Policy Analysis of Multi-Actor Systems

Enserink, B.; Bots, P.W.G.; van Daalen, C.; Hermans, L.M.; Kortmann, L.J.; Koppenjan, Joop; Kwakkel, J.H.; Ruijgh-van der Ploeg, M.P.M.; Slinger, J; Thissen, W.A.H.

DOI
10.5074/T.2022.004

Publication date
2022

Document Version
Final published version

Citation (APA)
Enserink, B., Bots, P. W. G., van Daalen, C., Hermans, L. M., Kortmann, L. J., Koppenjan, J., Kwakkel, J. H., Ruijgh-van der Ploeg, M. P. M., Slinger, J., & Thissen, W. A. H. (2022). *Policy Analysis of Multi-Actor Systems*. (2nd edition ed.) TU Delft OPEN. https://doi.org/10.5074/T.2022.004

TU Delft open

Policy Analysis of Multi-Actor Systems

Second Edition

Bert Enserink
Pieter Bots
Els van Daalen
Leon Hermans
Rens Kortmann
Joop Koppenjan
Jan Kwakkel
Tineke Ruijgh
Jill Slinger
Wil Thissen

eleven

Policy Analysis of Multi-Actor Systems

Policy Analysis of Multi-Actor Systems

Bert Enserink
Pieter Bots
Els van Daalen
Leon Hermans
Rens Kortmann
Joop Koppenjan
Jan Kwakkel
Tineke Ruijgh-van der Ploeg
Jill Slinger
Wil Thissen

eleven

Published, sold and distributed by Eleven
P.O. Box 85576
2508 CG The Hague
The Netherlands
Tel.: +31 70 33 070 33
Fax: +31 70 33 070 30
e-mail: sales@elevenpub.nl
www.elevenpub.com

Sold and distributed in USA and Canada
Independent Publishers Group
814 N. Franklin Street
Chicago, IL 60610, USA
Order Placement: +1 800 888 4741
Fax: +1 312 337 5985
orders@ipgbook.com
www.ipgbook.com

Eleven is an imprint of Boom uitgevers Den Haag.
ISBN 978-94-6236-299-4

Online edition 2022 published by TU Delft Open
ISBN: 978-94-6366-575-9 (online)
DOI: https://doi.org/10.5074/T.2022.004

Preface

Preface to the Second Edition (2022)

In 2020, after ten years of user experience by our teaching staff and thousands of students practising multi-actor problem structuring, we decided the PA of MAS book needed an update. In its basis and structure, the book did what it was supposed to do: teach students how to create order in chaos and to think systems: multi-actor systems. Consequently, this new edition is not a complete overhaul.

As our own experience as policy analysts and teachers grew, we noticed the synthesis chapter needed an upgrade; here writing skills and analytical craftsmanship should be combined to forge a rich problem description allowing for characterization and framing of the problem. This chapter is the essential link between the analytical part (Chapters 3, 4 and 5) and the actionable part in Chapters 7 and 8 where the plan of action and research plan are presented, which might culminate in an issue paper in which the framed problem and envisioned follow-up activities are presented to a potential commissioner.

Moreover, over the last decade, new insights, new analytic methods and new data and modelling techniques have been gaining ground and some of the examples and issues presented in the first edition became outdated. The latter were replaced by more recent examples; but knowing that good examples make happy learners, others were kept as they convey such clear messages.

One prominent development in the past ten years was the rise of e-publishing, blended and online teaching and 'Open Science'. TU Delft has the ambition to make open research and open education the standard of its scientific practice, and turning this book into an Open Textbook is part of this ambition. We owe it to the financial and practical support of TU Delft Open, the Faculty of Technology Policy and Management, and the cooperation of BOOM Publishers that we can offer this book as Open Textbook, which will make this book affordable and accessible for many more students. For those preferring a paper copy, BOOM can provide a printed version.

This second edition, like the first edition, is based on the input of a large group of engaged colleague policy analysts; four more colleagues joined the team, which now consists of: Dr P.W.G. (Pieter) Bots, Dr Ir. C. (Els) van Daalen, Dr Ir. B. (Bert) Enserink, Dr Ir. L.M. (Leon) Hermans, Dr L.J. (Rens) Kortmann, Prof. Dr J.F.M. (Joop) Koppenjan (EUR), Prof. Dr Ir. J.H. (Jan) Kwakkel, Dr Ir. M.P.M. (Tineke) Ruijgh-van der Ploeg, Dr J.H. (Jill) Slinger, Prof. Dr Ir. W.A.H. (Wil) Thissen.

Just like the first edition, this second edition will not be the final one; open textbooks allow for continuous feedback and updating. We hope our readers will continue to send us critical constructive comments to further improve the book; therefore, we expect that this book will be alive and kicking for many more years to come.

Bert Enserink

Preface to the First Edition (2010)

This book *Policy Analysis of Multi-Actor Systems* is the result of interdisciplinary cooperation in teaching and learning in courses on problem analysis and problem structuring methods at bachelor and master level at the Faculty of Technology, Policy and Management (TPM) of Delft University of Technology. A first draft was published in 1999 carrying the Dutch title 'Analyse van Complexe Omgevingen'.

A first English version dates back to April 2006. A major revision by Bert Enserink, Leon Hermans and Jan Kwakkel took place in 2008 and the first book version is a new step in this highly iterative process. Consequently, this book is the product of intensive interaction and discussions on teaching problem structuring methods amongst TPM staff members over a period of many years. The main contributors are Dr Ir. B. Enserink, Dr Ir. L. Hermans, Ir. J. Kwakkel, Prof. Dr Ir. W.A.H. Thissen, Dr J.F.M. Koppenjan and Dr P.W.G. Bots.

Numerous other colleagues were involved in discussing and defining concepts, revising texts and teaching classes, including Ir. D.P. Kamps, and Ir. G. Bekebrede, Dr P. Ker Rault, Dr E.M. van Bueren, Dr Ir. A.R.C. de Haan and Prof Dr W.E. Walker with other colleagues and students who participated in the course over the years. The current version will not be the final one as we know that science evolves through constant debate and change. We therefore welcome any comments.

Bert Enserink
Leon Hermans
Jan Kwakkel
Wil Thissen
Joop Koppenjan
Pieter Bots

Table of Contents

1 Introduction

'If you have only four fingers on one hand, that's not a problem, that is a situation.'
Kingdon, 1984

'Successful problem solving requires finding the right solution to the right problem. We fail more often because we solve the wrong problem than because we get the wrong solution to the right problem.'
Russell L. Ackoff, 1974 (on cit)

Policy analysis in multi-actor systems. Now what does that mean?

To start with policy analysis: although it can mean various things to various people in various situations, we can say that 'policy analysis' is about using analytical tools and a systematic way of working to support policy-making processes. For instance, we can use analysis to inform policy-makers and decision-makers about the pros and cons of different policy alternatives or we can use a systematic approach to support various parties in reaching an agreement on a suitable policy as a future course of action to address a problem.
In this chapter, we will explain how policy analysis contributes to problem-solving, and we position this book in the scientific debate on problem structuring during the initial stages of the policy analysis process.

1.1 The Challenge of Policy Analysis in Multi-Actor Systems

This book places policy analysis in a multi-actor environment. This means that it addresses policy problems and policy processes that involve multiple actors ('parties'), who are typically organized in a network rather than in a classic hierarchy. This means that no single actor will be able to unilaterally impose their desired solution on others, but rather that some form of cooperation between parties is required. Therefore we talk about multi-actor systems. In such a setting, complications quickly arise. Typically, different actors will have different views of a situation. They may not agree on what the main problem is, they may not accept the same forms of evidence as 'facts', they are almost certain to subscribe to different priorities and preferences for particular solutions and they may have different opinions about what is fair and just in policy-making. Any one of these multiple actors is likely to change views over time. Moreover, if these actors are addressing a problem that is characterized by complexity and uncertainty, then how do we go about supporting policy-makers and decision-makers, as policy analysts?

Text box 1.1 Example of the involvement of many actors
In the area of water management and water policies, we can see that at the international level there is not one single UN agency responsible for water, but rather that it is handled by UN-Water, an umbrella agency that includes a multitude of UN organizations (see: www.unwater.org/). On a national level, in the Netherlands for example, the national water plan is the joint responsibility of different ministries (see: www.platformparticipatie.nl/nationaalwaterprogramma/nationaalwaterprogramma_/default.aspx). Each of these ministries has its own priorities in terms of water using sectors to be served, and water problems to be solved. Increased flood risks due to climate change; insufficient water for agriculture, industry and nature; pollution, by industry, agriculture or households; water needs for recreation and tourism; siltation of fresh water resources, where nature and human uses are at odds. What problems take priority, in what locations and how to solve these problems? If these national ministries want to implement their plans, they need the cooperation of a whole range of other organizations, not least the regional authorities such as water boards, provinces and municipalities.

In the end, even with many actors and different interests, policy decisions and plans have to be made. Not doing anything is also a decision, which may not be in everyone's best interest either. The question is: how to support decision-makers and other stakeholders with meaningful analysis? In this book we provide readers with an answer to this question.

1.2 The Problem Structuring Focus

Our point of departure is a systematic way (i.e. done according to a plan; methodical) of analysing a problem situation which we call problem structuring. The principal objective of this book is to offer tools and approaches for problem structuring that help to create a clear picture of complex situations and to mark out a path for supporting the process towards a policy decision. We call the product that results from the activity of problem structuring a (rich) problem description. It is important to distinguish the process/activity from the product/outcome. Problem formulation, i.e. the structuring of a problem, is an activity fundamental to the problem-solving process.

A poorly structured problem creates the risk of a failure to recognize an urgent or impending problem in time, thus making it more difficult and more expensive to find a solution. Incorrect structuring may result in selection of the wrong solution, which will not alleviate the problem. It is even conceivable that an admirable solution will be designed and implemented to solve a problem that did not exist.

Text box 1.2 Examples of the consequences of inadequate problem structuring
Some solutions do not solve a problem at all, like the many schools constructed in rural areas in Latin American and African countries in places where there are no teachers. In such situations problem structuring has not been performed or it has been done in too limited a way, which has led to solutions that focus on school buildings rather than also taking into account teaching capacity.
A common example of a solution for a problem that does not exist or creates a new problem is the construction of infrastructure where there is no real need or use. The so-called 'Betuwelijn', a rail line dedicated to transport heavy goods and containers by train from Rotterdam Harbour in the Netherlands to Germany to warrant Rotterdam's position as an international hub for container transport, is an example of failing infrastructure. In their enthusiasm the Dutch built 160 km of rail line, which were ready in 2007, but forgot about the 70 km of new rail line needed in Germany to connect their line to the German rail system. Construction of the latter part is currently expected to be finished in 2026. Consequently the Betuwelijn does not reach its full capacity and its exploitation is leading to big financial losses. Although traffic has been gaining traction, many heavy trains are following the old routes, causing nuisance in the urban areas they are passing through.

