A System Dynamics Based Planning Solution for Integrated Environmental Management and Policy: the IDeaMaP Toolbox

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Abstract

This article provides a description of a group model building technique developed for application to local and regional environmental planning problems. Although having much in common with other approaches recently reported in the system dynamics literature, this approach has a number of unique features including a major focus on the facilitation of comprehensive stakeholder involvement, ownership and learning as the foundation for all subsequent planning and policy development activities. . As an aid to discussion this approach has been labelled "IDeaMaP", a name designed to capture the notion of the cognitive mapping that is part of the process. The IDeaMaP approach has been developed as an exercise in ecological economics, a field of study based on an holistic and transdisciplinary approach to questions of sustainability and related environmental problems. However, research by the authors indicates that ecological economics lacks a process for achieving transdisciplinary and holistic outcomes, and the present work is an attempt to provide such a process. The authors have used IDeaMaP successfully in a number of environmental management areas, and here describe it in the context of the holistic management of a rural city's water supply.

Introduction

Interest in the environment is hardly a new phenomenon for system dynamics practitioners. Since *Limits to Growth* (Meadows *et al.* 1972), there have been a number of articles that reflect a research interest in the environment (eg. Ford 1990, Ford 1996, Ford 1997, Ford and Bull 1989, Gill 1996, Mashayekhi 1990, Ruth and Pieper 1994 and Sudhir, Srinivasan and Muraleedharan 1997). The present article reflects the efforts of the authors to extend further the principles of system dynamics, systems thinking and learning organisations into the environmental management arena. Following discussion of some key aspects of the environment debate, an introduction to the transdiscipline of ecological economics will provide context for and lead into a detailed description of the full IDeaMaP process.

Environmental policy makers around the world are focused on the achievement of some kind of balance between environmental and economic sustainability. This is a time when environmental care has become, to greater or lesser degree, a permanent exhibit on political agendas. There seems to be an ever present political will to demonstrate progress towards, or at least a degree of sympathy with, the concept of sustainable development as outlined in (among other sources) the Brundtland Report (WCED 1987). The implication is the need to reconsider economic planning as a process limited by ecological capacities. More recently, political statements and even legislation have emphasised the need to consider economic and ecological needs in an *integrated* way. In the Australian states of New South Wales and Queensland, for example, legislation is currently under review to impose 'integrated' sustainability orientated frameworks for development assessment and planning (Department of Urban Affairs and Planning 1997). The search to locate processes or methods that provide more than acknowledgment of the need to change our ways with regard to environmental management is intensifying. Also included is the notion of some greater degree of community involvement and empowerment in development decision making.

From the perspective of environmental management and policy, one of the more interesting developments in recent years has been the advent of the ecological economics movement. Growing from a perceived need to reconsider established environmental policy processes and ideas, ecological economics was created as an explicitly *transdisciplinary* field through which holistic solutions could be developed (Costanza *et al.* 1991). While ecological economics was originally set up to provide for a more constructive dialogue between mainly ecological scientists

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and economists, some ecological economists are now exploring ways and means for integrating all interests with a stake in environmental management and policy (Meppem and Gill 1998, Gill 1997a, Wolfenden 1997a, 1997b).

The New England Ecological Economics Group (NEEEG) of the University of New England in Australia is active in researching processes to facilitate constructive dialogue between economics, ecology, sociology, resource engineering, geography and philosophy (and others) on the academic side and resource managers, environmental lobbyists and the general community on the other. The fundamental philosophy is that well facilitated transdisciplinary learning is the best possible prerequisite to the search for effective solutions to environmental management and policy problems. Moreover, due to the interconnectedness and complexity of environmental issues, there is an imperative to take an holistic or systems view of problems.

An outcome of this ongoing research and practical on-the-ground work is the Integrative Decision Making for Planning Process , which, in the interests of brevity and identity we have labelled ‘IDeaMaP’. IDeaMaP is a response to the main items on the ecological economics and international political agendas: the need to facilitate new learning and lateral responses to the problem of restoring balance between the ecology and economy. It was developed by the authors in an evolutionary way through successive research and consulting applications. The transdisciplinary heritage of our process is demonstrated through its synthesis from the economics, resource management, learning organisation and system dynamics territories. The only intellectual capital we can claim is with regard to the ‘cement’ with which we have bound the constituents of our synthesis and our particular ideas on how the process of consultation that underlies IDeaMaP should be managed. Our process is an innovative synthesis of ideas, not a new set of techniques and theories. This paper represents a report on progress; it is doubtful if the process will ever attain a final form in a world where new opportunities, applications and ideas continually arise to challenge our thoughts.

Facilitating Holistic Thinking and Learning

From the transdisciplinary, holistic foundations discussed above, the very first task in any development planning exercise is to attempt some kind of systematic exploration and pooling of stakeholder understandings and perceptions. At this stage, there should be no attempt to apply some kind of normative thinking or preconceptions to the issues at hand. As Chambers (1997) has related, development planning and policy making always has a foundation on a diversity of perceived realities. There is the reality of the experts: economists, ecologists, sociologists and every other academic interest group has its own tradition through which reality is described and interpreted. Community interests including the environmental lobby have perceptions that might not be even close to those of farmers and other resource managers.

There have been many experiments and some good results to report for (usually private sector) policy processes founded on the explicit recognition, exploration and effective management of diverse stakeholder perceptions. The learning organisation framework is based on this. An ever expanding literature to account for the successes of learning organisation applications would include Senge (1992), Stacey (1993), Chawla *et al.* (1995), Wheatley (1992), Morecroft *et al.* (1994), Seagal *et al.* (1997) and O’Reilly (1995). Essentially, these applications have demonstrated the effectiveness of planning based on the explicit exploration of diverse perceptions and the development of policy strategies as the product of facilitated emergent learning and maintained diverse group ownership. These strategies are likely to be quite different from those developed through more conventional ‘top down’, expert-driven decision making.

