3

Multicriteria Mapping as a Problem Structuring Method for Project Front-Ending

Josie Coburn and Andy Stirling

Introduction

Historically, project management has relied on modelling decision problems mathematically and computing the 'best' solution. But there do emerge several obstinate, even prohibitive, difficulties for these sorts of models. How to deal with the intractability of real world uncertainties, of kinds that defy the probabilistic reductions of mathematical 'decision models'? How to address (fully legitimate) forms of ethical reasoning that go beyond the simple scalar trade-offs that lie at the core of decision models? When consequences are difficult to characterise in any one robust way, how rational is it to insist on doing so anyway? What about the ambiguities and irreconcilabilities in the divergent values and interests around the management of projects in a complex and turbulent world, difficulties that make it misleading to produce any single, notionally definitive picture? And how to balance the often-invisible effects of

J. Coburn (✉) • A. Stirling
Science Policy Research Unit, University of Sussex, Brighton, UK
e-mail: Josie.Coburn@sussex.ac.uk; A.C.Stirling@sussex.ac.uk

G. Bell et al. (eds.), *Problem Structuring Approaches for the Management of Projects*,
https://doi.org/10.1007/978-3-319-93263-7_3

power—operating as much within the management of large and complex projects as outside (Stirling and Coburn 2017)?

Problems which display these types of characteristics and cannot be solved by traditional modelling methods have variously been described as 'practical problems' (Ravetz 1971), 'wicked problems' (Rittel and Webber 1973), 'messes' (Ackoff 1979), 'ill-structured problems' (Kitchner 1983), and problems which require 'soft systems thinking' (Checkland 1985). More recently, 'wicked messes' (Holt 2004) have been defined as problems which entail both complexity in the problem situation itself, 'dynamic complexity' (Brady and Davies 2014), and the complexity of different stakeholders having different perspectives, 'behavioural complexity' (Williams 2009).

In particular, it is a pervasive dilemma in project management (as in decision-making more widely (Collingridge 1982; Genus and Stirling 2017)) that the highest stakes decisions must typically be made at an early stage in a project at a time of maximum uncertainty—before there has been a chance to gain much relevant information (Williams et al. 2009). This problem is further compounded by the tendencies for dynamic project trajectories to gather 'momentum' (Hughes 1983) and 'lock-in' once they are underway (Arthur 1989). This provides a strong motivation to invest in collecting information to help reduce uncertainties and provide a more robust basis for making key decisions early on in projects (Samset 2009). However, it is also important to note that where uncertainties are high, there is a danger of information overload because there is a lack of knowledge about which information will be important as the project progresses, and therefore the quality of information gathered at this stage is more important than quantity (Samset 2009).

In the project design stage, past experience shows repeatedly (as in the bridge building example in Saadi and Bell's (Saadi and Bell 2018) chapter in this book), that effective stakeholder engagement can offer particular benefits. Arguments put forward for paying attention to the perspectives of multiple stakeholders early on in projects include bounded rationality, incomplete information, satisficing, and cognitive biases (Williams 2009).

To address these issues, there is growing agreement that the definition of project management needs to be broadened beyond simply delivering

a project on time, within budget, and within scope, 'the technical core', to include developing the design of the project or the project front-end, 'the strategic envelope' (Morris and Geraldi 2011). At the front-end of projects 'we often have quite messy, poorly structured situations, where objectives are not clear, where different constituencies have conflicting aims, and where the way forward requires vision and leadership as well as hard analysis and design' (Morris 2002). Project front-ending is about identifying the right project, scoping the project, and engaging key stakeholders early on in the process (Williams et al. 2009). It is about learning, understanding, and making sense of the project in the very early stages (Williams et al. 2009).

In an increasingly interconnected and turbulent world, in which projects are typically becoming more complex, larger, and more time-constrained (Williams 2009), new problem structuring methods (PSMs) have emerged to cope with the increasing complexity (Rosenhead and Mingers 2001). PSMs originate in the operational research tradition but 'accept as a fact that the most demanding and troubling task in formative decision situations is to decide what the problem *is*' (Rosenhead and Mingers 2001). These methods are plural, iterative, both quantitative and qualitative, allow consideration of uncertainties, and they acknowledge the fact that different stakeholders have different perspectives.

PSMs emphasise the need for qualitative and participatory approaches to address these issues in the management of projects (Rosenhead and Mingers 2001). Work has already been done in this area, for example in using scenario planning to conceptualise, define, and design the right projects (van der Heijden 2009). Scenario planning in this context is about understanding the whole system and bringing together different bodies of knowledge, acknowledging that different stakeholders have different points of view, and working to reduce the problem of knowledge 'silos' (van der Heijden 2009). It is an iterative research process, alternating between storytelling to build and refine possible scenarios, and expert consultation to validate and develop the scenarios further.

Soft systems methodology (SSM), which is an iterative, structured learning process for moving 'from finding out about a problematical situation to defining/taking action to improve it' (Checkland and Poulter 2007), provides another example of a method which can be applied at the

front-end of projects to address some of these issues (Saadi and Bell 2018; Winter 2009). SSM is about problem setting rather than problem solving, which makes is particularly appropriate for project front-ending (Winter 2009).

In this chapter, we introduce multicriteria mapping (MCM) as a PSM for project front-ending. MCM is a structured yet flexible hybrid quantitative-qualitative appraisal method, which allows stakeholders to deliberate clearly over crucial uncertainties and interpret the strategic implications of contrasting equally reasonable ways of 'framing' problems and solutions. Applied to the management of projects, this systematic exploring of different 'framings' of problems and solutions makes MCM an effective approach for project front-ending.

First, the MCM method is described in relation to addressing some of the issues discussed above. The MCM process consists of four stages: choose options, define criteria, assess scores, and assign weights. In an MCM interview or group session, participants can redefine and add to a list of predefined 'core options', to create a range of options for appraisal. They can develop their own sets of criteria to evaluate the options. Participants assign optimistic and pessimistic scores under each criterion for each option to reflect uncertainties. Weights are assigned to each criterion at the end to express different values and priorities. Moving freely between these steps, care is taken at every stage to note down the qualitative reasons for scoring choices as well as the numbers. The resulting interlinked quantitative and qualitative results provide a very broad and deep picture of the complexities, whilst also clearly highlighting the practical decision implications under particular conditions.

