as prime).

In agenda 2 (*Promote Interaction*), the activities centred on developing 'skills', 'knowledge' and 'communication channels'. Whilst interaction was mainly focused on important issues of interdisciplinarity, the agenda was also concerned with promoting intersectoral relationships. People said that OR needed to move from being a primarily 'backroom', problem-solving form of expertise to being a more pro-active discipline where raising awareness of issues amongst stakeholders and problem structuring are key activities. Also, it will require OR practitioners to be more outward looking and facilitative than is currently the norm.

Agenda 3 (*Promote Public Participation*) recognised the difficulties of having a catch-all public participation remit: it is not realistic to try to engage 'the public' in improving OR in general. Rather, the emphasis needs to be on local participation in projects, taking care to differentiate between general public expressions of concern and special interest group involvements.

The three agendas can usefully be regarded as nested systems: agenda 3 nesting in agenda 2, which in turn nests in agenda 1. Therefore, ensuring local public participation in projects is one aspect of keeping OR interactive and outward looking, and should have an impact on how interdisciplinary and intersectoral communications are conducted. Similarly, both of these agendas have important implications for developing the methodology of OR.

The action plans for each of the agendas are arguably the primary outputs of this research, together with the bond formed amongst the participating OR practitioners.

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However, the group was intent on keeping its feet on the ground, and realised that enthusiasm in a mini-conference will not automatically translate into actual change unless some preparatory actions are taken. Concrete steps for effecting such changes were identified. These steps were translated in our final report into a series of recommendations to both the Operational Research Society and OR practitioners more generally (see Midgley and Reynolds, 2001, for details).

One participant at the 2002 ISDR Conference in Manchester suggested that the three agendas produced could well be applied more generically to other research traditions and disciplines. We fully agree with this observation and invite others from different traditions to find synergy with these ideas. The significant issue is that OR as an interdisciplinary tradition has not only the systemic tools for identifying appropriate agenda items but the potential for pursuing them in the purposeful service of other disciplines, traditions and management practises.

CONCLUSION

In relating OR to other disciplines and practices, the President of the UK-based Operational Research Society enjoys a scenic description:

> "The picture is of a frog and a pike living in a lily pond. From time to time, the frog would hop from one lily pad to another and the pike would stealthily swim to the pad. The pike's intent was clear: he wanted to eat the frog and would snaffle the lily pad if necessary. As the pike opens its jaws to swallow its prey, the frog

leaps onto another pad to live a little while longer. For the definition, OR is the frog and what we do is the lily pad. Other groups will always snaffle what we've been doing - and this is a compliment"[7]

The environmental planning community might be likened to a pike, and OR frogs have sat on a variety of environmental lilypads over the years, each of which has been hungrily consumed. As Daniel *et al* (1997) argue, practitioners of OR and environmental management can usefully learn from one another, and both disciplines will be enriched through a dialogue in which the contribution of each is respected. The question is whether greater benefits might be gained by all interested parties – frogs and pikes - if future methodological developments in OR are more actively directed and mobilised, instead of simply leaving the frog to jump whenever the pike bites.

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[7] Mike Pidd, 2000, <u>OR Newsletter</u>, 353, p.16 (reiterating a definition originally offered by Richard

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Authors*

Gerald Midgley (Director, Centre for Systems Studies)

Centre for Systems Studies, Business School, University of Hull, Hull,

HU6 7RX, UK. G.R.Midgley@hull.ac.uk

Martin Reynolds (Lecturer in Systems)

Centre for Complexity and Change, Open University, Walton Hall, Milton

Keynes, MK7 6AA, UK. M.D.Reynolds@open.ac.uk

Tel: 01908 654894

* Please use Reynolds for correspondence