Apart from the explicit learning organisation based work, there are many examples of systematic approaches to achieving participative process in the general field of soft operations research (soft OR). Soft OR is a generic term that includes a number of methodologies. Lane (1994), Jackson (1994) and Checkland and Haynes (1994) provide a survey of these methodologies that include Soft System Methodology (SSM), Strategic Choice, Critical Systems Heuristics, Strategic Options Development and Analysis (SODA), and Strategic Assumption Surfacing and Testing. As examples of soft OR, each of these approaches can be expected to have the following characteristics (Checkland 1985):

- oriented to learning;
- assumption that the world is problematic but can be explored using system models;

- assumption that system models are intellectual constructs; and
- a focus on issues and accommodations.

According to these characteristics, the preliminary stages of IDeaMaP can easily be construed as an example of soft OR. Although IDeaMaP was initially developed in isolation from this soft OR heritage, the similarities are not surprising to the authors. After all, these approaches have all evolved as researchers attempt to unravel real world complexity as the first step towards defining a problem and the subsequent proposal of management opportunities (after Ackoff 1979).

The uniqueness of the IDeaMaP approach is the relatively seamless and intuitive procedure through which stakeholder perceptions are explored, merged and integrated into subsequent quantitative analysis. The process is dedicated to the preservation of stakeholder empathy and 'ownership' at all stages (particularly following the introduction of a computer). IDeaMaP is related to Rapid Rural Appraisal (RRA), but provides an approach that is perhaps better able to deliver truly integrated outcomes.

The established territory of RRA involves the merging of a participatory learning approach with cognitive mapping. It has long been applied in the development planning area; though its success has always depended on the commitment of initiating bureaucracies to empower consulted communities in final decision making. RRA is an exercise in strategic scoping; a preliminary systematic investigation into community priorities and politics, and to a degree, it is also a mechanism through which the local system knowledge of community stakeholders might be accumulated and sorted as an input into the larger decision making processes adopted. From the mid 1980's, the emphasis on community participation in RRA increased, effectively giving rise to Participative Rural Appraisal (PRA) as a distinct though related methodological area (Chambers 1997). The emphasis is on group interactive learning rather than survey based data collection and associated remote quantitative analysis. PRA is very much about community empowerment in decision making. It involves...'project appraisal, analysis, planning, action, monitoring and evaluation' (Chambers 1997 p. 119). Despite the rural focus implied in its title, PRA (and RRA) has been applied to natural resource management, agriculture, welfare planning, health and nutrition and urban planning situations.

In his extended introspection on the successes and failures of RRA and PRA, Chambers (1997) considered the need for institutional adjustments, or a change in bureaucratic culture, as a necessary prerequisite to realising the capacities of participative, community involved, planning and decision making. The development infrastructure is, in general, simply not committed to the kind of power transfers that community leadership in planning should involve. There remains a fundamental disconnection between the community consultative and final decision making stages of development planning (especially when the empowered agencies are in command of the money supply). This implies that the learning generated from a well orchestrated PRA process is being less than completely harnessed. This is the foundation from which our own work in IDeaMaP was developed: our process is explicitly about facilitating a strong connection between the scoping (or holistic, participative system learning) stage of planning, through to final decision making. Ours is a process purpose designed to facilitate the sharing of power across a much more transdisciplinary community. The fundamental critical success factor in community involved decision making is the consistent and purposefully cooperative involvement of relevant empowered decision makers from the outset. In other words, government (and/or corporate) policy operatives must participate as stakeholders from preliminary scoping through to final decision making and monitoring.

Other commentators on the need for, and advantages to be realised from, transdisciplinary, community participative approaches to public decision making include, among many others, Sanchez *et al* 1988, Stringer 1977, Susskind and Elliot 1983, and Lawrence 1982. The common theme is the search for a coproductive process, in which the community and the specialist are both involved. Feedback between all participants provides a foundation for learning and prospects for negotiated agreement and even consensus. Many advocates identify an enhanced prospect for lateral thinking and of sustained diverse community empathy as the most desired outcomes (see Meppem and Gill 1998 for a detailed review).

The First Step of IDeaMaP: a Facilitated Group Learning Process for Project Scoping

The very first step of our process involves the systematic, transdisciplinary/participative exploration of an issue or situation. Our general reading and practical experience suggest that there are some key needs for this kind of strategic scoping:

- simplicity and transparency to all participants;
- a process that facilitates the articulation of individual or disciplinary system understandings in a uniformly understandable way;
- a process designed to facilitate transdisciplinary or across-group learning;
- a process that asserts a consistent systems thinking perspective;
- a process that can document a group's learning and serve as an intelligible record or learning summary that is readily interpretable by others;
- a process that facilitates and seamlessly integrates with any subsequent quantitatively orientated analysis;
- a process that is regarded as an integrated first rather than adjunct step in an overall development or policy planning process.

The last requirement is the most difficult to promote and achieve. The implication is that our scoping process must fit within a larger, and similarly innovative total development planning package that encompasses preliminary scoping through to formal quantitative analysis and assessment. To implement the first step, the whole package needs to be adopted. And that will require an inevitable degree of authority divestment from central decision making institutions across an appropriately holistically constituted consortium of effectively empowered stakeholders. It implies the sharing of authority from a restricted set of disciplinary interests across a much more transdisciplinary group. The task is, however, nowhere near as daunting as it may sound. The trend towards this kind of authority sharing (through community participative decision making) and a higher degree of integration across disciplinary borders is now written into or is proposed for key planning legislation at all levels of government in many countries. All that is lacking is a clearly articulated set of tools with which to address these largely politically inspired sentiments. It is our aim to deliver an appropriate tool box, packaged in a format that will appeal to the emerging political agenda of community empowerment and that is explained in a language understandable within the mental models prevailing in the public bureaucracy. We attempt to incorporate the mechanics of systems thinking and learning as automatic, self-emerging features.