Next, each stage of the MCM method is illustrated with reference to the design challenges faced by a small manufacturing company, and the strategic challenges faced by a large multinational company. Finally, the broader implications of engaging stakeholders using MCM are discussed, including opening up and broadening out the decision problem.

Taken together, this chapter provides a brief introduction to MCM and how it can be applied as a PSM at the project front-end, using two case studies as examples. It is not intended to be a definitive guide to using MCM at the project front-end. However, there is a detailed manual to accompany the MCM method (Coburn and Stirling 2016), as well as

numerous publications which describe the use of the MCM method in practice in more detail than can be covered in this chapter (Bellamy et al. 2013; Raven et al. 2017; Stirling et al. 2007; Stirling and Mayer 2001; Stirling 1997).

Multicriteria Mapping

The basic challenge for front-ending in the management of projects (and arguably any complex decision-making problem) is how to weigh up, for a wide range of potential options, the various pros and cons, as viewed from divergent perspectives, and find a way to justify the best course of action.

Over the years, a diverse family of multicriteria appraisal techniques have been developed in the wider field of decision analysis to aid complex decision-making. These approaches have unlikely origins in military logistics and operations research developed in the Second World War. Such techniques have tended to become increasingly complex over time and they are employed in many forms, to differing degrees and with varying success in fields such as transport and land-use planning, siting, energy policy, waste management, medicine, commercial decision-making, and technology assessment (Stirling and Mayer 2001).

However, what all these techniques hold in common is that they tend to embody a 'justificationist' approach to decision-making (Collingridge 1982), used to justify specific favoured strategies, policies or investment choices and to yield a single apparently 'best' solution to the decision-making problem, marginalising or ignoring the importance of divergent values, multiple equally valid choices, and intractable uncertainties inherent in any complex decision situation (Stirling 1997).

Adopting a more open and participatory approach to appraisal for project front-ending could be described as taking a more 'precautionary' approach to the associated uncertainties (Stirling and Mayer 2000). Grounded in decades of practice in management, public administration, and law (Stirling 2017), precaution takes seriously that uncertainties cannot satisfactorily be reduced to probabilistic risk or expected values in

multicriteria appraisal. Although such reductions are typically favoured by incumbent interests seeking decision justification (Collingridge 1982), the resulting unduly precise and prescriptive results can be highly misleading (Stirling 2010). Rather than pretending at an ostensibly comprehensive and objective aggregated picture of an 'optimal decision' (as decision modelling is often used to do), precaution enjoins that project front-ending be recognised as inherently normative and contingent, with a key role for exploring the impacts on different possible decisions of divergent but equally legitimate social values and perspectives. MCM is a tool that recognises that diverse values and subjective framings are thus not marginal or subsequent to project appraisal, but must always form the central focus of analysis.

No matter how finely the methodological protocols are specified in appraisal of any kind, apparently minor differences in their initial framing assumptions can lead to potentially major variations in resulting decision recommendations. MCM offers a means systematically to explore the pluralities and conditionalities in these variations. Figure 3.1 shows a

Equally relevant to quantitative and qualitative approaches		
setting of agendas	defining problems	posing of questions
prioritising of issues	deciding on context	choice of methods
power relations within process	definition of options	selection of alternatives
treatment of dissensus	design of process	drawing boundaries
More relevant to expert and quantitative approaches		
discounting of time	formulating criteria	characterising metrics
setting of baselines	basis for probabilities	including disciplines
handling of uncertainties	recruiting of expertise	commissioning research
constituting proof	exploring of sensitivities	interpreting results
More relevant to participatory and discursive approaches		
identification of stakeholders	phrasing of questions	bounding of remits
recruitment of participants	provision of information	choice of focus
personalities of protagonists	medium of discourse	style of facilitation
documentation of findings	dynamics of persuasion	adoption of norms

Fig. 3.1 A selection of factors influencing the framing of appraisal

variety of dimensions in which contrasting positions may be taken in the implementation of any method (like modelling in project management) concerning the framing of options, issues, contexts, and uncertainties. Slight variations in any of these dimensions will typically yield significantly contrasting pictures of the relative performance of different alternatives.

Of course, this variability can partly be addressed by standardising methodological conventions, such that different studies are disciplined to apply the same framing assumptions. But this would always leave open questions over whether any given ordering is simply an artefact of particular contingent decisions about standardisation. The problem remains, that standardisation can be based equally reasonably around different sets of framing assumptions, which hold contrasting implications for the ordering of alternative options. Of course, these difficulties are not unique to decision modelling. Albeit differing in their details, the very general nature of the many kinds of framing assumptions mean that similar challenges apply equally across all quantitative, qualitative, and hybrid methods in decision analysis. But the more assertive the presentation of prescriptive results, the more serious the resulting problems.

The appropriate role for PSMs, then, is not to pretend at deriving a single definitive 'science-based' picture of contrasting options. Instead, the value of PSMs lies in the clarity and rigour with which they can show which specific assumptions and perspectives lead to which conclusions. What precaution calls for in project front-ending, then, is use of methods that resist the technocratic approach to appraisal and avoid attempting to claim a singular definitive output. Focusing on the implications of various kinds of uncertainty, precaution urges greater transparency and conditionality—and associated deliberation and accountability—in the justification of why one project management pathway should be preferred to another.

Of course, to the extent that many multicriteria appraisal methods also involve reduction and aggregation of uncertainties, they also share these problems. What is needed in these approaches as elsewhere, are specific methodological features allowing exploration of divergent assumptions concerning the factors shown in Fig. 3.1 (Stirling 1997; Wynne 1997). It is this crucial aspect that MCM adds to traditional multicriteria appraisal.

In short, the 'mapping' of perspectives in MCM enables all decision participants and stakeholders to understand the complex issues in focus, as they are seen from different points of view. The means by which MCM achieves this, however, lies not just in the technical details of the method, but also in its organising norms, the overall architecture and context of associated appraisals, and their associated bodies of practice (Stirling and Coburn 2017).