In this chapter, we will examine the question of what a problem actually is. Although failures may seem obvious in hindsight, it is not easy to conduct problem structuring well. We will show the difficulties that arise during attempts to define the nature and content of problems and we will position ourselves in the field of policy analysis (Thissen & Walker, 2013).

It is important to recognize that a *policy analysis process* and a *policy process* are not the same. The policy process is the context in which a policy analyst operates. The policy analyst needs to be aware of this context when advising policy or decision-makers who are faced with a policy problem. The policy analyst conducts an analysis process in support of a policy process.

1.2.1 The Policy Process as a Problem-Solving Process

According to Nobel Prize winner Herbert Simon (1977, 1991), people solve problems in four steps: intelligence, design, choice and implementation. 'Intelligence' involves gathering information, identifying a problem and examining the problem situation. 'Design' entails developing alternative solutions that are possible. 'Choice' means selecting an alternative from the available solutions. 'Implementation' puts the selected alternative into effect. These four steps form the basis for numerous attempts to conceptualize decision-making, problem-solving and design processes in wide-ranging disciplines.

A policy process can be seen as a problem-solving cycle consisting of stages during which a policy problem is addressed. Many different representations of such a policy cycle can be found in the literature, but the general idea is similar. Figure 1.1 shows a representation of the public policy cycle consisting of four subprocesses that take place continuously (arrows). Every subprocess involves two types of actors (shown in rectangles).

- Agenda setting: citizens raise issues so that they will be brought to the attention by politicians in the political arena as policy problems.

- Decision-making: politicians decide, after deliberation, negotiation and formal decision procedures, on policies that are to be implemented by government.
- Policy implementation: administrators translate policies to more specific formal rules and guidelines that are implemented by executive agencies.
- Policy impact: the execution of new rules by public servants will lead to societal effects which may be perceived as problematic by some societal stakeholders. This will lead to the next policy cycle requiring a new policy decision.

Although the policy cycle is illustrated here for public policy-making, it can be translated to policy processes in other contexts.

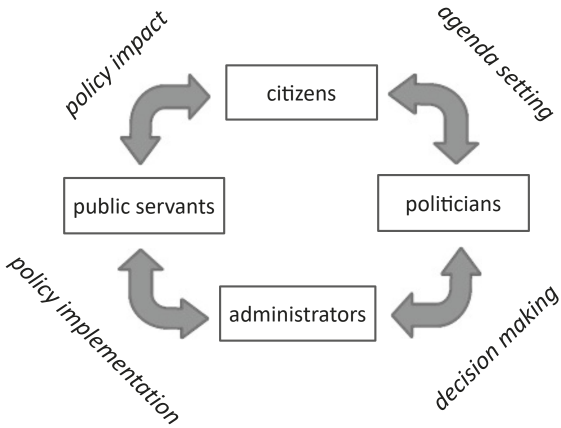


Figure 1.1 Cyclical representation of a policy process

The activities of a policy analyst can be aligned with a perspective of the policy process as a problem-solving cycle consisting of stages (Jann & Wegrich, 2017). Supporting the policy process thus implies conducting activities that support this problem-solving cycle.

In Chapter 2 we will see that actual policy processes are more complex than presented here by means of the policy cycle framework. The main message, however, is that the policy analyst supports a policy process and that the policy analysis process, i.e. the activities of the policy analyst, takes place in the context of the policy process.

1.2.2 Policy Analysis to Support Problem-Solving

A policy analyst can support any subprocess of the policy cycle. Policy analysis conducted prior to decision-making is termed ex ante policy analysis, and policy analysis conducted following a policy decision is termed ex post policy analysis. The ex ante activities will usually be conducted to support the decision-making subprocess and ex post activities are usually conducted as evaluation activities of the effects of implementing a specific policy. However, agenda setting and implementation may also be supported by policy analysis.

Articles and textbooks on policy analysis often distinguish a number of phases according to which a systematic policy analysis process is conducted. Table 1.1 shows the steps identified by a number of authors in this field.

Table 1.1 Policy analysis as a sequence of steps

Bardach (2000)	Walker (2000)	Patton et al. (2012)
Define the problem	Identify the problem	Verify, define and detail the problem
Assemble some evidence	Identify the objectives of the new policy	Establish evaluation criteria
Construct the alternatives	Decide on the criteria with which to evaluate alternative policies	Identify alternative policies
Select the criteria	Select the alternative policies to be evaluated	Evaluate alternative policies
Project the outcomes	Analyse each alternative	Display and distinguish among alternative policies
Confront the trade-offs	Compare the alternatives in terms of projected costs and effects	Monitor and evaluate the implemented policy
Decide	Implement the chosen alternatives	
Tell your story		

Although there are differences in the activities that are defined by different authors, the general sequence is similar. It can be seen that Walker (2000) and Patton et al. (2012) include both ex ante as well as ex post policy analysis in their steps. In general, during the policy analysis process the policy problem is explored in some detail in order to clarify the problem situation. It is also necessary to determine what would be considered to be a successful solution to the policy problem. This is done by identifying criteria for success. In addition, various candidate solutions (i.e. alternative policies) are selected and evaluated. This enables the choice of a policy, which has to be monitored and evaluated after implementation.

The summaries of activities in Table 1.1 suggest a chronology, but the authors consider them to be important activities, which are not necessarily taken in exactly that order. In practice, the policy analysis process is regarded as a cycle in which numerous iterations are possible.

This book focuses on ex ante policy analysis to support the early phases of decision-making. In the terminology by Simon (1977), the policy analyst supports decision-makers with intelligence and initial design. In the sequence of the stepwise policy analysis activities shown earlier, we roughly consider the first iterations of the steps up until a qualitative evaluation of alternative policies in order to provide an overview of the trade-offs involved.

What sets this book apart from other texts on ex ante policy analysis is an emphasis on the multi-actor perspective, hence the title *Policy Analysis of Multi-Actor Systems*. What also distinguishes this book is that specific attention is given to supporting decision-making under uncertainty. In many policy problems there are significant uncertainties about the current situation and about how the situation may develop over time, and decisions have to be made despite of and in light of these uncertainties. This multi-actor perspective and attention for decision-making under uncertainty are reflected in the tools and techniques that are presented and/or the way in which these can be utilized. Over the course of the book we will see that the activities that can be conducted by the policy analyst are more varied than the style of policy support described here in this introductory chapter.

1.2.3 Policy Problems: Gaps and Dilemmas

Before addressing the complexities and the specifics involved in supporting the early phases of decision-making in order to address policy problems, we first need to specify what we mean when we speak of a policy problem. The definition that we will use is adapted from earlier definitions by Hoogerwerf (1987) and others. We speak of a policy problem if two conditions are met:

1. There is a gap between an existing or expected situation and a desired situation.
2. There is a dilemma: there is a difficult choice between possibilities that can (partly) close the gap but that also have undesirable outcomes.

In other words, there needs to be a gap, as well as some perspective of a possible, if partial, solution. If there is a gap, but no solution, there is no policy problem, only a situation (refer to the citation from Kingdon, 1984, at the beginning of this chapter).

Most decisions concerning implementing measures, or creating or modifying facilities or projects, are driven by a desire to solve problems, or at the very least to make them controllable. Before making such decisions, it is important to know precisely what the problem is that you are planning to address.

Contrary to what one might expect, it is often far from clear what problem a certain decision or plan should solve and how. Even if a problem may seem clear, it is important to beware that certain solutions may lead to new problems.

Text box 1.3 Examples of solutions possibly leading to new problems
China is finishing the construction of a canal system to channel more than 40 billion cubic metres of fresh water annually from the Yangtze River in southern China to the more arid and industrialized north, where there is a huge shortage of fresh water sources. Will this South-North water transfer solve the water problem in the North-Eastern provinces? What about the increased evaporation and the 330,000 people that had to be relocated? How will this diversion impact on the water balance and the water quality in the southern part of China?
Biofuels and biomass energy are used as alternative sources of energy. Are biofuels and biomass energy sustainable and reducing our CO_2 emissions, or are they drivers for new problems such as higher emissions, deforestation and rising food prices?

To determine the desirability of a solution, it is important to understand different aspects of a problem. To that end it is necessary to appropriately structure the problem.

An additional complication is that in reality, actors often do not agree upon what the actual problem is. They each have their own objectives and their own ideas about what the desired situation should be.

Text box 1.4 Example of different perceptions on a problem
A crowded airport may be perceived as a capacity problem of the airport, as a noise nuisance problem, as a problem related to CO_2 emissions, as a safety threat or more than one of these. The range of potential solutions that will be considered strongly depends on the way in which the problem is structured. The issue of scale also plays an important role. Are the problems at the airport seen as a local problem, a national problem or an international problem? This will

also influence the solution space. This does not only hold for geographical scale. The problems at the airport can be seen as related to air transport only or to transport and mobility issues in general, which will also have consequences for the types of solutions that are considered.

This raises the question of how the analyst, in the midst of all these problem perceptions, can come up with a useful problem description (see, for instance, Thissen, 2000; Wildavsky, 1979). Therefore we need to have insight into what the concept 'problem' actually means, what analysing or structuring a problem really is and which mechanisms have to be dealt with in developing a problem description.

As analysts we need to be aware of the fact that an 'objective' problem does not exist and that there can be several problem descriptions, each of which can be correct and relevant. This also implies that an analyst can never just copy the problem description of the problem owner who has commissioned the analysis. The analyst has to compare that problem description to his own analysis of the situation and the problem perceptions of other actors. The next section describes the challenges to be faced and difficulties that can be encountered when structuring a problem.

1.3 Approach Taken and Outline of This Course Book

An appropriate problem description, based on a systematic and sound analysis of the complex environment of policy problems, is crucial for successful policy analysis and supporting problem-solving. In this book we provide a way to develop such a problem description.

It all starts with a good understanding of the role of problem structuring in supporting policy processes and in dealing with complex policy problems, for which the next chapter offers theoretical perspectives. A useful problem description provides a sound basis for determining whether the situation merits further action, and, if so, what actions are indicated. As will be further explained in Chapter 2, insights are therefore needed in (1) substantive, i.e. content related, aspects and (2) actor, network and institutional characteristics.

Substantive aspects include, but are not limited to

– the perception of the gap: what are the key attributes of the desired situation? What are the differences with (expected) reality? How serious is this? What are the causes of this situation? What possibilities exist to improve or solve the problem situation?
– availability of knowledge required to select a good solution

Actor, network and institutional characteristics, among other things, focus on:

– identification of the relevant actors, their beliefs and perceptions regarding the problem situation and their means to influence the situation
– actor interdependencies and interactions
– the formal and informal rules governing decision-making

Problem structuring efforts need to address the broad spectrum of issues covering substantive, actor and network, and institutional aspects in a coherent manner. In the process, choices also need to be made regarding what is most important, and what less so. How these choices are made may significantly affect the results.

Similarly, *where* the analysis starts may significantly affect the outcome. The starting point may be a focus on substance, or a focus on the actors, processes and institutions in the policy arena. If the initial analysis concentrates on substance, political and institutional issues will come to light only later, if at all. If, on the other hand, the initial attention goes to the political arena, political or institutional problems (such as the lack of trust between key actors involved) will come to the front, and the substantive aspects of the issue may be driven to the background or suppressed altogether, since solutions for the trust problem may be found in entirely different fields.