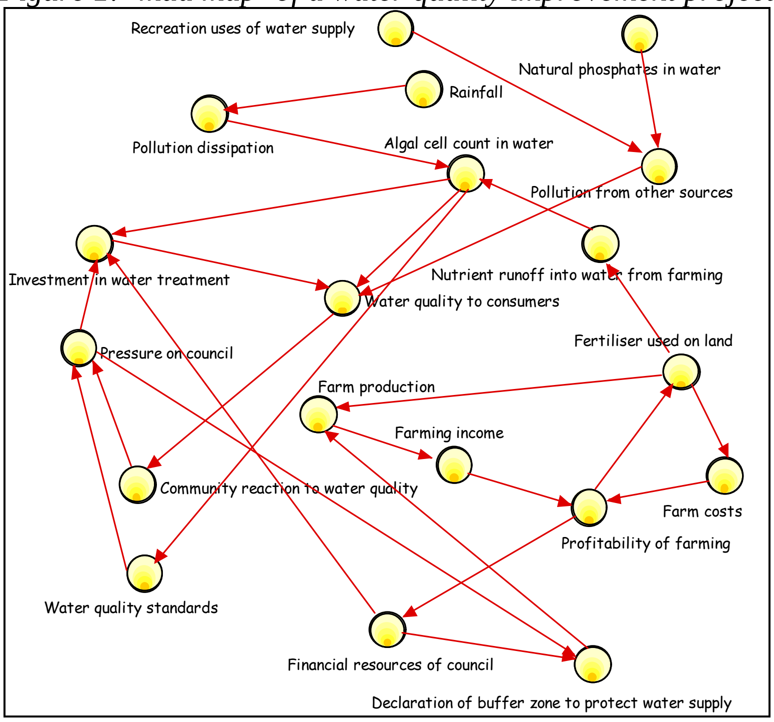
There are many approaches that might be used for our first, strategic scoping step. We have adopted a very crude form of cognitive mapping that will be familiar to any system dynamics practitioner, community consultant or development planning specialist. Our first step involves the construction of a simple, group derived influence map or pattern model. We describe the process as "mud mapping" to reinforce its simplicity and accessibility to any planning group. The conceptual heritage of the our mud mapping is shared by the institutional economics, learning organisation, system dynamics and social ecology (cognitive mapping) fields. The methodology is analogous to Eden's (1980) work on cognitive mapping which, in turn has its foundations in Kelly's (1955) 'theory of personal constructs'. A similar strong association would also apply to the flow diagramming aspects of PRA as discussed previously.

The aim is to facilitate the exploration of stakeholders'[1] initial perceptions with regard to a development or policy issue and to facilitate a process of perceptual evolution through the carefully managed dialoguing and consequent group learning. To achieve these ambitions, we impose the need for all participants to express their thoughts in a common format; that of simple graphical images. This imposes a challenge for all participants; particularly those representing a strong disciplinary tradition. Chambers (1997) makes the observation that disciplinary professionals are often inclined to harness any element of mystique or aura-of-the-expert which may be evident within communities they confront. This may be associated with deliberate obfuscation or with a reliance on a 'trust me' mentality when dealing with those from different disciplinary backgrounds. Disciplinary experts may feel secure when supported by their foundation of 'conventional disciplinary wisdom'; that reliance may take the edge off any attempt to explain difficult concepts more transparently. Our mud mapping process removes that cushion of disciplinary support and exposes all participants equally to the task of explaining concepts in a manner that is understandable to all. If relevant, axioms or assumptions need to be surfaced and considered by the group. Economists in particular may feel particularly uncomfortable in this given the stylised nature of many of the assumptions that underlie their image of how socio economic systems should function. Community representatives are, for example, often bemused by the implication that profit maximisation is the singular motivation in their lives or, indeed, that they may not fit a desired behaviour pattern to be considered appropriately rational.

Similarly, environmental lobbyists are often challenged to explain their passion for an ecology-first foundation for policy making. The problem resides in the continuum of ecophilosophical positions likely to describe the values, attitudes and beliefs of the participants in any group. Like alternative religions, ecocentric (ecology first) and anthropocentric (human first) philosophical positions are not a part of a single value set; they exist as separated points on a continuous spectrum; perceptions are defined and interpreted through the internal imagery of different mental models. Those mental models condition the interpretation and shape the articulation of abstract concepts; if the mental models are not shared, concepts may be misinterpreted. ‘Mud mapping’ is designed to facilitate the surfacing of those more abstract value based perceptions for group introspection and to improve the prospects for learning orientated dialogue. All this activity, however, is an automatic or implicit aspect of the ‘mud mapping’ process. Only the facilitator needs to be fully aware of the social dynamics involved; and that knowledge will shape his or her attempts to manage or manipulate group discussion to purposefully achieve the learning goals of the exercise.

Our version of influence or cognitive mapping is a very intuitive process; deliberately so. An example will illustrate the ideas more effectively than additional abstract description. The map presented in Figure 1 was developed for a local community water quality improvement project. The problem is one of water contamination linked to agricultural practices. The stakeholder group comprised farmers, ecological scientists, local government planners, engineers, community representatives, an economist and a facilitator experienced in the use of mud maps. Constituting a group such as this is a major and time consuming component of the process. Normally, we would iterate group formation through a carefully managed process of individual stakeholder interviews. These are designed to enable the development of some working knowledge about the ‘politics’ of the problem (who represents what aspects of the issue and how the different factions react to it). Individuals are consulted about the most appropriate membership of the working group. Each stakeholder is asked to suggest an appropriate list of participants. Eventually, an appropriate group membership can be developed and problems with regard to misrepresentation can be avoided. This aspect of the process can take days or even weeks of input on the behalf of the facilitator. This process is open ended and continues as part of the early problem definition and system exploration steps.