As such, MCM is—in short—an interactive method for exploring contrasting perspectives on complex strategic and policy issues and their practical implications for alternative options. In helping to 'open up' decision-making by systematically 'mapping' the practical implications of alternative options, knowledges, framings, and values, MCM is argued to enable more participatory analysis that bridges qualitative and quantitative cultures in a unique way. Strongly grounded equally in utilitarian and interpretive theories, the method aims to strike the balance between enabling participants to stay 'in the driving seat' in expressing their views, whilst also allowing rigorous comparisons across different perspectives.

As a means to provide accountability in addressing these challenges, MCM highlights the following qualities (Stirling and Mayer 2001):

(1) relative flexibility and breadth of scope in accommodating any particular view;
(2) openness to an entire range of divergent choices, values, and framing assumptions;
(3) candour about uncertainties and their implications for decision alternatives;
(4) a heuristic for 'mapping' (rather than prescribing) assumptions in these regards;
(5) systematic discipline and rigour allowing reproducibility within a particular exercise;
(6) transparency and verifiability under external review, to allow due accountabilities;
(7) easy accessibility such as to help enable effective participation in wider appraisal; and
(8) practical feasibility and efficiency as part of a real world decision process.

Striving to realise these qualities, MCM has been used in a wide variety of areas, including the appraisal of energy strategies (McDowall and Eames 2007; Stirling 1997), food production options (Stirling and Mayer 2001), obesity policy options (Stirling et al. 2007), organ transplantation options (Burgess et al. 2007), and sustainability transitions (Raven et al. 2017). Facilitated by readily accessible user-friendly browser-based software, MCM is supported by a comprehensive manual (Coburn and Stirling 2016) that helps ensure the achievement of the aspired qualities in appraisal, as well as providing further accountability to participants and third parties.

To elaborate on this background, the most fundamental principle in MCM is that it is participants (rather than facilitators, analysts, designers, or the sponsors of analysis) who should be in the 'driver's seat' in project front-ending. With the software allowing participants to develop their own appraisal and to interact with each other as they work, there are a number of concrete ways in which this can be achieved in MCM. The process starts with an effort to initially characterise the decision options. Attention then moves to defining the evaluative criteria. Each option is assessed under each criterion. Uncertainties are expressed by systematically distinguishing possible 'pessimistic' and 'optimistic' conditions. At every stage, great care is taken to elicit the reasons for the quantified judgements. Then criteria are weighted—also noting evaluative discussion—to reflect their relative importance. The final stage is to consider the resulting patterns in overall performance ranks. The process is iterated between stages as necessary until a refined picture is arrived at, which the participant is content provides a satisfactory reflection of their considered view.

The ability of other appraisal methods (like those typically used in the management of projects) to 'broaden out' and 'open up' representation of diversity and complexity is often limited by structural features of those methods. With the principle that the participant is in the driving seat, MCM seeks to reduce such constraints. Perhaps the most important example of this is the way MCM extends the focus away from a single option (like an already fully scoped project), in order to give balanced attention to a range of alternatives. It is a basic principle of MCM that a diverse array of options is selected at the outset such as to address a full

relevant envelope of possibilities—and that participants can add new options at any time in the process.

Another common constraint in appraisal is use of a predefined set of evaluative criteria. In the case of modelling for project management, the ease with which different issues can be considered is biased by the metrics that are favoured by the particular applied methods (such as single numerical values for costs in cost-benefit analysis, probabilities in risk assessment or 'utility' in multicriteria appraisal). With attention typically forced on utilitarian trade-offs (rather than broader relations between criteria), the weighing of options, issues, and priorities is typically mediated by complex algorithms and models, rather than being subject to direct and transparent deliberation. In MCM, by contrast, participants are challenged all the time qualitatively to justify their inputs; but they can select, define, measure, and prioritise their criteria as they wish. Nor is there any attempt to impose a single shared value tree on divergent criteria schemes. MCM also seeks to avoid imposing any dependence on expert assessments, instead allowing participants to undertake their own appraisal, which may make use of (and so be disciplined by) available forms of expert evidence, but which is also free to diverge from such established evidence and analysis, with reasons duly explored and qualitatively noted.

MCM allows different dimensions of options to be traded off against each other, but it also allows participants to stipulate (with justification) that some aspects may not be subject to trade-offs. Recognising the importance of more complex relations like legal or ethical constraints, MCM allows instead that particular options or criteria may display absolute thresholds to their acceptability. And the expression of uncertainty in MCM is also more open to complexity than is typically the case in decision modelling. MCM elicits a performance range between whatever participants consider to be reasonably 'pessimistic' or 'optimistic' scenarios. Again, as much attention is given to documenting qualitative reasons behind these scenarios as to quantifying scores. And at the end of a session, MCM allows each participant directly to review a summary of how their results will be reported. Unless a participant expresses satisfaction with how their findings are represented, the results cannot be used.

Whilst there can be no panaceas in this complicated field, it is these practical characteristics of MCM that help to address the quality criteria discussed above as a means to 'open up' greater flexibility, diversity, transparency, and accountability in project front-ending—and which thereby at the same time help build greater robustness in addressing the complexities of the real world.

The Practice of MCM

In this section of this chapter, each step of the MCM process will be illustrated using two case studies. The first case study examines the strategic challenges faced by a large food production company (Stirling and Mayer 2001). In the late 1990s, the introduction of genetically modified (GM) crops and foods in Europe was a highly controversial risk issue. Advocates argued that GM crops would bring unprecedented economic benefits whereas opponents were concerned about the potential for serious irreversible harm. This led to the evolution of a 'precautionary' approach to the regulation of GM crops. However, there was a lack of confidence in this process because there were disputes over the scope of the risk assessment and over what constituted an adverse effect. In this case study, a range of agricultural strategies for the production of oilseed rape, including both GM and non-GM options, were explored using MCM. The study was a collaborative effort by the University of Sussex working both with Unilever (a large multinational company favouring GM food production at the time) and with Genewatch (a non-governmental organisation (NGO) expressing strong concerns about the adoption of GM foods). It is a feature of the more flexible and open character of MCM that it can help facilitate rare strategic collaborations of this kind.