While ideally, in a balanced approach, all the different aspects are considered and synthesized, experience and personal judgment are important in attempts to achieve this ideal – if possible at all.

The approach taken in this book assumes that a policy analyst mostly becomes involved at the initiative of a client/problem owner, i.e. an actor who feels a need for support. In the description of our approach, we first take the problem owner's initial problem perception as a starting point. Next, we show how an approach starting with a focus on the substantive aspects of an issue can be extended and integrated with an analysis of actors and institutions. As problem situations evolve over time, and efforts to solve or ameliorate them will inevitably occur in the future, we add an exploration of possible future situations that could affect the situation.

Figure 1.2 illustrates the key elements of this approach. The initial problem perception of the client or 'problem owner' is taken as starting point. Chapter 2 provides, among other things, some practical suggestions for the development of the very first problem description.

Next, three types of problem structuring methods and techniques are proposed that help in the critical analysis of this initial problem description, in order to develop an improved version of the problem description, which we call a rich problem description, that is more likely to lead to the realization of a suitable solution. The approach starts with systems analysis methods (Chapter 3). This comprises a number of basic techniques and methods for analysing and structuring problems, or parts of problems. The various techniques cumulate in a so-called system diagram, in which the problem is delineated, defined and positioned in its dynamic context. This system diagram can then be updated and adjusted based on the outcomes of additional analyses. Analysis of the actor environment, the networks and stakeholders engaged in the problem is another important topic, elaborated in Chapter 4. Next, exploring the future as a strategy for dealing with contextual uncertainty is discussed in Chapter 5.

These three analytic activities are not independent. System analysis provides indications about actors that do or may affect the situation, while the inclusion of new actors can lead to the need for addition of new relevant factors in the system analysis. Similarly, insights from both system and actor analysis guide the selection of possibly relevant future developments, and vice versa. Given the importance of overall consistency of the different analyses, special attention is given to the synthesis of the results of different analyses in Chapter 6.

Problem structuring results in a rich problem description. After problem structuring, the question is if the policymaker has sufficient information to make a policy decision. If this is not yet the case, then the policy analyst develops a suggested path forward. This may, for example, consist of the analyst conducting an impact assessment of the identified alternatives, conducting more detailed research into a specific alternative, investigating the underlying values of actors involved in the problem situation, etc. The suggested path forward may also include participative activities, such as focus groups, that involve actor interaction, in which the role of a policy analyst may be more facilitating. Alternatively, it may be concluded that the rich picture is not yet fully developed and requires a further iteration of problem structuring.

Chapter 6 provides a framework to characterize a problem situation that can help in developing a plan of action following problem structuring. Depending on the problem situation, different types of activities, such as research, design or mediation, may be proposed and specified in such a plan of action. Within the context of this course, particular attention is given to conducting research as a follow-up activity (Chapter 7). Finally, the problem structuring results and the suggested plan of action can be communicated to the client in the form of a so-called issue paper, and guidance for this can be found in Chapter 8.

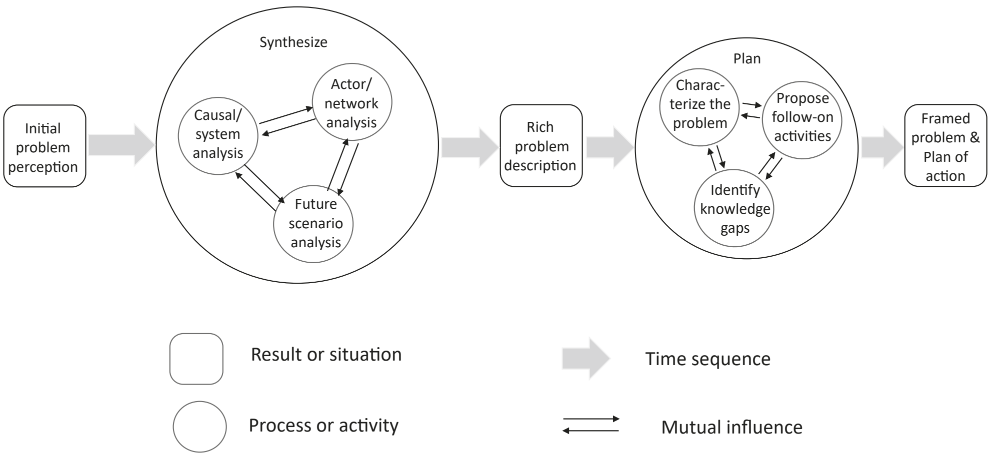


Figure 1.2 Steps in problem analysis and outline of the approach followed in this book

References

Ackoff, R. L. (1974). *The Art of Problem Solving*. New York: Wiley.

Bardach, E. (2000). *A Practical Guide for Policy Analysis: The Eightfold Path to More Effective Problem Solving*. New York: Chatham House Publishers.

Hoogerwerf, A. (1987). De levensloop van problemen: definiëring, precisering en oplossing. *Beleidswetenschap, 1*, 159-181.

Jann, W. & Wegrich, K. (2017). Theories of the Policy Cycle. In: F. Fischer, G. J. Miller & M. S. Sidney (Eds.), *Handbook of Public Policy Analysis. Theory, Politics, and Methods*. Boca Raton, FL. Taylor & Francis Group (pp. 43-62).

Kingdon, J. W. (1984/1995). *Agendas, Alternative and Public Policy*. Boston: Little, Brown and Company.

Patton, C. V., Sawicki, D. S. & Clark, J. J. (2012). *Basic Methods of Policy Analysis and Planning*. New York: Routledge.

Simon, H. A. (1977). *The New Science of Management Decision*. Upper Saddle River: Prentice Hall PTR.

Simon, H. A. (1991). *Organization Science, 2*(1) (Special Issue: Organizational Learning: Papers in Honor of (and by) James G. March), 125-134.

Thissen, W. A. H. (2000). *Issue-Formulation in a Multi-actor Context: A Five Step Approach. Proceedings of the IEEE Conference on Systems, Man and Cybernetics*, 301-306.

Thissen, W. A. H. & Walker, W. E. (Eds.) (2013). *Public Policy Analysis: New Developments*. Springer.

Walker, W. E. (2000). Policy Analysis: A Systematic Approach to Supporting Policymaking in the Public Sector. *Journal of Multi-Criteria Decision Analysis, 9*, 11-27. https://doi.org/10.1002/1099-1360(200001/05)9:1/33.3.CO;2-V.

Wildavsky, A. (1979). *The Art and Craft of Policy Analysis*. Hampshire and London: MacMillan Press.

2 Problem Formulation in Complex Environments

> *'A problem well stated is a problem half solved.'*
> Charles Kettering (1876-1958)

Problem formulation is an important analytical activity. A badly or wrongly formulated problem will lead to a problem continuing or getting worse, or to the wrong problem being solved, or to implementing a solution that serves a different goal. It may even create a new problem. Therefore in this chapter we look at the process of problem formulation, the dimensions of problems that need to be considered and complexity encountered. In the second part of this chapter we position problem formulation as part of a policy process, wherein the latter is not a rational stepwise procedure but rather an iterative and opportunistic decision-making process. In the final part of the chapter we will position problem formulation as a first step in problem analysis.

2.1 Coping with Complexity

Complexity is the everyday reality of the problems faced by analysts and problem solvers concerned with complex socio-technological systems. For technicians and engineers, the complexity of problems tends to be one-dimensional and is often technical in nature. In reality, however, there are few clearly structured problems with a single problem owner, a single problem definition, a small number of players and few alternative solutions, of which one is objectively the best. There are numerous examples of technically and organizationally complex or unstructured problems in which different rationalities play a role, knowledge is disputed, often with conflicting problem definitions and conflicting interests.

Dunn (1981) notes that one of the lessons we have learned from policy sciences and the science of public administration is that problems with a good or medium level of structuring seldom occur in the complex reality of the world we live in. Whereas conventional methods will solve well-structured problems, analysts confronted with complex situations must first actively explore the problem and its context to formulate an approach. This is usually done in an issue paper (see also Chapter 8). Exploration of the problem situation and the definition of what exactly the problem is are therefore the first steps that must be taken towards solving a complex problem. Dunn (1981: 106) explains this in the following way:

> Whereas well-structured problems permit analysts to use conventional methods to resolve clearly formulated or self-evident problems, ill-structured problems demand that the analyst first take[s] an active part in defining the nature of the problem itself.

Dunn (1981) refers to complex issues of this nature as 'ill-structured' problems, as opposed to 'well-structured' problems. Rittel and Webber (1973) used the distinction between 'tame' and 'wicked' problems, and other labels referring for instance to messy problems, ill-defined problems, untamed problems or ambiguous problems. Characteristic features of these ill-structured problems are the large number of players who are involved, the conflicts of values and the unlimited number of potential policy alternatives. Global current examples of these kind of 'wicked' problems are the development of policies to recover from the COVID-19 crisis lockdown, to develop policies to comply with the climate change agreements, the uncontrolled and unaccounted emissions of air transport, the energy transition in Europe and the tension between (cyber-)security and privacy. At a national scale, examples in the Netherlands include the expansion of Schiphol Airport, the gas transition, the taxation rules for multinationals and the location of wind farms on land. Next to value conflicts and abundance of alternatives, several identifiable factors influence the complexity of a problem. Some of these characteristics of problems or dimensions are listed in Table 2.1.

Table 2.1 Dimensions of complexity

Low Complexity		**High Complexity**
Well defined		Poorly defined
Well structured		Poorly structured
Closed		Open
Static		Dynamic
Static context	versus	Dynamic context
Scientific		Practical/Applied
Individual		Collective
Single level		Multi-level
Local		International

Complexity springs from numerous sources, as shown in Text box 2.1. Whereas a complex technical problem can usually be solved by a technical or engineering solution, the complexity of players caused by different perspectives and conflicting interests implies that solutions either need to be negotiated or are imposed by a party with the power to do so. Next we will examine these technical and social dimensions of problems in more depth.

Text box 2.1 Example: Airbnb as a complex problem
Airbnb and Uber probably are the most well-known and fast-growing peer-to-peer platforms in the early 21st century. The unprecedented success of these internationally operating platforms not only is a threat to traditional local service providers such as hotels and taxi services; it also leads to issues such as doubts on the fairness of competition; discussions on the terms of employment and liability; deterioration/improvement of the quality of services; and unforeseen impacts including congestion, safety violations, and complaints and policies to prevent tourists driving out inhabitants from popular tourist destinations in Europe.