Figure 1: ‘mud map’ of a water quality improvement project



A map like Figure 1 can take a whole day to develop. Every second of the process is a learning path for the group. At the end of the exercise, the group will have completed a very thorough and systematic exploration of the integrated dimensions of the proposal or issue. More important still, they will have developed a uniform (or close to uniform) set of perceptions about what is involved and the prospective implications. In effect, this first step has neatly and effectively sorted out the main sources of perceptions variation that usually surface as unresolved antagonisms further down the track in more conventional development assessment processes. Each linkage identified in the map is the result of a conversation. The apparent simplicity of the map may disguise the often involved discussions that might underlie the development of its final structure. The map itself is not important; what matters is the process of learning that has accompanied its generation. In the end, the map is simply a summary of the underlying discussions; it is a record or a transcript that has the added advantage of transparency to others not involved in its initial construction. We do not claim that the final map and the system understandings underlying its structure will be immediately apparent to third parties. We do claim, though, that with some straight forward explanation, the final mud map can be made intelligible to others, probably more meaningfully and almost certainly in less time than might be the case with other forms of problem modelling.

Mud mapping (or, more correctly, the group learning process underlying its construction) can of itself yield insights into policy or management options. The group may be able to identify strategic points of system 'leverage' consistently with Stacey's (1993) recommendations for effective learning organisation management procedure. That is, the group may identify key relationships within the system that are most amenable to policy or management manipulation in order to produce a system response or outcomes consistent with the groups' requirements. The process may also yield some insights into appropriate instruments through which the system can be manipulated. If a policy response can be developed in this way, a major benefit is that all participants will have a very clear understanding of its heritage and of the causal mechanisms through which it will exert influence. Another important benefit is the inevitably enhanced degree of group or community ownership that will accompany ensuing policy actions.

Breaching the void between low technology and high technology mud maps

For many projects, however, much can be gained by a more detailed and exhaustive exploration of underlying cause and effect relationships. This would particularly be the case where some divergence persists between interest groups. Also, recommendations or management options identified through the process may need to be assessed in accordance with prevailing legislative requirements or with broader policy formulation conventions. This is particularly the case for rural or environmental development projects, and even more so for those projects targeted at agency financial support. Further, as pointed out by Forrester (1994), there is a danger that the technically superficial understanding developed in this way can lead to ill-advised interventions. In response to all these requirements, we could proceed to IDeaMaP Step 2 which, in effect, involves moving the group mud map onto a computer via system dynamics software. We would describe this as a shift from low technology mud mapping to a higher technology version. The emphasis is still on mud mapping and diverse group involvement.

The shift is, however, very difficult as the journey needs to confront one of the most entrenched antagonistic mind sets that planning facilitators are likely to encounter in their work: suspicion of 'black box' planning. Many community groups are possessed of a very deep rooted, culturally embedded intolerance or even antagonism towards computerised modelling (of any sort). Those with the strongest objections can invariably recount some adverse reactions to expert modelling based policy decision making in the past. Resource managers, for example, have been confronted by a multitude of (usually expert driven) decision support systems and their experiences with those have contributed to the development of a healthy perennial scepticism for the mysterious machinations of consultants wielding black boxes.

To support our concerns in relation to black box decision making, we refer to Stuth and Lyons (1993) who provide a comprehensive coverage of the (recent) state of the art in computerised planning systems. Of the various decision support systems (DSS) available, even those packaged around the notions of integrating ecological and economic system considerations, few in reality deliver anything other than a reductionist, economics biased foundation for decision making. Stuth et al (1993) propose an intensive program of training for prospective users as a prerequisite to support the delivery of these systems. They suggest that prospective practitioners (in places as diverse as China, South East Asia, the Indian Sub-Continent and the West) should be made to understand "...the design logic and effective use of the DSS" which may "...require teaching the fundamental principles and knowledge upon which the system is based" (Stuth et al p. 236).

From the preceding discussion, it must be apparent that Stuth et al's (1993) recommendation represents almost the antithesis of the learning orientated approach recommended for planning in this paper. The presumption is that prospective clients must be trained to accept all the implicit assumptions and 'expert wisdom' embodied within a packaged DSS. There is no element of stakeholder group originated learning or ownership here. Rather, the whole exercise is purpose designed to assert the continued hegemony of the expert in public decision making.

With this background, it is very difficult indeed to avoid an adverse reaction to the shift from hand drawn to computerised mud mapping. Once the computer aspect is introduced, many planning group participants focus on their 'black box' antagonisms rather than on the evolutionary learning process that is still the main aim of the second stage of the IDeaMaP process. The fact that what is being presented is the opposite of a black box (ie. a "white box" after Andersen and Richardson 1997) may escape the group's attention under these circumstances.

As a response, our group is always careful to introduce the capacities of the later, higher technology stages of IDeaMaP in a gradual, carefully paced way. In effect, a well facilitated group should be guided towards a high degree of self-realised need for something 'more thorough' in analytical capacity to extend from its hitherto 'analogue' mud mapping activities. Contemporary, graphically based, interpretations of the system dynamics computer language (such as iThink) have the potential to very effectively support the 'painless' transition towards 'harder' analysis. The graphical interface involved is intuitively related to analogue mud mapping. We harness this similarity to ensure as seamless a transition as possible. The next step is to simply add a few more symbols to our mud map (stocks and flows) to initiate the more specialised steps to follow. The computer itself is introduced strategically (depending on the specific audience involved, we may avoid that introduction until the very end). First though, the group needs to develop some consensus on the need for this extra level of detail. That is usually easy given the almost invariable requirement by those public policy agencies with influence over implementation for some form of quantitative measurement. . In most development planning, for example, there remains a standard need for some kind of formal benefit cost assessment. The group is normally confronted by two choices for handling the subsequent stages of their planning work. The conventional approach is to secure the services of an expert consultant or hand over the assessment task to an agency professional. This is likely to introduce a critical dislocation between the group and the final emergent decision. The group would loose its empowerment and possibly, at least some degree of empathy with the ensuing recommendations.