The second case study analyses the technology design capability challenges faced by a bicycle component manufacturing subsidiary company in Taiwan (Liu 2006). Multinational companies must be competitive in a global market and key ways of achieving competitiveness include the reducing of costs of products; improving the performance of products; and getting products to market faster than other companies. In recent decades, Asian subsidiaries of large multinational firms have contributed to these competitive processes by developing second generation design

capabilities, whereby Asian locations not only manufacture products designed in other locations, but also contribute to the design of products themselves (although in second generation design no functional changes are made). In this case study, a range of strategies for enhancing second generation design capabilities in the Taiwanese subsidiary of a large multinational bicycle manufacturing company were examined using MCM.

Defining the Focal Goal

In order for any appraisal to be systematic and consistent, there needs to be clarity about the aims of the different options being appraised. This is a characteristic that must be established deep in the design of the appraisal exercise as a whole. Accordingly, a 'focal goal' must be adopted at an early stage in an MCM exercise—ideally in discussion with a range of stakeholders—such as to describe a broadly shared societal aim, function, quality, or value that it is the purpose of the appraised 'options' to address—like 'how best to provide mobility in this city?', or 'how best to resolve this medical condition?' Here, the overarching purpose of MCM is to represent as authentically as possible a diverse range of relevant perspectives, concerning the best ways to achieve this broadly shared focal goal. Obviously, as in any appraisal method, the particular definition of a focal goal will carry wide implications (hence the necessity for accountability on this). It is subject to this, that the MCM method then allows systematic exploration of a 'mapping' of the contrasting ways to fulfil this 'focal goal' (Coburn and Stirling 2016).

Identifying Options

Once the focal goal has been defined in appraisal design, the next stage in the MCM process is to identify the 'core options' to be appraised. As a feature of project design, a diverse set of 'core options' is defined in order to encompass the widest possible envelope of contrasting relevant ways in which the focal goal can be seen to be addressed. It is this set of core options that forms the basis for systematic comparison across the perspectives of different participants. Again, the set as a whole will be

more robust, if definitions are justified in relation to relevant literatures and settled in consultation with a range of stakeholders in project oversight. Since core options will be appraised by all participants, the number that can be comfortably appraised by each participant is limited (ideally to six or seven). Defining too many will compromise the ability of participants to deliberate sufficiently deeply on each—or to add further options of their own. It is therefore important to define these core options according to the principal dimensions along which perspectives differ on the focal goal—for instance in relation to radically different political interests or styles of response. If project timing and scope allows, a set of 'discretionary options' can also be defined, which not all participants will appraise, but which are available for comparison across participants, for those who do wish to appraise them.

In the food production case study, six 'core' policy options were identified and defined in advance by the researchers in consultation with a project board, as listed in Table 3.1. As is the case in any comparable appraisal, some of these options were somewhat hypothetical and all were

Table 3.1 Core options used in the food production case study

Option	Definition
Organic agriculture	All farming and food production conducted under present-day organic standards
Integrated pest management	All farming and food production conducted via systems designed to limit, but not exclude, chemical inputs and with greater emphasis on biological control systems than conventional systems
Conventional agriculture	All farming and food production conducted under present-day intensive systems
GM oilseed rape with segregation and present systems of labelling	Labelling based on the presence of foreign DNA or protein in the final product
GM oilseed rape with post-release monitoring	Monitoring for effects (mainly environmental) conducted on an ongoing basis after commercialisation
GM oilseed rape with voluntary controls on areas of cultivation	Areas of growing of GM oilseed rape restricted on a voluntary basis to avoid unwanted effects such as gene flow and cross fertilisation of non-GM crops

highly stylised. All participants were invited to appraise these core options and then define their own further 'additional options' on this basis, in order to address any gaps or nuances of definition they felt should be addressed in the core set. Addressing a range of relevant issues that might otherwise have been missed, participants added as many as six of these additional options.

In the bicycle component manufacturing case study, seven core options were defined by the researcher following a series of semi-structured interviews with key stakeholders. Appraised by all participants, these are listed in Table 3.2. A further nine discretionary options were also identified, which individual participants were free to choose whether or not to appraise.

Identifying Participants

Arguably the single most important factor in MCM concerns the choice of which perspectives are relevant to the appraisal, how to partition them and how best to represent each. In order to be as robust as possible in reflecting relevant interests, priorities, knowledge, and values, it is important to identify the most diverse possible set of stakeholders, according to whatever are deemed to be the most relevant criteria of difference (e.g. political orientation, context, and demographics). Again, this is best undertaken in consultation with an oversight panel, and in parallel with the definition of the core options themselves. The MCM process is relatively time consuming and therefore only a subset of all conceivable perspectives can be included, which makes it especially important to justify each perspective that is identified and the choice of particular participants through whose appraisals this perspective will be addressed.

In the food production case study, the 12 participants were all senior representatives of leading contending protagonists in the UK debate over the use of GM technologies in food production. So, the group as a whole spanned a diverse range of institutional interests and perspectives. And, as such, each participant held (albeit from different perspectives) a strong professional knowledge of the issues raised in contemplating GM strategies and their alternatives, as well as specialist expertise on certain

Table 3.2 Core options used in the bicycle component manufacturing case study

Option	Further details
The Asian subsidiary's five-year design capability enhancement programme should focus on designs for second-generation products	Different from designs for the market, the Asian subsidiary company's design capability enhancement should focus on the design for evolutionary products
The advanced engineering group at headquarters should expand capacity to enhance research and development (R&D) and patent management to drive innovation	The advanced engineering group should expand its capacity to include all product group experts to focus on research and patent management to drive innovation
We should have a team to work out a product design checklist	Loose, not detailed checklists. A single function team should consist of designers from different locations for the same product category in order to produce reliable output
We should codify common design know-how by product category	Codifying common design know-how can provide useful information for training purposes and basic design guidelines
Every design engineer working at the Asian subsidiary company should be assigned one experienced designer from another location as a mentor	In order to meet the five-year design capability enhancement goal, the designer should be assigned one design expert at a time until qualified
Implement a location rotation plan for designers	Location rotation is the most effective way for engineers to imitate an experienced design engineer's good practice; it can also help to understand the culture differences and build up a stronger team relationship
We should focus on multi-product design skill training	Due to the project needs, the designer is expected to be equipped with two or more product design capabilities

aspects of these issues. Both as individuals and in their institutional context, then, the selected group of participants may be considered to be significant actors in the policy arena.