Way ahead of all other conceivable factors, the number of parties or actors involved in policy-making is the primary complicating factor, because the number of potential interrelationships, coalitions, issues and conflicts increases exponentially as the number of involved parties

increases. The social complexity is boosted by interdependencies, and differences in power, knowledge and information levels. Take the City of Amsterdam as an example where the local authorities want to restrict the maximum number of nights property owners are allowed to rent out their premises to tourists. They have to deal with Airbnb HQ and its lawyers (who try to deny responsibility), with local property owners (who do not like the restrictions and sometimes rent out illegally), with housing associations and neighbours/inhabitants (who oppose and complain about Airbnb guests being noisy, and littering and occupying their cafes), with hotel and catering industry (who want fair competition) and with many tourists and tourist attractions flourishing on traction, with the police, fire department and taxing agency, with their own municipal organization for control on compliance and many more.
It is clear that the second most important complicating factor is the difference in problem perceptions held by these actors, stemming from their differing ambitions, interests and cultural-historical backgrounds. As indicated, they each experience different complicating factors of a technical/material nature, such as the nuisance caused by drunken partyers, the ignorance of and unfamiliarity with (fire) safety regulations, the absence of a level-playing field and the lack of means to check compliance.

2.1.1 Technical Dimension of Problems

In this section, we will use some examples to examine the role of technology, or the technical aspects, in complex problems and their resolution. When talking about the technical dimension of a problem, we refer to the substantive aspects of a problem such as transport, construction, civil engineering, environment, safety or economic aspects. Any reference to techniques or technical aspects should therefore be interpreted broadly.

Technology can play different roles in a complex problem. There are countless examples of technology solving problems (e.g. the Internet and Skype as a solution to long-distance communication and more recently Zoom and Teams as tools for teaching online), but also as the direct cause of problems (e.g. air pollution and environmental degradation as a result of industrialization or mining activities) or indirect cause of new problems (e.g. safer cars provoking risky driving behaviour or data centres consuming huge amounts of (scarce, green) energy). Moreover, something that is technically feasible is not always socially or ethically desirable (e.g. nuclear weapons or genetic modification). The norms that scientists, engineers and technicians apply sometimes diverge greatly from those of other groups in society. Controversies surrounding technologies such as nuclear energy, biotechnology, cryptocurrency, artificial intelligence and prenatal diagnosis/genetic screening spring from differences in the norms applied by different sections of society.

Intentionally or otherwise, technology may have a major impact on the organization of a society. The invention of the motor vehicle in conjunction with mass production using conveyor belts and growth of the oil industry opened the door to mass mobility. Automobiles (and now mobile phones) impacted everyday life enormously – they changed the way people lived, worked, commuted, communicated and spent their free time. It suddenly became possible to transport individual goods and people over long distances. Its influence is visible everywhere, and nowhere more so than in the United States, the prime example of a motorized nation, where it has impacted urban development (sprawl), the distribution of communities and facilities (e.g. shopping malls at the outskirts of town), the layout of the road infrastructure and public spaces, the near absence of public transport, the settling of the Great Plains and so on.

Technical solutions sometimes trigger new problems. The automobile may have driven the American dream and solved the transport problem; it also brought air pollution, CO_2 emissions, traffic congestion, accidents and social segregation. Fresh problems such as these are countered in turn by new technical solutions, such as cleaner and more economical engines, deformation zones and automatic lane-warning and vehicle control systems. New policy measures may also be introduced such as energy taxes, the compulsory wearing of seatbelts and rush-hour tolls. Until today, emotions run high in the discussion on congestion and road-pricing in the Netherlands; some people even claim their freedom is at risk. A similar story can be constructed considering the advancement of social media and fake news; about Facebook and privacy or about Huawei and alleged Chinese espionage. In fact, almost any new technology or technical solution to a problem creates both positive/intended and negative/unintended effects.

Often difficult choices must be made between the pros and cons of a technical solution. It is a question of deciding whether the new problems spawned by a solution are better or worse than the original problems. Is carbon sequestration and storage a solution or a problem? Is Alibaba's Sesame credit system combined with facial recognition techniques by Intellifusion and the Chinese government's use of algorithms and AI techniques for social control good or bad? Is in post-Corona times an app registering everyone's whereabouts a necessary life-saving precautionary health measure or an impingement on citizens' privacy and a tool for political regimes to exercise control? In this modern age, we are inclined to see technology as the universal remedy to all our problems, but evidently, this is not always true. In the presence of many of these examples, we must be mindful of Ackoff's statement (see the start of the first chapter) and ask ourselves which problem we are actually solving.

We must also be wary of overestimating the power of technology. Despite the highly advanced state of medical science, many diseases remain incurable or unavoidable. At the same time, technology provides only limited possibilities for remedying the environmental impact of our high-quality transport systems, and experts disagree fiercely about how to calculate that impact. A good early 21st century example of these phenomena is the improvement of fuel efficiency of traditional car engines being completely cancelled out by the gain in weight and size of the average car. As electric driving is rapidly expanding the promise of a clean commute, in practice the CO_2 gain is limited as most of the electricity needed for charging the batteries is still being generated by traditional coal-fired power plants. In short, a problem may be complex because of the absence of a technical solution or the unintended impacts of the solution. But even when a technical solution is present, it does not necessarily mean that we can solve the problem. Diverging interests may constrain the implementation of such a solution. For instance, capacity problems and noise hindrance issues at Amsterdam Schiphol Airport may be abated by building a new airfield at sea, but disputes on the costs, risks and environmental impact of such an island prevent serious studies of the effects of this solution.

In summary, the technical dimension of problems can be problematic in itself; technology can be part of a solution to a problem but also be the cause of new problems arising. Taking a systems perspective (which is the focus of Chapter 3) can help to define and delineate a problem and study the impacts of technology,

2.1.2 Social Dimension of Problems

The number of actors involved and the divergence of their interests and goals are important determinants of the complexity and solvability of problems. As illustrated by the Airbnb case in Text box 2.1 the growing number of actors not only exponentially increases the number of potential relationships, it also increases the number of potential conflicts of interest. Social factors such as mutual dependence and differences in levels of power, knowledge and information – and the possibility of utilizing those differences – determine in part the opportunities for social groups or actors to exert influence on the problem and possible solutions. Moreover, the parties involved usually have different perceptions of, and opinions on, the problem. This disparity stems, among other things, from the differences that exist in their ambitions, interests and cultural-historical backgrounds.

Neglecting the social complexity and ignoring the legitimate concerns of other stakeholders may disrupt policy processes and decision-making. In 1994, the Netherlands Governmental Scientific Council, a government think tank, published a report that stated as one of its conclusions that the tendency of engineers to concentrate on technical details and produce elaborate proposals provoked unnecessary resistance (WRR, 1994: 7). The Council also stated that major projects needed to be viewed as social transformation (because of the social effects of, for example, the building of a motorway: such as accessibility to areas, changes in business capacity, noise nuisance, effects on health and quality of living) and recommended integrating the social and political processes in all phases of formulating and solving problems and decision-making (WRR, 1994: 105). A current example is the settlement of damage to private property in North-East Groningen in the Netherlands, which was caused by earthquakes that were triggered by decades of extraction of natural gas from the deep underground. Cracks, subsidence and ultimately collapsing houses are threatening the life, health and well-being of the people living in the area. It also threatens their socio-economic well-being as their houses lose value, cannot be sold anymore and the village society is falling apart as the government, dedicated agencies and especially the semi-private sector company NAM have failed to respond to complaints and to compensate for the losses.[1]

In the private sector, too, there has been a change in attitude as companies face social resistance when over-exploiting resources and contaminating the environment. Especially in Western countries, public pressure obliges big multinationals to adapt their policies; all over the world national governments are instating environmental regulatory regimes and sustainable policies.

This pursuit of integration of political/social and technical elements is entirely in line with the ‘Polder Model’ in the Netherlands that puts consultation in the place of hierarchical administration. Essentially, the Polder Model dictates that all interests must receive attention when solving problems. In the Netherlands the decision-making culture is based on the principle of consensus (Hendriks & Toonen, 2001). In practice, this consensus model does not work perfectly though, for example, because groups of stakeholders have insurmountable or fundamental objections or because there is much disagreement about the nature and formulation of the problem. Examples of the latter are the discussion on energy transition and the Netherlands off-natural gas, or whether rare expensive

1 See for instance: www.rijksoverheid.nl/onderwerpen/gaswinning-in-groningen/schade-door-gaswinning (accessed November 2021).

medicines should be reimbursed by medical insurance or whether obliged COVID vaccination would have prevented a lockdown. Rather than focusing debate on the technical opportunity or solution these discussions centre on usefulness and necessity and moral justification of the proposed solutions.

It is the absence of consensus about a problem in particular that makes problem-solving complex and difficult. Problem definition and system demarcation become essential as different questions get mixed up, address different aspects, affect different stakeholder groups and occur on different scales. It brings to the foreground questions such as: What is the problem? Where are the boundaries of the system under examination? What assumptions exist regarding the context of the problem? How much policy space is there to solve the problem? In this book we will present the basic methods that allow a policy analyst to just do that: define and demarcate the problem considering the different stakeholder perceptions.

Outside the Netherlands, typically more hierarchically organized societies are to be found, and here too huge conflicts of interest and contestation are common. These conflicts are dealt with in a different, often more hierarchical, style of policy-making, but worldwide agreements on issues such as ‘good governance’ and ‘public participation’, e.g. the Arhus convention (see: http://ec.europa.eu/environment/aarhus and www.unescap.org/huset/gg/governance.htm), require the initiators of large engineering projects and new policies to instigate strategic and environmental impact assessment (EIA) studies to allow for the public to have a say (see for instance: www.iaia.org.) Even China, which is considered to have a hierarchical, state- and party-dominated governmental system, formally adopted the concept of ‘harmonious society’ and institutionalized an extensive system of environmental regulations (Enserink & Koppenjan, 2007). Moreover, China’s State Environmental Protection Administration (SEPA) intends to strengthen public participation in the EIA process. The new regulation includes stipulations on openness of information; safeguarding participants’ rights; and procedures and methods for public involvement, including opinion surveys, consultations, seminars, debates and hearings.[2]

In summary, the actors at play, the stakeholders affected, their perceptions, means and objectives are largely influencing the complexity of a situation. Therefore Chapter 4 is dedicated to analysing and mapping the world of actors and stakeholders.

2.1.3 Institutional Dimension of Problems

In an ideal world, a single powerful ‘comprehensively rational’ policy-maker would be at the heart of your client organization or government, making policies in an orderly and organized fashion, going through the sequence of steps sketched in the policy cycle (see Chapter 1). For the analyst operating in this hypothetical world, it would suffice to execute scientific research and advise the rational decision-maker based on the outcomes of the study. Our world, though, is far messier and less predictable; policy issues are highly contested; even the problem formulation may be highly contested; there is no single centre of power and consequently, it is not always clear who is responsible for policy-making. So, who holds the power to turn your recommendation into an outcome?