A key aim for IDeaMaP is the maintenance of a planning group's empowerment from issue scoping through to decision implementation and monitoring. We suggested at the outset, the critical need to include empowered decision makers in the discussion group. With these people on board, it is possible to maintain this continuity notwithstanding the need for formal agency compliance assessment. Our recommendation is that the second and later (higher technology) stages of IDeaMaP in fact provide more analytical capacities than are ordinarily accessible to expert assessment professionals working alone. These capacities are introduced through the power of system dynamics programming. The second stage of IDeaMaP involves an important facilitated learning element for participating expert assessment professionals. In other words, the facilitator can sell the capacities of system dynamics modelling as an all inclusive project assessment framework. System dynamics modelling can handle benefit cost analysis with ease. The major advantage of our suggested approach, however, is the capacity to integrate group derived learning directly with the more formal aspects of project assessment; the usual dislocation between the community consultation stages and final decision making associated with conventional planning procedure is very much avoided.

Similarly to Andersen and Richardson (1997), we would not normally suggest complete group participation in the technical aspects of developing a 'digital' or fully quantified system dynamics version of the hand-drawn or 'analogue' mud map. Those activities comprise Step 3 of IDeaMaP. We do, however, recommend universal participation in Step 2: the development of a more 'precise' mud map using the system dynamics symbolic language. Step 2 may be referred to as ‘qualitative system dynamics’, after Wolstenholme (1990). This will achieve the aim of introducing the more precise pictorial language available through the software, and of the analytical capacities available following formal specification of the final electronic map. This participation, we have found, removes much of the suspicion relating to the translation of the analogue map into its digital counterpart. Another advantage is the capacity of the facilitator to outline the precise nature of the quantification tasks involved in building a working mud map (ie. model) and thus inform participant self selection for involvement in IDeaMaP Step 3. The whole group will, of course, be consulted as a resource for data and other quantitative inputs associated with that later step.

In our experience, the management of community involved development planning through an exclusive reliance on system dynamics software packages like iThink never produced the level of broad acceptance and empathy required to sustain active group enthusiasm and involvement. In earlier work, Gill (1996) proposed the prefacing of formal system dynamics modelling with the community participative development of a social fabric matrix (after Hayden 1982). Though invariably successful in generating a high level of shared insight and learning, a major problem remained in effecting an intuitively seamless transition from matrix to model. The matrix approach is laterally different at least in appearance to the graphical interface underlying subsequent system dynamics modelling efforts though it is directly analogous to ‘mud mapping’. It was always difficult (though never impossible) for participants to consider both aspects as two components of a unified overall process. Following an extensive review of cognitive mapping procedures, the current format for IDeaMaP was developed as a successful process for bridging the gap between the articulation of intuitive system understandings and computerised scenario testing and analysis. The present approach is in accord with the “maintain visual consistency” aspect of Andersen and Richardson’s (1997) group modelling scripts.

IDeaMaP Step 2: Refining the Mud Map

In order to maintain group empowerment and process empathy, and in the light of our desire to avoid computer induced anxieties, we are always careful to introduce the movement from blackboard to computer as a mechanism through which we might develop a more precise picture of the groups’ thoughts. System dynamics software programs like iThink offer the capacity for a more precise and detailed recording of group learning than can neatly be achieved by hand. In effect, we are careful to introduce the software as an ‘electronic white board’. We facilitate an appreciation for the software’s more analytical capacities as needs arise and understandings progress.

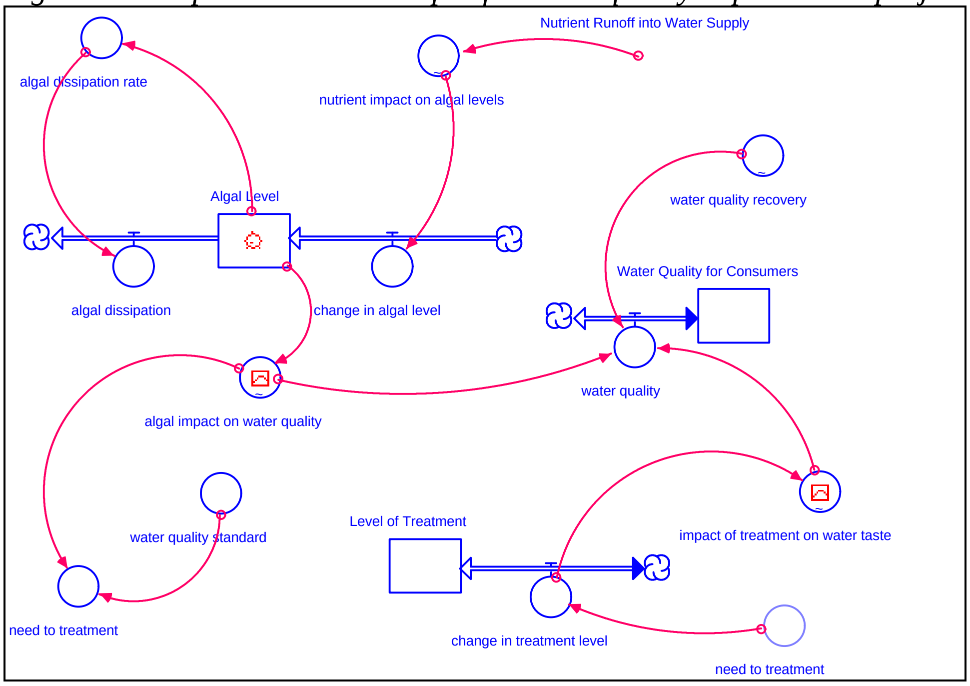
The graphical interface of programs like iThink and Powersim closely approximate the analogue mapping language used in IDeaMaP Step 1. When the software is introduced along the lines recommended above, it would be usual for the second, more detailed mapping step to progress smoothly. Individuals with little or no computer familiarity seem to find the process as amenable as those who use computers regularly. It is a straight forward matter to introduce the extra symbols associated with this second mapping step. On the foundation of the experience derived through Step 1, the added concepts of stocks, flows and auxiliaries are relatively easy to grasp. More importantly, we invariably find that this more detailed mapping exercise yields extra insights into problems and issues. Group learning is refined and extended; and this more detailed mapping process enables a better articulation of possible policy or management options. In the language of learning organisations, this second step is orientated to the exploration of leverage points as strategic opportunities for control (Stacey 1993). To illustrate, (a part of) the reworked mud map for the previously considered water quality case study is presented in Figure 2.