As in many comparable appraisals, it was necessary in order to secure involvement under conditions of adversarial political debate, to give all participants an undertaking of anonymity. Individual names and institutional affiliations are therefore not identified. Instead, each

participant was assigned a letter that was used throughout the analysis and in the presentation of results, with the associated perspective described only in the broadest of terms (like 'environmental NGO', 'government regulator' or 'biotech industry').

In the bicycle parts manufacturing case study, the ten participants were all employees of the company, covering a range of perspectives including design engineers and managers from three different locations. In this more circumscribed context, the different relevant countries, divisions, and facilities were relatively self-evident to the organisational decision context and it was not necessary to undertake some of the more elaborate stakeholder identification and anonymisation procedures.

The MCM Elicitation Process

The MCM elicitation process can be undertaken as a two–three hour individual interview or as a group deliberation involving individual appraisals and facilitated collective discussions interspersed over the best part of the day. Either way, the process consists of four stages, as illustrated in Fig. 3.2—although it is an iterative process and participants are

Fig. 3.2 The MCM process

welcome at any stage to revisit previous stages and add, remove, or edit their earlier responses. First, participants are asked to review the core options as defined by researchers. They are free to redefine any of these if they wish and appraise the new variant as an additional option, or they can add any entirely new options to address any gaps. But participants are also asked as a minimum to appraise all of the core options in order that these can be compared across all perspectives.

Next, each participant is invited to define their own criteria by which to appraise the options. The criteria are the factors which they think are important in judging how well or poorly each option could perform in their view, as a means to achieve the focal goal. For instance, these may involve issues such as cost, health, environment, or well-being—or refer to other parallel effects on other social goals. Although different criteria may be related, each must be independent, in that judgements of performance according to one criterion are not dependent on the performance under other criteria. Participants are asked to describe their criteria as fully as possible, since general terms like 'sustainability' or 'efficiency' may have different meanings for different people. As the appraisal unfolds, criteria definitions often become more fine-grained.

Once the options and criteria have been defined, participants are invited to score the performance of each option with respect to each criterion. Participants are asked to record an optimistic and a pessimistic score for each option for each criterion, which allows them to express uncertainties and context-dependent variabilities about how well or poorly an option could perform under a given criterion and, crucially, why. At each stage in the process, the qualitative reasons for each quantitative score are recorded. If an interviewee does not wish to express uncertainty, they are free to give the same value for both the optimistic and the pessimistic scores (and they also invited to justify this choice).

At the end of the scoring stage, participants can express the relative importance of their criteria by assigning each a weight. The weightings reflect how much participants care about the differences in option performance under each criterion. At this stage, participants are shown a ranks chart, which depicts how well or poorly each option performs under all criteria taken together, along with key accompanying notes from the

scoring stage explaining why. Partly informed by this picture, participants adjust their weightings until they are happy that these express the relative importance of their different criteria. If they are not content that the resulting rankings provide a fair representation of their own considered view, they are invited to revisit the previous stages of the process and modify their responses—with reasons—until they are content with the final picture. All iterations are documented for later analysis.

After a number of perspectives have been collected in this way, the research team analyses the qualitative and quantitative results to develop a rich picture of different priorities, contexts, uncertainties, ambiguities, and conditionalities bearing on the performance of different options.

Analysis of MCM Data

Typically, MCM analysis begins with exploring how the options performed, which criteria were chosen to appraise the options, and how the criteria were weighted (White 2017). The analysis of MCM data is an iterative process, in which the researcher makes hypotheses about patterns in the data, based on both the quantitative data from the charts and the accompanying qualitative data from the notes. These hypotheses can then be tested by grouping the data in different ways. Criteria can be grouped into issues, engagements can be grouped into perspectives, and options can be grouped into clusters. It is important to keep a log of which hypotheses have been tested and what observations have been made as the analysis develops.

This process might start with looking at an overall ranks chart for all of the participants and for all of the criteria, as illustrated in Fig. 3.3, then

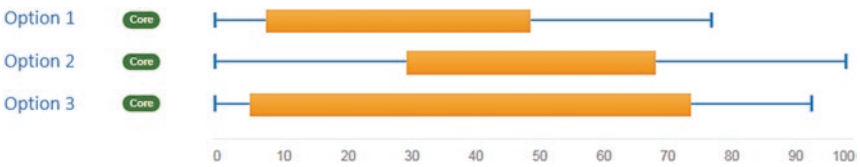

Fig. 3.3 An overall ranks chart in MCM (The horizontal scale shows poor performance on the left and good performance on the right. The orange bars show the interval between the mean pessimistic and mean optimistic ranks assigned by each participant. The blue lines show the rank extrema, the interval between the lowest and highest ranks assigned by any participant.)

producing charts grouped by perspective or by issue and comparing them to the overall rankings to explore variations and similarities between the patterns. Crucially, the analysis should be guided by the rich qualitative data which accompanies the quantitative data to understand why there are variations and similarities.

Analysis from the Food Production Case Study

Several important insights were made from analysis of the results of the food production case study (Stirling and Mayer 2001). First, there were a series of other agricultural strategies that were thought to be viable and broadly comparable with the pursuit of the basic organic, integrated pest management (IPM), conventional, and GM strategies considered in this study.

Second, a very wide range of criteria were thought to be relevant to the evaluation of GM crops and alternative food-production strategies, many of which are quite remote from the narrow scientific and health issues addressed in orthodox risk assessment. They are listed in Table 3.3. The implication of this was that unless broader issues were included in the evaluation of GM foods, the regulatory system would struggle to gain public support (Barling et al. 1999).

In terms of uncertainty, variabilities expressed about different options under different criteria were typically less than those found between different perspectives. Therefore, it was not the technical dimensions of uncertainty which were the key issue: rather, it was the more intangible qualitative aspects concerning the divergent interests, values, and framing assumptions adopted by different participants.