In practice, policy-makers, influencers, lobbyists and analysts are spread across many levels in public and private organizations and types of government. Therefore, it may not

2 Worldwatch Institute, 5 June 2019, www.worldwatch.org/china-strengthen-public-participation-environmental-impact-assessments.

be easy to identify and know your audience, to find out who controls the instruments you need to solve the problem, especially when several actors control part of these instruments and they need to cooperate to solve the problem. What makes your task even more daunting is the fact that each organization has its own way of working, formal and informal ways of organizing itself and the policy process it is organizing or in which it is participating. As Paul Cairney (2019) summarizes,[3]

> Each venue resembles an institution driven by formal and informal rules. Formal rules are written-down or widely-known. Informal rules are unwritten, difficult to understand, and may not even be understood in the same way by participants. Consequently, it is difficult to know if your solution will be a good fit with the standard operating procedures of organisations (and therefore if it is politically feasible or too challenging).

Institutional complexity, therefore, is also about legislation and procedures and the fact that problems often cut across sectors. An integral approach required for problem-solving often implies that regulations, norms and values from different sectors come together and this can cause conflict and confusion (Klijn & Koppenjan, 2014). Institutional complexity occurs whenever an organization is confronted with incompatible prescriptions from multiple institutional logics (Greenwood et al., 2011). For instance, Qiu et al. (2019) who studied the case of the Hong Kong-Zhuhai-Macao Bridge project describe how the governance of these kind of megaprojects is facing the challenge of institutional differences among actors, groups and political regimes, and the macro-environments, which bring about conflicts and uncertainty. Institutional arrangements therefore can add to the complexity of such (mega-)projects and not seldom are a cause of problems. For instance, the disconnect between (national) policymakers and the practice of (local) field workers is a well-known phenomenon in water and sanitation projects in many developing countries. This disconnect though is not unique for developing nations; the Dutch childcare benefits scandal (Dutch: *toeslagenaffaire*) is a recent example from the Netherlands concerning false allegations of fraud made by the Tax and Customs Administration while attempting to implement and regulate the distribution of childcare benefits as designed by the Dutch parliament.[4]

When focusing on problem analysis institutional arrangements, the division of tasks, jurisdictions and responsibilities is highly relevant as this is often a source of tensions and important for co-defining the decision arenas (who are the relevant stakeholders and decision-makers at what moment?) and for defining the solution space. The alignment of institutions is a requirement for successful problem-solving and implementation. Methods for analysing this institutional context included in this course book are the formal chart and interdependencies table presented in Chapter 4.

3 https://paulcairney.wordpress.com/2019/12/19/policy-analysis-in-750-words-what-can-you-realistically-expect-policymakers-to-do/.

4 www.cnbc.com/2021/01/15/dutch-government-resigns-after-childcare-benefits-scandal-.html.

2.1.4 Normative Dimension of Problems

Traditional policy analysis was positivistic[5] in character in 'speaking truth to power' and stressed value neutrality and rationality (Wildavsky, 1979). A large variety of authors objected against this positivistic paradigm and attempted to establish a more post-modern paradigm which allows for social constructivism and appreciation of different perspectives (Durning, 1993; Mayer, 1997; Thissen & Walker, 2013). Schön and Rein (1994) for instance claim that participants in policy processes might have different frames through which they see and value things. For them the logical next step was to conclude that the objectivity of the policy analyst is an illusion and the analytical process is loaded with implicit and explicit value choices, as is the policy process it is meant to support (Monnikhof, 2006).

In the previous sections, we already mentioned that moral and ethical dilemmas might add to complexity. We like to frame these as 'value conflicts'. Values are lasting convictions or matters that people feel should be strived for in general, and not just for themselves, to be able to lead a good life or to realize a just society (van de Poel & Royakkers, 2011). Good examples of such values are equity, equality and sustainability, both widely accepted and heavily disputed at the same time. Although most of us will support the idea that all people are equal and the colour of our skin or sexual preferences should not matter, in practice in many countries and societies they do. A black lesbian in Uganda will be in a less privileged position than a white straight male in Kansas, USA, but even in a relatively liberal country like the Netherlands the LGBTI+ community is fighting for acceptance and discussions are ongoing on implicit or even institutionalized discrimination. The Dutch 'Zwarte Piet' (*blackface*) debate and the lively demonstrations of the Black Lives Matter movement at the start of the second decade of the 21st century – also in the Netherlands – show these values are contested. The interpretation of sustainability also widely differs for instance when comparing statements made by representatives of oil and gas companies such as Shell and Exxon and representatives of Saudi Arabia, after the Glasgow 2021 Agreements on the one hand, and the ones expressed by environmentalists on the other.

Well-known and much debated is of course the utilitarian idea that an action or institution must be judged by the extent to which it contributes to the achievement of a collective utility. Public policy in this perspective should lead to higher public welfare, which is defined as the sum of the welfare of all individuals; and the distribution of the welfare among the individuals is not relevant as long as the average utility goes up. Consequently, as Monnikhof (2006) discusses, policies are legitimate if some people gain (a lot) while others may lose (a lot). The solution to this problem or maybe the circumvention was given by Pareto who spoke about optimality when a situation has been achieved in which no one can be made better off without making at least one other person involved worse off. For practical reasons welfare theory was then expanded with the Kaldor-Hicks criterion which implies that those having advantage from the new situation, the winners, could fully compensate the losers and still have some gain left. Unfortunately, most of these losers are never (fully) compensated for their losses and when the losers do not have a

5 Positivism is the philosophical idea that only what can be scientifically verified or proven by logical reasoning or mathematical proof is true. Pure positivists trust in science only. In contrast relativists argue that knowledge is not absolute; truth and morality exist in relation to culture, society and the historical context.

legal entity (like the air, the landscape, etc.) compensation and mitigation often are not included in the economic calculation of costs and benefits (Monnikhof, 2006). Utilitarianism still is prevalent in government policy; for instance large infrastructure projects such as dams and highways are often constructed referring to national importance and their contribution to national welfare, while having a big negative impact on local scale both on nature and on society. Resistance against large infrastructure projects, therefore, often finds it roots in the uneven distribution of costs and benefits of these projects and the absent or insufficient compensation of those who incur the negative effects or costs.

It gets more problematic when human life is involved. Cost-benefit analysis when considering the safety of coastal defences, mining operations or large clusters of the chemical industry tries to take along safety issues and potential victims of failing operations and the risk of disasters. But how do you value human life? Measures used include the 'lifelong earning capacity' (also used by insurance companies), but as earning capacity is much lower than in more economically developed countries this approach entails that human life in developing countries like Kenya or India is considered less valuable than in more developed countries in the West. People in Bangladesh, for example, thus may run higher consequences from drowning because of sea-level rise than people in the Netherlands.

In summary, the normative dimension of problems largely determines the complexity of a situation and underlying values determine actor objectives and problem perceptions. Methods for analysing values and objectives are discussed in Chapter 4.

2.2 Framing Complexity

Van de Graaf and Hoppe (1989) report a useful typology of problems, similar to a typology of problems of risk by Douglas and Wildavsky (1982). Both are based on the distinction between technological complexity and social complexity (Table 2.2). The axes of the typology consist of (1) the degree of certainty of knowledge (i.e. high/low) and (2) the degree of consent about the nature of the problem (the gap between an existing or expected situation and the desired situation).

Table 2.2 Typology of tamed and untamed problems

		Degree of Technological Uncertainty	
		Small	**Large**
Degree of social consensus on a problem	**Large**	1. Tamed problems	2. Untamed technical problems
	Small	3. Untamed political problems	4. Untamed problems

Source: Own work after van de Graaf and Hoppe (1989)

This results in four types of problems:

Type 1. Tamed problems: problems without social conflicts and for which technical solutions are available. The problem-solving process is characterized by analysing the problem and applying the most suitable solution.

Type 2. Untamed technical problems: problems that everybody feels should be solved, but technological solutions are not yet available. Investment in research is necessary to find a solution.

Type 3. Untamed political problems: problems for which technical solutions are available, but about which a social conflict exists regarding their application.

Type 4. Untamed problems: problems with the duality of uncertain technical solutions and lack of social consensus. From a social point of view there is a clash between values and interests of stakeholder groups and no certainty about the technical knowledge.

According to van de Graaf and Hoppe (1989), problem-solving strategies seek to mould problems of types 2, 3 and 4 in a way that makes them fit into type 1, i.e. untamed problems need to be tamed. This is achievable by reducing technological uncertainty and creating social consensus. This approach will often require a redefinition of the problem. For instance, defining HIV/AIDS, obesity or internet privacy as an issue of social responsibility and behaviour and not as a purely technical or medical issue opens the door to different types of solutions, such as awareness campaigns aimed at prevention and at modification of lifestyles and (sexual) behaviour. Redefinition frequently makes it possible to find solutions that reconcile the interests of parties who originally oppose each other. Another example is the construction of surface tunnels in new highway and railroad infrastructure as a way of limiting the impact (noise, view, air quality) on the surroundings, like the A4 Delft-Vlaardingen highway in the Netherlands. This latter example illustrates that new technology is not always necessary in order to tame these types of problems, rather political will to generate the finances needed to use (existing) technology for compensation and mitigation measures. Although all the earlier may be true, one should keep in mind that, when dealing with real untamed problems, taming them is essential but highly difficult: it is easier said than done, as we will see for instance in Sections 2.2.3 and further.

2.2.1 Structured and Unstructured Problems

Table 2.3 shows yet another typology of policy problems derived from van de Graaf and Hoppe (1989) and using the dimensions on consensus on values and consensus on knowledge. When there is consensus on values as well as knowledge, providing information will suffice and no extensive active participation is required. Such problems can be solved in a technocratic way but when facing the more contentious ones, special attention should be paid to the design of the decision-making process and the way information is handled or negotiated within such a process (e.g. de Bruijn et al., 2002; Klijn & Koppenjan, 2016; Koppenjan & Klijn, 2004). When both knowledge and values are contested, interactive analysis is the only way forward. As de Bruijn and Porter (2004: 268) argue,

> especially when the subject is pressing to the stakeholders, knowledge needs to be negotiated and when both values and knowledge are contested the process of involving actors is an important aspect of the analysis itself.

When facing an ill-structured problem, discussion on values is required and policy-makers need to engage in a process with stakeholders to jointly find the necessary decision-making space. When confronted with a moderately structured problem extensive consultation of stakeholders and good communication is the way forward.

Table 2.3 Typology of problems

		Consensus on Values	
		NO	YES
Consensus on Knowledge	NO	Unstructured Problem	Moderately Structured Problem
	YES	Ill-structured Problem	Structured Problem

Source: Enserink (2005) after Simon (1973) and Keeney and Raiffa (1977)

De Bruijn and Porter (2004) in this respect talk about 'contested problems' when referring to the degree of consensus. They provide us with a kind of decision tree on what to do when confronted with a complex issue (see Figure 2.1). Answering the five questions listed next will lead the analyst to a suitable strategy for problem-solving (de Bruijn & Porter, 2004: 265). We rephrase their questions to make their conceptual scheme fit the purposes of this course. Answering these five questions will lead you through the decision tree and provide you with advice on how to continue (see Figure 2.1).

1. Can the problem be solved and the solution decided upon essentially by one actor (i.e. authoritarian) or by a consensual process of multiple actors (i.e. network)?
2. Are the interests and objectives of the actors involved closely aligned?
3. Is there consensus on the knowledge/technological information?
4. Is the issue considered vitally important to the stakeholders?
5. Is there agreement that the decision is urgent?