IDeaMaP Step 3: integrating ‘hard’ and ‘soft’ data into the picture

The major advantage of the second, more detailed computerised map is its capacity to become a repository of data. Into this more detailed map we can plug any and all available data; regardless of whether that is ‘hard’ or ‘scientific’ or ‘soft’ or impressions derived.

It is vital that the consultant maintains a faithful representation of the group’s thinking when undertaking the more specialised tasks associated with this quantitative modelling step. Otherwise, it will be very easy to lose the group’s confidence in their ownership of the whole process. To achieve this aim, we would ordinarily constitute a self selected sub-group of stakeholders wanting to maintain some direct involvement with the quantification process. Those individuals would present a resource to support the technical specification of group derived relationships. The facilitator will lead and undertake the required technical modelling tasks involved; though through a process of progressive iteration with the 'technical sub-group' and, on occasion, the whole group. An important interface between the technical modelling process and continued group learning and empathy is general participation in the construction of system dynamics table functions. These represent one of the most powerful learning orientated features of our selected software; providing a non technical way for groups to explore, develop learning in relation to and formally specify the 'shape' or nature of key qualitative and quantitative system relationships. Normally, we would develop a preliminary table function through the input of the technical sub-group. Critical or controversial relationships can also be explored with the entire group if required. When the computerised map is adequately specified, it is possible to explore the validity of what may often be controversial assumptions through the 'flight simulator' or graphical interfacing capacities of the software. This is the essence of IDeaMaP Step 4. The model developed through Step 3 cannot be regarded as being in any way definitive until it has received the kind of group exposure, feedback derived refinement and approval that is the aim of that final step.

Figure 2: Computerised 'mud map' of a water quality improvement project



IDeaMaP Step 4: scenario testing and analysis

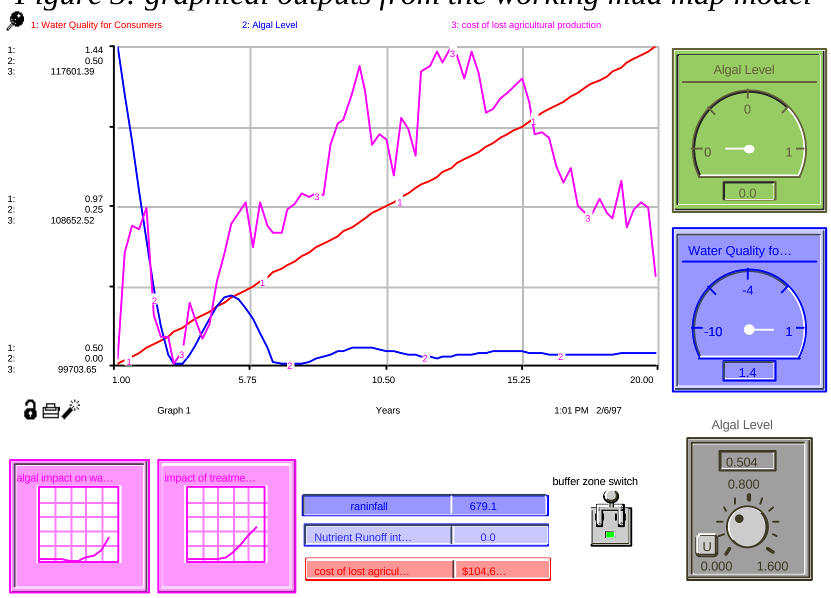
Our computerised map or 'model' is intended only as a device for the facilitation of learning. In other words, the group will have much to gain by 'playing around' with the final model produced. The model, in this regard, is a tool for the systematic exploration of project and policy implications. The first task is to check the accuracy of the data entered in Step 3. We do this by simply getting the group to attest to the reality of the results. If the model performs in accordance with the groups' expectations, then it is validated to the degree that it is reflective of the collective wisdom/intuition of those involved in its creation. This kind of reality checking is a very powerful validation procedure as it will automatically incorporate the reactions of those diverse stakeholders who are the main players associated with its final approval and community acceptance (provided, of course, that that diverse representation has been involved in the facilitated discussions up to this point: as should always be the case).