With regard to notions of overall performance, GM options performed best overall only under the perspectives of government or industry participants, whereas they performed generally worse under the perspectives of academic and public interest participants, as shown in Fig. 3.4. Each chart shows the ranges in option performance rankings on an arbitrary subjective interval scale, running from low performance on the left to high performance on the right. However, even under certain government and industry perspectives, non-GM options including, notably, organic cultivation performed better under certain conditions. Perhaps most

Table 3.3 Classification of criteria into groups and subgroups

Biodiversity	Agriculture	Health	Economic	Social	Other
Chemical use	Weed control	Allergenicity	Consumer price benefit	Individual consumer choice, benefit, need, and participation	Ethical
Genetic pollution	Food-supply stability	Toxicity	Farmers' or commercial users' yield/profit benefit	Institutional impacts and demands	Knowledge base
Secondary wildlife effects	Agricultural practice	Nutrition	Society—economic benefit overall	Social need, benefit, and trajectory	
Unexpected effects	Other effects	Unexpected effects			
Ethical		Ability to manage			
Aesthetic					
Visual					

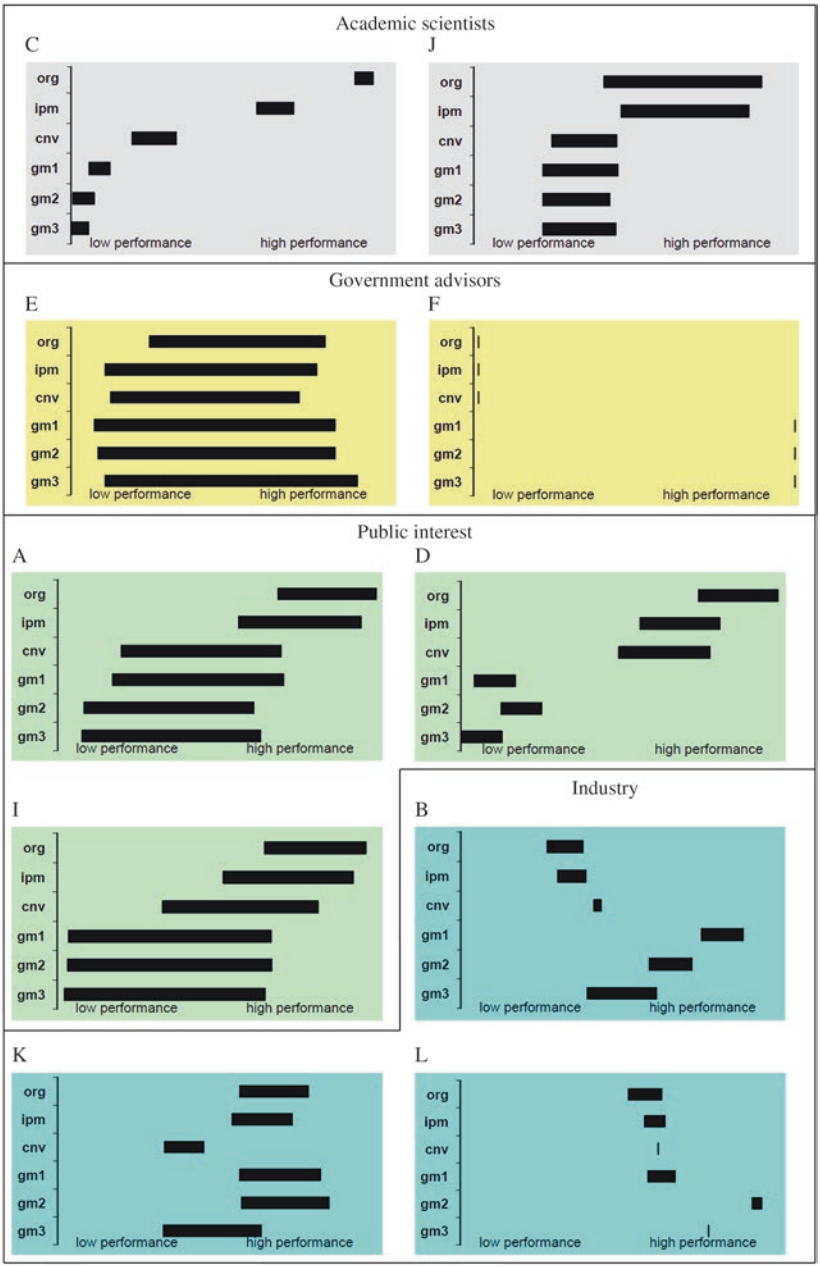

Fig. 3.4 Final ranks charts of food production case study participants shown in groups

surprisingly, the voluntary controls regime performed worst or joint-worst among the regulatory strategies for GM crops under the perspectives both of industry and of public interest group participants alike.

The broadening of the scope of the regulatory appraisal process may be seen to offer an important way of improving the match with the wider debate, and this has corresponding implications for the fostering of trust and the reduction of polarised conflicts. An appraisal process which excludes factors which are held by some constituencies to be important may fail to secure the crucial property of public confidence. It will also fall short of basic principles of analytical rigour in appraisal (Stirling 1999).

The study also showed the value of taking a comparative approach because the need to compare and contrast helped to elicit a better understanding of the nature of the relative strengths and weaknesses of the different options. The participants were not satisficing by appraising only the performance of one option against a single yardstick, as is often the case in appraisals.

Overall, this exercise demonstrated that MCM does offer a way of combining ostensibly 'technical' and explicitly subjective factors in appraisal. Indeed, crucially, MCM provides a means of systematically documenting the inextricable relationships between these two often-reified aspects of appraisal.

Apparently simple conclusions are often rather poorly sustained by the real complexities of appraisal. They are widely contested and no longer serve the purpose either of reassurance or of justification. A more effective way to achieve such ends and achieve more robust decision-making may be to show precisely how different considerations and perspectives have been involved in an evaluative process and what were the implications.

This case study shows that MCM does seem to offer an effective means to facilitate more robust policy-making and decision-making at many levels.