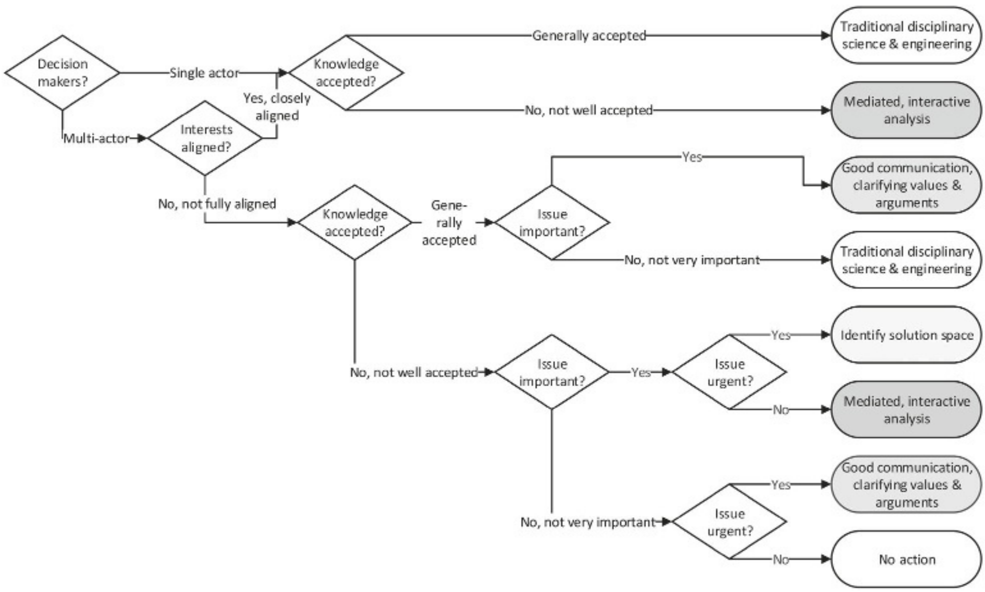


Figure 2.1 Decision tree to diagnose whether a situation requires stakeholder engagement (Source: After de Bruijn and Porter 2004; Enserink et al. 2010 cc Jill Slinger)

Choosing a path through the decision tree will lead to one of five actions which can easily be linked to the policy analysis styles included in the hexagon model described by Mayer et al. (2004) which will be introduced in Chapter 6:

1. Traditional disciplinary science and engineering: professional analysts using scientific methods and tools conduct the analysis, ratio leads to a best outcome.
2. Mediated interactive analysis and democratizing science: important stakeholders are actively involved and make the crucial decisions regarding these analyses. For instance, they should decide on the scope of the analysis and what method to use.
3. Good communication, clarifying values and arguments: the main stakeholders should be consulted to obtain information about their 'frames' and perceptions of the problems at issue. The main interest of the analyst is to present his or her findings as transparently as possible.
4. Identify solution space: focus is on the process and legitimacy of decision-making as the issue is urgent and important. Diverse knowledge sources and interests, although not closely aligned, must be taken into account. It is important for stakeholders to make a 'no-regret' decision that offers sufficient space for future decision-making.
5. No action: sometimes any resulting knowledge or information is so unlikely to be used that analysis would be a waste of time and resources.

2.2.2 Objective versus Subjective Problems: The Role of Perceptions and Interests

Conceptually we defined a problem to be the gap between the desired and the existing or expected situation, but given that different stakeholders hold different ideas about what is desired and different perceptions of the existing (or future) situation, the analyst's task is complicated (see Figure 2.2).

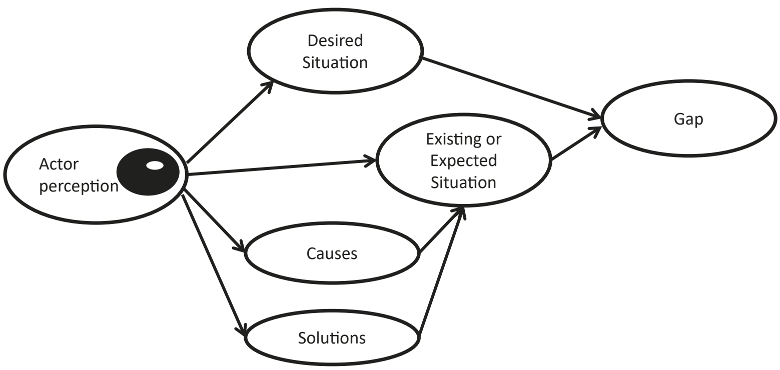


Figure 2.2 Problems as a perceived gap

Complicated may evolve into *complex* as different actors may have very different ideas about the desired and/or existing situation and about how the problem should be formulated and solved. 'Problem perception' is the term used to describe these subjective views of actors on problems which may in the end lead to different problem definitions. Logically, this can result in a concrete problem situation in which different definitions of 'gaps' exist alongside one another, gaps of which other participants involved may not even be aware. An example of such a situation is depicted in Text box 2.2 where we introduce the example of the former railway overpass in Delft in the Netherlands and the lengthy decision-making process that led to the new solution: a tunnel and an underground railway station allowing for the former rail track area to be developed into a new living/working/recreational area.

Text box 2.2 Example of objective and subjective problems: the Delft railway passage
By the turn of the century trains passed through the city area of Delft in the Netherlands on an elevated rail track, cutting the town into two parts and causing noise pollution, nuisance and safety threats for the citizens (see Figure 2.3). The Netherlands Railways wanted to intensify rail traffic on this so-called 'old line' between Amsterdam and Rotterdam. Growing passenger numbers in the future would require doubling its capacity. Clearly realization of the initial plans for doubling the elevated track would increase the level of hindrance (esp. noise pollution). The definition of the problem, or gap between the existing or expected situation and the desired situation, is not clear and surrounded by uncertainties.

Figure 2.3 Old and current situation in Delft (pictures by author)

The objective problem
In the Noise Abatement Act, noise pollution is expressed in terms of the noise volume, in decibels, at the outer wall of a dwelling. The maximum permissible volume due to railway traffic is 57 dB. A dispensation may be granted up to 70 dB, and higher volume levels can be permitted under certain circumstances. Inside the dwelling, the maximum permissible volume is 37 dB. To achieve such a low value, extreme noise insulation measures, such as installation of triple-glazing, must be taken. In the vicinity of a railway station (1500 metres on both sides), the permissible volume is 5 dB higher. The trains on the former railway viaduct at Delft for instance gave rise to peak loudness levels at outer walls of dwellings of between 93 and 98 dB. However, in the Noise Abatement Act, the peak volume is not the determining factor: it is the mean volume per hour that is considered. This means that a situation can arise in which residents are being woken up every night by the rumble of goods trains and the hiss of railway lines even though formally the volume does not exceed the stipulated levels.

The subjectivity of the problem
Residents: The current use of the railway viaduct in Delft causes serious noise and health nuisance. The peak noise largely exceeds what is permitted! We wake up several times every night! Measures should be taken immediately. Expansion of the railway service will worsen these problems.

Municipality: The existing viaduct causes nuisance and is undesirable within the urban setting; the railway infrastructure and any expansions must be placed below ground. The latter will create opportunities for city redevelopment.
Netherlands Railways: The current use is within the limits set by the Noise Abatement Act. To maintain the quality of passenger services in the 'Randstad' area it will be necessary to intensify the use of this section of the track in the near future; while in the longer term the capacity will have to be doubled. Noise abatement and mitigation measures will reduce the hindrance for residents along the track.
Passengers: Comfort, speed and reliability of the rail service must be guaranteed; the present capacity causes too many delays.
Ministry of Transport: The current use is within the limits set by the Noise Abatement Act. Priority in the new railway infrastructure is being given to the high-speed rail link (HSL) and the preferred HSL route does not pass through Delft.

The Delft textbox example makes clear that problem perceptions are linked to actors, their positions and roles. It may even be the case that one actor is still thinking in terms of problems while another is already talking about solutions; actually it is quite common that the preferred solution of one actor is seen as a problem by another actor. A number of explanatory variables exist for differences in perception. These differences are related to such circumstances as:
– the background and history of the actor concerned;
– the position and interests of the actor ('where you sit is where you stand');
– communication patterns (who talks to whom);
– individual reference frameworks (selective perception);
– the available vocabulary (what can be discussed);
– the modelling method (graphical, mathematical, procedural).

Text box 2.3 The Delft railway passage – continued
Returning to our example of the train track in Delft: the complexity grew when during the debate on the need for a tunnel, the discussion on costs and especially on (financial) risks was gaining prevalence. The Mayor and Aldermen of Delft were willing to invest in the tunnel project and to bear a large part of the financial risks in order to persuade the Ministry of Transport and Waterways to also invest in the way more expensive tunnel solution. Opponents accused them of bringing the city to bankruptcy and clashed with proponents in the Delft City Council over almost anything regarding the tunnel project and the area redevelopment process. Interestingly, with hindsight, we can conclude that both sides were both right and wrong. The city of Delft took big financial risks and when economic crisis hit the Netherlands Delft no longer could fulfil its financial obligations and received a so-called Article 12 Status, implying it was under curatorship by the national government because of its structural financial problems. As an ultimate consequence, the new city hall building that would have been constructed on top of the underground railway station lost its top floor. When the economy started to blossom again and investors returned the financial problems diminished. Around 2020 the new railway station has become a modern city icon and construction works in the 'New Delft' city development area are well underway. The criticism on the boastful plans has dwindled.

Problems

2.2.3 The Problem Formulation Battle

The way a problem is defined is not neutral. Problem formulations indicate the elements of a situation that matter and those that matter less. This not only marks out the problem field, it also identifies the relevant and less relevant variables and standards. In the Delft example, these are: the nuisance for the city dwellers, the capacity for the railroad services for the Dutch Railways and financial risks for the municipality of Delft and the Ministry of Transport. Consequently, problem formulation sets the direction of possible solutions and excludes others. Problem formulation thus influences the division of potential costs and benefits for the parties involved in the problem. Indeed, the supposedly unfair distribution of costs and benefits, the absence of (sufficient financial) compensation and insufficient mitigation are quite often a reason for resistance against major infrastructure works (Monnikhof, 2006).

> *'The thought process and the exercise of power are closely related to each other. They may coincide or follow on from each other, but they continuously influence each other.'*
> (Hoogerwerf, 1992: 13)

This explains why the formulation of a problem is a contentious activity; it is a political and strategic choice that centres on what the nature of the problem is and, by extension, what the most promising solutions are, and sometimes on the question of whether or not a problem exists. Problem owners who are confronted with the costs of an existing situation usually find themselves lined up against parties with a vested interest in the continuation of the existing situation because they stand to benefit from it (and can saddle others with the costs). At times stakeholders who are confronted with the cost of a solution usually oppose the initiator or problem owner because it is in their interest to maintain the status quo. In brief, the formulation of a problem is of a political nature and often the cause of conflict (Schattschneider, 1960). Nonetheless, the first and most important challenge of the analyst is to come up with a proper substantive (scientific) problem definition that is considered legitimate to other actors. This probably implies active involvement of stakeholders in the problem formulation process (de Bruijn et al., 2002).