The *iThink* software conveniently includes some very polished and straight forward presentation functions. The whole stakeholder group can focus on the kind of graphs and other output devices presented in Figure 3. These are intended for general lay person familiarity. An essential aspect of Step 4 involves the 'unfolding' of the last iteration of the system dynamics map (the latest versions of *iThink* have a built-in unfolding facility whereby the model is revealed progressively rather than as a completed, visually confusing whole). The group will already be familiar with the symbols through their participation in Step 3 and will derive confidence in the last iteration through the involvement of their more technically inclined colleagues in the technical sub-group. We would not normally explore the mathematical relationships involved with the whole group unless specifically pressed. Of course, the technically inclined can delve as deeply as they like outside of the main meeting forum; just to make sure that there is no element of 'black boxishness' involved. The last thing an effectively facilitated discussion group needs is an impression that they have been superseded by a computer. That would lose their confidence in the process and the advice it generates.

The 'flight simulator' interface developed as an extension device for the group can be applied to test participants' understanding of the issues systematically and/or to test discussion-evolved management or policy options. The flight simulator interface is the ideal environment through which to explore the capacity of previously identified leverage points to influence the system in desired directions. It also offers very powerful capacities for extending and refining group learning. Discussion relating to controversial policy options can be focused through the fight simulator interface. That process is likely to produce further model refinements and a more precise accounting of the group's understanding of the problem or issues at hand.

Perhaps the greatest capacity of the last analytical step is its capacity to integrate with conventional 'downstream' development assessment arrangements and to generate the conventional stable of project assessment indices (benefit cost ratios, internal rates of return, net present values and the like). As outlined previously, system dynamics modelling can handle conventional benefit cost analysis with ease. The difference here, though, is that the conventional decision criteria are embedded within the model so they can earn and reflect the understanding of a far more diverse group of system agents than is usual with conventional expert derived assessments. Importantly, those quantitative decision criteria are automatically contexted within the much larger, richer and realistic setting of the complex multi-dimensioned issues at hand. Final decision makers are presented with a suitably diverse accounting of project implications and an automatically generated sense of likely community reactions and support.

Figure 3: graphical outputs from the working mud map model



Other Applications of IDeaMaP

Some of our IDeaMaP applications have not extended past detailed mud mapping (eg. Wolfenden 1997c and Gill 1998. Others have progressed from mud mapping to full system dynamics modelling (eg. Gill 1997a). Irrespectively, all have yielded insights into process refinement and a universal degree of enthusiasm among participants. The very lateral, though intuitive nature of the process often generates some initial anxieties with those accustomed to alternative planning and assessment procedures. That almost invariably transforms to committed acceptance under appropriately managed facilitation. It is helpful to convene mapping sessions in 'neutral territory' to help break down possible difficult institutional prejudices and associations. Given the cosmopolitan nature of all our groups, the whole exercise should be facilitated in such a way that no single interest group will feel itself handicapped through operating within someone else's territory. In essence, our process is all about facilitating an important degree of detachment from institutional or experiential 'mind sets' or ingrained procedures to maximise the prospects for collective lateral and innovative thinking.

Conclusions

In this paper, the authors have discussed some issues from the field of ecological economics, and the way they are adapting methodologies derived from the system dynamics and learning organisation frameworks for use in that field. Although the IDeaMaP approach described is in many ways similar to other system dynamics approaches, and can be aligned in some ways with soft OR methodologies, it nevertheless contains some new ideas. The need to provide a relatively seamless transition from the influence diagram stage to the quantitative modelling stage has prompted the authors to develop a simplified influence diagram process that they call 'mud mapping'. While similar in various ways to other problem definition and system description approaches, 'mud mapping' has been purposefully designed to integrate the low technology community knowledge elicitation process with sophisticated system dynamic modelling techniques. This approach has been found necessary because of negative reactions engendered in stakeholders when computer modelling is introduced. In order to avoid alienating and thus effectively disenfranchising some members of stakeholder groups, the use of the computer is introduced in such a way that they can be much more relaxed about its use. This leads to a better inclusive outcome as all stakeholders can participate in the problem solving and policy analysis stages that are carried out with the simulation models. Above all, though, IDeaMaP is a systematic approach to harnessing the potential synergies from effectively managed transdisciplinary cooperation and the empowerment of participating stakeholder groups in final decision making.

References

Ackoff, R.L. 1979. The Future of Operational Research is Past. *Journal of the Operational Research Society*, 30(2):93-104.

Andersen, D.F. and Richardson, G. P. 1997. Scripts for group model building. *System Dynamics Review*, 13(2):107-129.

Arthur, W. B. 1989. Competing technologies, increasing returns and lock–in by historical events. *The Economic Journal*, 99 (March):116–131.

Chambers, R. 1997. *Whose Reality Counts? Putting the First Last*. Bath: Intermediate Technology Publications.

Chawla, S. and Renesch, J. 1995. *Learning Organisations: Developing Cultures for Tomorrow's Workplace.* Portland: Productivity Press.

Checkland, P.B. 1985. From Optimization to Learning: A Development of Systems Thinking for the 1990s. *Journal of the Operational Research Society*, 36(9):727-767.

Checkland, P.B. and Haynes, M.G. 1994. Varieties of systems thinking: the case of soft systems methodology. *System Dynamics Review*, 10(2-3):189-198.

Costanza, R., Daly, H.E. and Bartholomew, J. 1991. *Goals, Agenda and Policy Recommendations for Ecological Economics*, in Costanza (ed.) *Ecological Economics: The Science and Management of Sustainability*. New York: Columbia University Press.

Department of Urban Affairs and Planning 1997. *Integrated Development Assessment: Environmental Planning and Assessment Amendment Bill 1997.* Sydney: UAP.

Dugger, W. M. 1979. Methodological differences between institutional and neo–classical economics. *Journal of Economic Issues,* 13(4):899–909.

Eden, C. 1980. Modelling Cognition in Complex Decision Problems. *Journal of Interdisciplinary Modelling and Simulation,* 3(2):119-144.

Ford, A. 1990. Estimating the Impact of Efficiency Standards on the Uncertainty of the Northwest Electric System. *Operations Research*, 38:580-597. (Reprinted in Richardson 1996).