Analysis from the Bicycle Parts Manufacturing Case Study

Similarly to the food production case study, in the bicycle parts manufacturing case study, some of the discretionary options performed better

than some of the core options (Liu 2006). The researcher concluded that these would be worth further appraisal in the future. For example, the following three discretionary options performed at least as well as the best core options in several of the appraisals, but they were not appraised by all interviewees and therefore their performance could not be compared across perspectives:

(1) We should have a global design engineers' competence development programme.
(2) We should create an incentive programme to stimulate design capability enhancement.
(3) We should implement a designer excitement programme for the Asian subsidiary company.

In contrast to the food production case study, in the bicycle parts manufacturing case study, the criteria used in the appraisal were defined by the researcher as well as the core options. This is not recommended MCM practice, but it can be done where constraints such as time availability or levels of engagement make it difficult for participants to define their own criteria. The criteria defined by the researcher in this case study were: company cost, training time, feasibility, motivation/empowerment, effectiveness, and risk.

Although there was considerable uncertainty expressed within perspectives and variation between the different perspectives, overall the results showed that mentoring and human relocation were thought to be good training methods by most stakeholders. More generally, second-generation design capability enhancement was thought to generate positive impacts for the entire organisation.

This case study shows that MCM can aid front-end decision-making within companies by engaging a range of stakeholders in the process and enabling systematic exploration of the options.

Conclusion: Broadening Out and Opening Up

In this chapter, we have discussed MCM as one PSM (among many) for expanding beyond a narrow focus in the management of projects to pay more attention to project front-ending, to engage multiple stakeholders, to include broader inputs, and to be more open about the outputs of the process in order to provide a more robust, transparent, and accountable basis for front-end decision-making.

Conventional appraisal for project management—as exemplified in typical practices around decision models, cost-benefit analysis, and technical evaluation—is often deeply flawed in these kinds of ways. The emphasis is typically on aggregation and reduction in order to help justify particular decision outcomes. Attention is often circumscribed in relation to the full range of pros and cons—for instance by disproportionate emphasis of the particular factors that happen to be illuminated by favoured metrics. Deep uncertainties, ambiguities, and ignorance are typically understated and reduced merely to probabilistic 'risk'. Particular framings of problems and solutions are privileged and others systematically downplayed. In these and other ways, project management tends to be strongly shaped in advance—and remains vulnerable to the excluded information.

In the 'real world' of management strategy and policy-making, such practices can provide effective short-term political or organisational resources for actors associated with decision-making. This is why they are so common. But they leave the decisions themselves vulnerable to uncertainties, ambiguities, and incomplete knowledge concerning the dynamics of the 'real real world' of complex and dynamic project options and environments. The narrowing in of inputs to appraisal and the closing down of outputs to wider discourse can have the effect of systematically marginalising the perspectives and knowledge of less powerful stakeholders—like users, workers, local communities, or least privileged (often most vulnerable) groups or organisations. Not only does this risk compromising vulnerabilities, legitimacy, and reputation, but by excluding some of the potentially most important perspectives on the issues at

hand, it can also make the decisions themselves seriously deficient for project managers too.

As Rosenhead and Mingers observe, the remedy for this is to realise that 'the most demanding and troubling task in formative decision situations is to decide what the problem *is*' (Rosenhead and Mingers 2001). This requires broadening out the inputs to appraisal in all the ways described above, as well as opening up the possible interpretations that can arise from the resulting evidence and analysis. It is to these imperatives that MCM offers a response—by providing a straightforward accessible framework for fully engaging with the real world diversity of problem-framings, favoured options, stakeholder interests, contextual conditions, social values, and technical knowledges in play; and by informing decision makers and wider relevant constituencies of the full latitude for legitimate disagreement over what might equally count—under different views—as the 'best decision'. It is in this sense that MCM helps enable project front-ending to be more precautionary—and therefore more robust.

In all these ways, the broadening out and opening up of project front-ending can enable appraisal not only to speak truth *to* power, but also more healthily to speak *about* power. By helping to balance the biasing effects of different power gradients in the closing down of project appraisal, MCM offers to assist in realising outcomes that are at the same time more operationally robust and more democratically legitimate.

References

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

Arthur, W. B. (1989). Competing Technologies, Increasing Returns, and Lock-in by Historical Events. *The Economic Journal, 99*(394), 116–131.

Barling, D., de Vriend, H., Cornelese, J. A., Ekstrand, B., Hecker, E. F. F., Howlett, J., … Top, R. (1999). The Social Aspects of Food Biotechnology: A European View. *Environmental Toxicology and Pharmacology*, *7*(2), 85–93. https://doi.org/10.1016/S1382-6689(99)00009-5.

Bellamy, R., Chilvers, J., Vaughan, N. E., & Lenton, T. M. (2013). "Opening Up" Geoengineering Appraisal: Multi-Criteria Mapping of Options for Tackling Climate Change. *Global Environmental Change, 23*(5), 926–937. https://doi.org/10.1016/j.gloenvcha.2013.07.011.

Brady, T., & Davies, A. (2014). Managing Structural and Dynamic Complexity: A Tale of Two Projects. *Project Management Journal, 45*(4), 21–38. https://doi.org/10.1002/pmj.21434.

Burgess, J., Stirling, A., Clark, J., Davies, G., Eames, M., Staley, K., & Williamson, S. (2007). Deliberative Mapping: A Novel Analytic-Deliberative Methodology to Support Contested Science-Policy Decisions. *Public Understanding of Science, 16*(3), 299–322.

Checkland, P. (1985). From Optimizing to Learning: A Development of Systems Thinking for the 1990s. *The Journal of the Operational Research Society, 36*(9), 757–767.

Checkland, P., & Poulter, J. (2007). *Learning for Action: A Short Definitive Account of Soft Systems Methodology, and Its Use Practitioners, Teachers and Students*. Chichester: John Wiley & Sons.

Coburn, J., & Stirling, A. (2016). *Multicriteria Mapping Manual, Version 2.0, SWPS 2016–21*. Brighton: SPRU, University of Sussex.

Collingridge, D. (1982). *Critical Decision Making: A New Theory of Social Choice*. London: Frances Pinter.

Genus, A., & Stirling, A. (2017, February). Collingridge and the Dilemma of Control: Towards Responsible and Accountable Innovation. *Research Policy*, 0–1. https://doi.org/10.1016/j.respol.2017.09.012.