Communicating the problem, therefore, is the next challenge for the policy advisor; how to bring about the message? How to create a strong message and how to choose the right words? In his book *Narrative Is Everything* Olson (2019) argues that the 'And, But, Therefore (ABT)' narrative template is the simplest and most powerful tool to communicate a message and to attract and keep the attention of your public. 'And, But, Therefore', he argues, is for all kinds of psychological reasons thought to be the most effective way to present a message. Referring to the Delft railway problem the message could have read: *the capacity of the rail track falls short and the noise hindrance is excessive, but enlarging the existing viaduct is not acceptable, therefore a radically different – underground – solution is needed.* This is a strong message stating the problem and showing the way out. But the earlier problem formulation might not be the right one. In his book *The Art of Political Framing* de Bruijn (2019) gives nice examples of framing and reframing and the impact of using the right words. For instance, in the sentence on the Delft railway expansion, the focus is on the capacity needed, but when the discussion focuses on the financial risks involved, a different frame might work: *A railway tunnel is more expensive, the construction works will have a big impact on the city centre and may take much more time to implement,* *but the hindrance caused by the viaduct is excessive and new chances for the development of Delft are created; therefore, it is legitimate to invest more public money in this infrastructure project*. This, too, is a strong message in ABT style, but which frame to choose is a matter of politics and may indeed be the essence of the problem formulation battle. It illustrates that the policy analyst almost inevitably will operate in a politicized environment in which choosing the right words contributes to the impact of your findings.

2.2.4 The Social Construction of Problems

It is usually assumed that there is a specific problem owner who puts forward a problem. A policy analyst who accepts an assignment to solve this problem should ask – if for no other reason than their professionalism – whether the client's problem formulation is acceptable and eventually redefine this formulation in researchable, workable and acceptable terms. The policy analyst has to operate in the field of tension that exists between the problem formulation made known by the client and the knowledge that other actors may view the problem very differently. One can question whether manuals that speak of 'problem exploration in the context of the assignment' do sufficient justice to the existence of different and sometimes contradicting problem formulations.

Some approaches define the phase of getting matters onto the agenda as a policy-analysing activity. Hogwood and Gunn (1984), for example, describe and examine 'issue-search' activities. Theories that describe the agenda-setting part of the policy cycle (such as agenda forming) highlight the fact that problems do not appear automatically on the agenda of problem solvers. Problems are not objective facts that are waiting 'somewhere out there' for somebody to discover them. The actors involved must experience them, put them into words and articulate them, i.e. submit them as claims to decisions-makers; a newer take on this topic is that of 'framing' (de Bruijn, 2019). Cobb and Elder (1983) refer to the process of 'issue creation' whereby initiators actively endeavour to place a problem they are experiencing on the agenda of the media, policy-makers and politicians. According to Cobb and Elder, the probability of gaining support and consequently agenda status will increase if a problem formulation:

- has major societal relevance (i.e. affects a large number of people);
- will bring about long-term effects as well as short-term ones;
- is specified to a lesser degree in technical terms;
- is not so specific;
- is presented as new.

2.3 Problem Formulation as Part of Problem-Solving

It will be clear that problem formulation is a critical but contested and difficult activity in policy analysis in complex environments. When dealing with wicked problems according to Rittel and Webber (1973) the formulation of the problem *is* the problem, and the main challenge for a policy analyst facing complex problems is 'finding problems worth solving' (Wildavsky, 1979). However, such problem formulation is not neatly separated from other activities in the problem-solving process. Problem-solving processes at the level of complex systems, networks and chains do not take place in a number of chronological phases but are rather extremely unstructured. 'Formulating problems', 'designing' and 'deciding' are activities that are linked in a complex way and have the nature of a strategic interaction process in which analysis and the exercise of power are important. As regards the content of the process of problem formulation, this means that the objective must not be to pursue a detailed problem analysis based on a substantive analysis and (scientific) research alone, rather a rich problem analysis also includes the perceptions of other parties and should be scientifically defensible. Combining these insights is important as a point of departure for interaction and mutual adjustment between parties.

As mentioned before, Herbert Simon (1977, 1991) claimed that people solve problems in four steps: intelligence, design, choice and implementation. These four steps form the basis for numerous attempts to conceptualize decision-making, problem-solving and design processes in a wide range of disciplines. As mentioned, Hogwood and Gunn (1984) identified nine core activities for policy analysis and Hoogerwerf (1987, 1992 or 1998) needed the same number to describe policy design processes. They all suggest a rational chronology of activities, but in the next sections we will look at policy theories that seem to contradict any rationality or chronology in policy-making; rather they suggest there are plural forms of rationality, e.g. political rationality. They sketch the dynamic and unpredictable nature of policy-making that analysts have to deal with; therefore it may be a rational choice to take note of these contextual characteristics!

2.3.1 Garbage Cans and Streams

Even though the inventors of the earlier models immediately point out that the phases are meant to be logical rather than chronological and recognize that feedback and iterations take place, this thinking in phases often results in attempts to tackle problems following a number of fixed, sequential steps. In practice though, problem-solving processes may prove to be extremely unstructured, often resulting in unexpected outcomes. Cohen et al. (1972) produced arguably the most radical conceptualization of this unpredictable character in their '*Garbage can model of decision-making*' (see Figure 2.4). This garbage can model applies to complex situations without a clear fixed hierarchy of objectives and values and where routine procedures seem absent. Moreover, in these situations it is not even clear who is participating in the decision-making processes as the latter is not regulated. These situations are called '*organized anarchies*'. With their model, Cohen, March and Olsen originally had in mind professional organizations such as hospitals and universities, but they soon discovered this model could also be applied for network-like situations, such as decision-making on public infrastructures where numerous actors are involved.

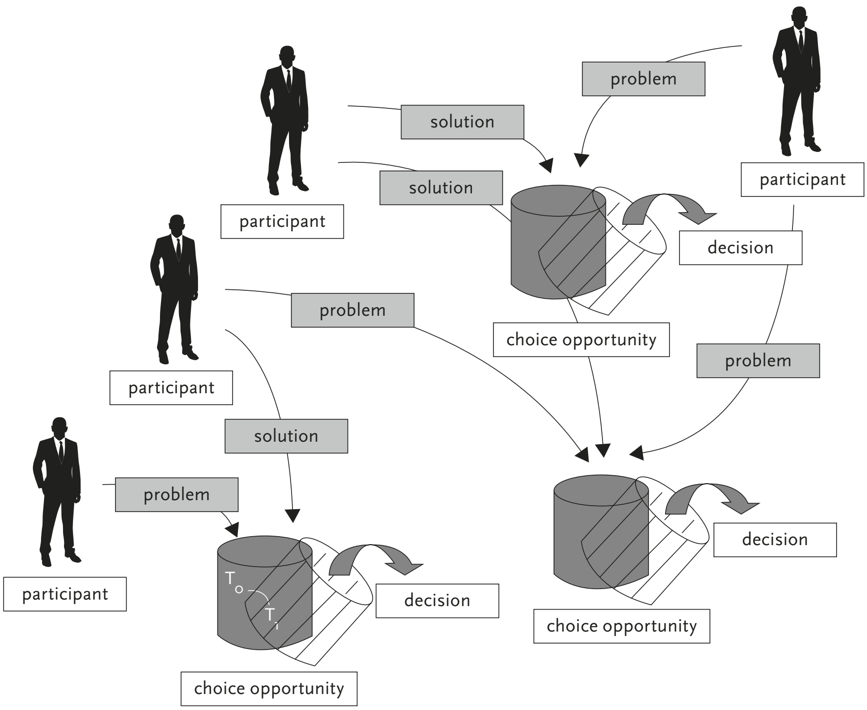


Figure 2.4 The garbage can model by Cohen, March and Olsen (Source: Koppenjan & Klijn, 2004)

Text box 2.4 Example of a garbage can solution
An example that seems to fit nicely the garbage can theory is the highly expensive seven-kilometres-long tunnel in the high-speed rail line between Amsterdam and Rotterdam in the Netherlands. This expensive bored tunnel was an unanticipated outcome of the highly politicized debate on the preferred trajectory: speed versus nuisance. The seven kilometres of bored tunnel would allow for an eight minute faster route with no stop-over in the city of the Hague. Even better: such a tunnel would save the vulnerable, valuable open landscape with ditches, meadows, cows and traditional windmills of the so-called Dutch Green Heart area. Tunnel boring technique in soft soils was new and 'hot' at that time; construction companies and consultants were promoting this newly discovered engineering opportunity; it was a solution looking for a problem. A solution which became available when the political parties needed a breakthrough in the stalled debate on the trajectory of the rail line.

In this radical perspective a decision moment is presented as a garbage can into which participants deposit their problems and solutions. The contents of such a garbage can depend on the moment in time in combination with the production of waste (the problems, solutions and participants), the availability of other garbage cans in the area and the speed at which the garbage cans are emptied. The result of decision-making therefore is almost impossible to predict and largely depends on what happens to be in the garbage can in the way of problems, solutions and participants at the decision-making moment. This garbage can theory can explain unexpected or unanticipated outcomes of decision-making processes. The radical idea of the garbage can is the absence of control and unpredictability of the outcome (Text box 2.4).

2.3.2 Problem-Solving Following the Streams Model

Cohen, March and Olsen (1972) refer to *streams* of problems, solutions, participants and decision moments/choice opportunities as shown in Figure 2.4. Kingdon (1984/1995) took this idea further, modified it in a number of places and applied the *streams* idea to public decision-making processes. Kingdon identified three *streams: problems, solutions and political events* (see Figure 2.5). This implied that political events such as changes of governments and/or changes in the political and social climate are seen as opportunities for solving problems or realizing opportunities. Shifts in political preferences may result in certain problems and/or solutions gaining (and others losing) political support. The change of administration in the USA from Obama to Trump to Biden for instance largely determined the fate of Obamacare, US foreign policy and the US stance on climate change. In contrast to the garbage can model, in the streams model actors or participants are located and active within and between the streams because, according to Kingdon, problems cannot be isolated from people (or groups or organizations). People need to articulate problems. The same applies to solutions: you need people to think them up and to bring them to the attention of other people in order to get them accepted and implemented. Kingdon introduces a new metaphor – *the policy window* – which refers to the coupling of participants, problems and political events. Without such a coupling of these streams, the decision-makers will not take a decision, no matter how urgent the problem may be or how promising a design is.