Ford, A. 1996. Testing the Snake River Explorer. *System Dynamics Review*, 12(4):305-329

Ford, A. 1997. System Dynamics and the Electric Power Industry. *System Dynamics Review*, 13(1):57-85.

Ford, A. and Bull, M. 1989. Using System Dynamics for Conservation Policy Analysis in the Pacific Northwest, *System Dynamics Review*, 5(1):1-16. (Reprinted in Richardson 1996).

Forrester, J.W. 1994. System dynamics, systems thinking and soft OR. *System Dynamics Review*, 10(2-3):245-256.

Gill, R. A. 1996. An Integrated social fabric matrix/system dynamics approach to policy analysis, *System*

Dynamics Review, 12(3):167-181.

Gill, R. A. 1997a, Final Report to the Western Sydney Waste Management and Planning Board, incorporated in: WSWM&PB Draft Regional Waste Plan for the Western Sydney Region, Sydney.

Gill, R A. 1997b. Exploring Transdisciplinary Themes: The New England Ecological Economics Group's Focus on the Meaning and Application of Ecological Economics. *The Ecological Economics Bulletin*, 2(1):6-10.

Gill, R. A. 1998, Report to the Armidale Building the Future Forum, NSW Premiers' Department Regional Coordination Program, Armidale.

Hayden, F. G. 1982. Social fabric matrix: from perspective to analytical tool. *Journal of Economic Issues*, 16(3):637–662.

Jackson, M.C. 1994. Critical systems thinking: beyond the fragments. *System Dynamics Review*, 10(2-3):213-230.

Kelly, G. A. 1955. *The Psychology of Personal Constructs*. New York: Norton.

Lane, D.C. 1994. With a little help from our friends: how system dynamics and soft OR can learn from each other. *System Dynamics Review*, 10(2-3):101-134

Mashayekhi, A.N. 1990. Rangelands Destruction Under Population Growth: the Case of Iran. *System Dynamics Review*, 6:167-193. (Reprinted in Richardson 1996).

Meadows, D.H., Meadows D.L., Randers J. and Behrens III, W.W. 1972. *The Limits to Growth: A Report for the club of Rome's Project on the Predicament of Mankind*. New York: Universe Books.

Meppem, A. and Gill, R. 1998, Sustainability as a learning concept, *Ecological Economics*, forthcoming.

Morecroft, J.D.W. and Sterman, J.D. (eds) 1994, *Modelling for Learning Organisations.* Portland Oregon: Productivity Press.

O'Reilly, K. W. 1995. *Managing the Rapids: Stories from the Forefront of the Learning Organisation.* Cambridge: Pegasus Communications.

Radzicki, M. J. 1990. Institutional dynamics, deterministic chaos, and self–organising systems. *Journal of Economic Issues*, 24(1):57–102.

Richardson, G. P. (ed.) 1996. *Modelling for Management Vols I and II: Simulation in Support of Systems Thinking*, Dartmouth: Aldershot.

Ruth, M. and Pieper, F. 1994. Modelling spatial dynamics of sea-level rise in a coastal area. *System Dynamics Review*, 10(4):375-389.

Sanchez, E., Cronick, K. & Wiesenfeld, E. 1988. Psychological variables in participation: a case study, In: Canter, D., Krampen, M. & Stea, D. (eds) *New Directions in Environmental Participation.* Sydney: Avebury.

Seagal, S. and Horne, D. 1997. *Human Dynamics: a New Framework for Understanding People and Realising the Potential in Our Organisations.* Cambridge: Pegasus Communications.

Stringer, P. 1982 Towards a Participatory Psychology, In: Stringer, P. (ed.) *Confronting Social Issues: Application s of Social Psychology. Vol. 2*. London: Academic Press.

Stuth, J. W. And Lyons, B. G. 1993. *Decision Support Systems for the Management of Grazing Lands: Emerging Issues.* New York: Parthenon Publishing.

Sudhir, V., Srinivasan, G. and Muraleedharan, V.R. 1997. Planning for Sustainable Solid Waste Management in India. *System Dynamics Review*, 13(3):223-246.

Susskind, L. & Elliot, M. 1983. Paternalism, Conflict and Coproduction: Learning from Citizen Action and Citizen Participation in Western Europe, In: Susskind, L. & Elliot, M. (eds) *Paternalism, Conflict and Coproduction.* New York: Plenum Press.

Senge, P. M. 1992. *The Fifth Discipline: The Art and Practice of the Learning Organization.* Sydney: Random House.

Stacey, R. D. 1993. *Strategic Management and Organisational Dynamics.* London: Pitman Publishing.

Wheatley, M. J. 1992. *Leadership and the New Science: Learning about Organisation from an Orderly Universe.* San Francisco: Barrett Koehler.

Wolfenden, J. A. J. 1997a. A systematic approach to dealing with the complex issues typically encountered within the context of Integrated Catchment Management. Proceedings of the 2nd National Workshop on Integrated Catchment Management, Canberra.

Wolfenden, J. A. 1997b. New Approaches to Sustainable Land Management: A case study in political pragmatism. Proceedings of the Australia New Zealand Society for Ecological Economics National Conference, Melbourne.

Wolfenden, J. A. 1997c. New Challenges for the Wastewater Industry: Service Standards and Corporatisation. *Resources Policy*, 4(2):6.

Wolstenholme, E. F. 1990. *System Enquiry: A System Dynamics Approach.* Chichester: Wiley.
World Commission on Environment and Development 1987. *Our Common Future.* Oxford: Oxford University Press.

[1] Our interpretation of stakeholders is inclusive of people living and working in the local community, agency staff with an interest in the area, decision makers, and professionals with relevant information and/or insights to impart.