Holt, R. (2004). Risk Management: The Talking Cure. *Organization, 11*(2), 251–270. https://doi.org/10.1177/1350508404041615.

Hughes, T. (1983). *Networks of Power: Electrification in Western Society 1880–1930*. Baltimore: Johns Hopkins University Press.

Kitchner, K. S. (1983). Cognition, Metacognition, and Epistemic Cognition: A Three-Level Model of Cognitive Processing. *Human Development, 26*(4), 222–232.

Liu, Y. (Judy). (2006). *Enhance Second Generation Design Capability by Realising the Issue of Communication v Location Specialization and Evaluate Its Potential Strategy by Using the MCM Tool* (MSc Thesis). Brighton: SPRU – Science Policy Research Unit, University of Sussex.

McDowall, W., & Eames, M. (2007). Towards a Sustainable Hydrogen Economy: A Multi-criteria Sustainability Appraisal of Competing Hydrogen Futures. *International Journal of Hydrogen Energy, 32*(18), 4611–4626. https://doi.org/10.1016/j.ijhydene.2007.06.020.

Morris, P. (2002). Science, Objective Knowledge, and the Theory of Project Management. *Proceedings of the Institute of Civil Engineers: Civil Engineering, 150*(2), 82–90.

Morris, P. W. G., & Geraldi, J. (2011). Managing the Institutional Context for Projects. *Project Management Journal, 42*(6), 20–32. https://doi.org/10.1002/pmj.20271.

Raven, R., Ghosh, B., Wieczorek, A., Stirling, A., Ghosh, D., Jolly, S., … Sengers, F. (2017). Unpacking Sustainabilities in Diverse Transition Contexts: Solar Photovoltaic and Urban Mobility Experiments in India and Thailand. *Sustainability Science*, *12*(4), 579–596. https://doi.org/10.1007/s11625-017-0438-0.

Ravetz, J. R. (1971). *Scientific Knowledge and Its Social Problems*. Oxford: Oxford University Press.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences, 4*(2), 155–169. https://doi.org/10.1007/BF01405730.

Rosenhead, J., & Mingers, J. (2001). *Rational Analysis for a Problematic World Revisted: Problem Structuring Method for Complexity, Uncertainty and Conflict*. Chichester: John Wiley & Sons.

Saadi, X., & Bell, G. (2018). Exploring the Use of Soft Systems Methodology (SSM) in Front-Ending Public Funded Rural Bridge Construction Projects in Bangladesh. In G. Bell, R. Pagano, C. Sato, & J. Warwick (Eds.), *Problem Structuring Approaches for the Management of Projects: Demonstrating Successful Practice*. Basingstoke: Palgrave Macmillan.

Samset, K. (2009). Projects, Their Quality at Entry and Challenges in the Front-end Phase. In T. M. Williams, K. Samset, & K. J. Sunnevåg (Eds.), *Making Essential Choices with Scant Information: Front-End Decision Making in Major Projects*. Basingstoke: Palgrave Macmillan.

Stirling, A. (1997). Multi-Criteria Mapping: Mitigating the Problems of Environmental Valuation? In J. Foster (Ed.), *Valuing Nature? Ethics, Economics and the Environment* (pp. 186–210). London/New York: Routledge.

Stirling, A. (1999). *Science and Precaution in the Management of Technological Risk: Volume I – A Synthesis Report of Case Studies*. Seville: EUR 19056 EN, European Commission, Institute for Prospective Technological Studies.

Stirling, A. (2010). Keep It Complex. *Nature, 468*, 1029–1034.

Stirling, A. (2017). Precaution in the Governance of Technology. In K. Yeung (Ed.), *Oxford Handbook on the Law and Regulation of Technology*. Oxford: Oxford University Press.

Stirling, A., & Coburn, J. (2017). *From CBA to Precautionary Appraisal: Practical Responses to Intractable Problems: Draft*. Brighton: SPRU—Science Policy Research Unit.

Stirling, A., & Mayer, S. (2000). Precautionary Approaches to the Appraisal of Risk: A Case Study of a Genetically Modified Crop. *International Journal of Occupational and Environmental Health, 6*(3), 342–357.

Stirling, A., & Mayer, S. (2001). A Novel Approach to the Appraisal of Technological Risk: A Multicriteria Mapping Study of a Genetically Modified Crop. *Environment and Planning C: Government and Policy, 19*, 529–555. https://doi.org/10.1068/c8s.

Stirling, A., Lobstein, T., & Millstone, E. (2007). Methodology for Obtaining Stakeholder Assessments of Obesity Policy Options in the PorGrow Project. *Obesity Reviews, 8*(Suppl. 2), 17–27. https://doi.org/10.1111/j.1467-789X.2007.00355.x.

van der Heijden, K. (2009). Scenarios Planning. In T. M. Williams, K. Samset, & K. J. Sunnevåg (Eds.), *Making Essential Choices with Scant Information* (pp. 68–84). Basingstoke: Palgrave Macmillan.

White, R. (2017). Multicriteria Mapping. In C. L. Spash (Ed.), *Routledge Handbook of Ecological Economics: Nature and Society* (pp. 321–330). Abingdon: Routledge.

Williams, T. (2009). Decisions Made on Scant Information: Overview. In T. M. Williams, K. Samset, & K. J. Sunnevåg (Eds.), *Making Essential Choices with Scant Information* (pp. 3–17). Basingstoke: Palgrave Macmillan.

Williams, T. M., Samset, K., & Sunnevåg, K. J. (Eds.). (2009). *Making Essential Choices with Scant Information: Front-End Decision Making in Major Projects*. Basingstoke: Palgrave Macmillan.

Winter, M. (2009). Using Soft Systems Methodology to Structure Project Definition. In T. M. Williams, K. Samset, & K. J. Sunnevåg (Eds.), *Making Essential Choices with Scant Information* (pp. 125–144). Basingstoke: Palgrave Macmillan.

Wynne, B. (1997). Methodology and Institutions: Values as Seen from the Risk Field. In J. Foster (Ed.), *Valuing Nature? Ethics, Economics and the Environment* (pp. 135–154). London: Routledge.