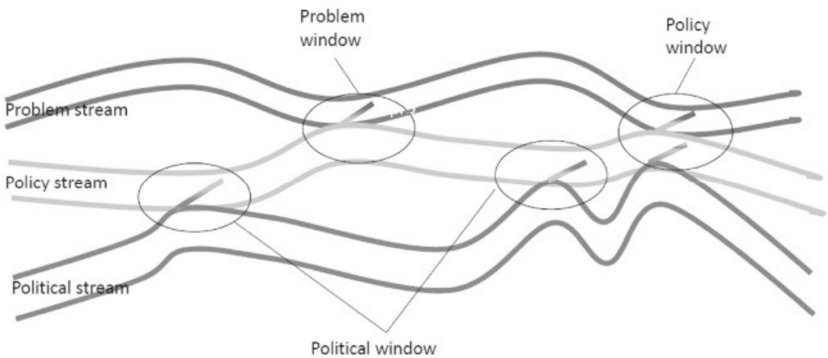


Figure 2.5 Kingdon's streams model (Source: Own work after Pauly 2001)

Policy windows do not come about automatically; they are created by '*policy entrepreneurs*': actors hunting for solutions to their problems, or problems for their solutions, or for support for their problem-solution combinations and choice opportunities looking for participants. In effect, the streams model turns the traditional phases model upside down: in the rational model, agenda setting and analysis of the problem are followed by the development and selection of the solution, based on unambiguous and explicit criteria; the streams model affords scope to solutions looking for problems and for decision-makers looking for solutions and problems.

Text box 2.5 Example of streams model decision-making
In the Dutch river dike debate in the 1970s/1980s it was thought that traditional dike reinforcement would damage important landscape features and natural landscapes in the area and the opposition to traditional enforcement was fierce. Numerous alternative dike construction methods, so-called 'smart dikes', were developed that would spare monuments and nature, but these solutions were considered (too) expensive. The extreme high river waters in 1993 and 1995 that led to complete evacuation of the area created the policy window where the three streams met: the problem was urgent; the solution was around and politicians needed to act. An emergency law was drafted leading to extensive dike improvement works that used 'smart' solutions at vulnerable places.

Kingdon's streams model may appear to be extreme at first sight, but closer examination will reveal several recognizable points. In the Netherlands for instance, during the 1970s and 1980s the decision-making on the improvement of the river dikes had been in a deadlock situation (see Text box 2.5).

A current example is the very fast development of COVID-19 vaccines; they could be developed starting from the vaccines that just had become available to counter the related SARS viruses, the problem was urgent and the political will to implement vaccination schemes was present.

Text box 2.6 Example of a solution looking for a problem
Yet another example of a solution looking for a problem is the so-called Betuwe Route – i.e. a ready-to-go design of a goods rail line between the harbour of Rotterdam and the German border. At the start of this century, it was presented and defended by the Netherlands national government without an initial clear discussion on the usefulness and necessity of the line. This explains why over time diverging problem formulations have been linked to the Betuwe Route – including the safety on the existing infrastructure, the supposed threat to the competitive position of the port of Rotterdam, the sluggish development of the Dutch economy, employment opportunities and solving environmental problems – all of them presented without any change to the pre-defined solution: a new rail line. A proper problem formulation would have centred not on the question 'How do we realize the Betuwe Route?' but on the question of 'How to improve the link between the port of Rotterdam and inland areas?' This kind of problem formulation would have left room for entirely different solutions, including transport by barges. Moreover, the challenge to legitimate the high expenses made proponents focus on solving problems in the Netherlands and may partly explain why in 2021 the connecting rail link in Germany is still under construction.

2.3.3 Problem-Solving in Arenas and Rounds

Building on the *garbage can* and *streams* model, it can safely be stated that decision-making regarding problems takes place in rounds and arenas and not according to chronological phases (Figure 2.6). Activities within these rounds may differ widely though; they can be undertaken to explore a problem, to design or select a solution or a combination thereof. A round ends with a 'crucial decision', i.e. a decision or outcome that is taken for granted and settles the debate on issues central in this round and acts as a point for departure for new rounds of negotiations and that influences the rest of the process. This does not necessarily imply that this decision will be elaborated further in a subsequent round. For example, the decision may have been to refrain from adopting a certain solution and to re-examine the question of what the problem actually is. The problem-solving process in the rounds model strongly resembles a boxing contest, i.e. the result of each round can differ and the winner only becomes apparent at the end (Teisman, 2000). To further complicate the decision-making process, sometimes several arenas exist simultaneously, where parties push and shove about problems and solutions in different places at the same time. These arenas are places where choices are made or the garbage cans where participants create, negotiate and decide about problem formulations and solutions. In these different rounds and arenas, decision-making processes are characterized by their zigzag course, ups and downs and iterations (van Bueren et al., 2003).

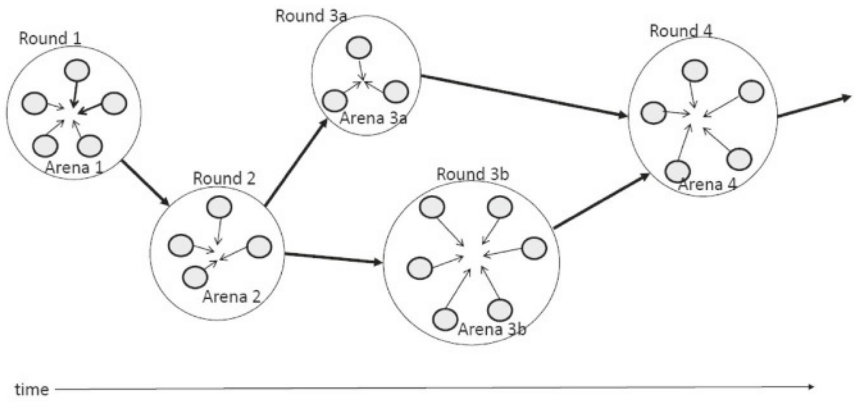


Figure 2.6 The rounds model: problem-solving in rounds and arenas (own work)

2.3.4 Problem-Solving and Advocacy Coalitions

Describing problem-solving as a sequence of rounds, where streams of problems, solutions and events are connected in and across different arenas, offers a rich picture but does not look specifically into the role that formal analysis and technical information can play in these processes. For this, yet another theoretical perspective from the policy sciences is useful: the Advocacy Coalition Framework (ACF). The concept of an ACF was developed by Sabatier and Jenkins-Smith (1988) to deal with 'wicked' problems and to better understand the roles that formal analysis and technical information play in the policy process (Sabatier & Weible, 2007).

The framework assumes that policy-making occurs within policy subsystems consisting of several theoretical components (see Figure 2.7). Within those subsystems, advocacy coalitions are formed by clusters of stakeholders who share a belief system. For instance, in many environmental policy problems, one could find typically an environmental or conservation coalition as well as a business development coalition. These coalitions have different beliefs, not only about 'how the world works' but also about 'what is good for the world', thus they hold different problem formulations. The coalitions aim to translate components of their belief systems into public policy, using for instance a lobbying strategy – aimed at the formal decision-makers, so-called sovereigns – to introduce their arguments into the decision-making process. For this, they have the resources to pursue their interests (Sabatier, 1988; Sabatier & Weible, 2007). According to the ACF, the sovereigns have legal power and adopt legislation and public policies while the coalitions attempt to influence this legislation via lobbying activities targeted at the different sovereigns during the decision-making process. The actors in a policy subsystem are affected not only by the processes within the policy subsystem but also by external factors and events in the broader political, physical and socio-economic system (Sabatier, 1988; Sabatier & Weible, 2007). Compared to the previous descriptive theories of problem-solving, the ACF assigns a bigger role to the argumentative dimension of policy processes, although it also includes specific factors that address the more political games of using resources strategically to pursue specific interests.

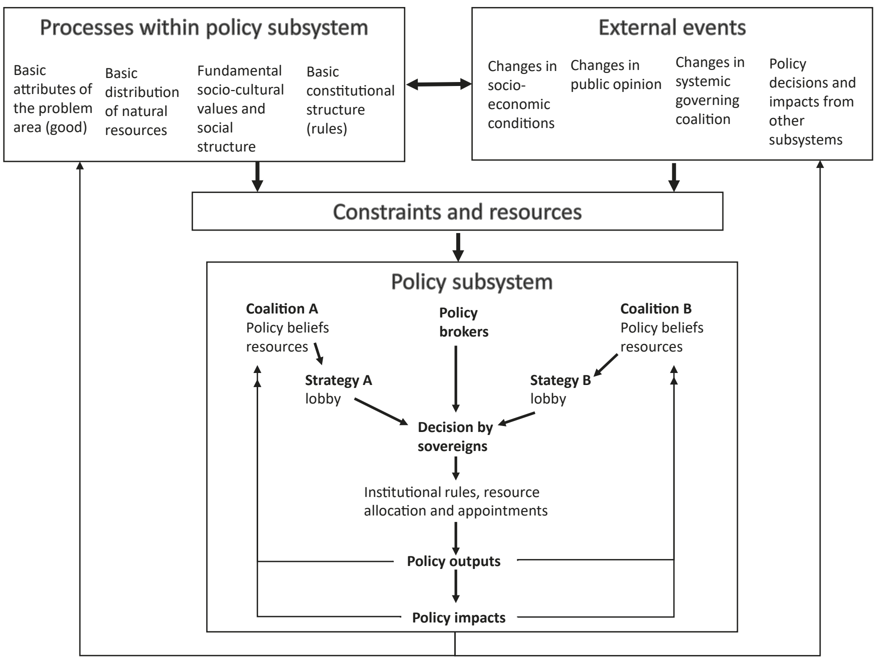


Figure 2.7 Advocacy coalition framework (own work after Sabatier, 1988)

2.4 Points of Intervention

In the previous sections we discussed that policy-making is neither straightforward nor a scientific process, rather it is haphazard and strategic and political in character. Solutions depend on the willingness of coalitions, political opportunism or the activity of policy entrepreneurs. The question arises: what kinds of solutions do fit what kinds of problems? Our task as the analyst is even more complicated; we noted in earlier sections that causes are hard to identify since various actors have different problem formulations, and normative positions determine what is considered problematic in situations. And what is more, complex problems – even if consensus exists – may have various causes and it is hard to distinguish between root causes and symptoms. Nonetheless, we will distinguish between different categories of solutions. Fundamental solutions address the cause of a problem situation and are more effective than solutions that focus more on the consequences of a problem (i.e. the characteristics of the problem situation). This explains why these latter measures are often referred to as the treatment of symptoms. There is a third category of solutions, i.e. solutions that seek to modify standards, or the level of ambition that is coupled to the desired situation. Lowering the standard is another way of closing the gap without much fuss. Finally, a fourth solution is to alter the perception of the problem by providing information, by reframing or by ridiculing and trimming down the problem (Text box 2.7).

Text box 2.7 Example of fundamental, consequential or norm relaxation approaches

As an illustration we take a look at the nitrate debate in the Netherlands. In early 2019 the Netherlands Supreme Court decided that no building permits would be granted as long as there would not be a guarantee for zero nitrate emissions because of these activities. Construction permits were halted, the problem was getting out of hand and somewhere, somehow somebody should provide a quick solution to reduce nitrate emission in the Netherlands. One member of Parliament suggested that – as cattle farmers alone are responsible for 43% of the nitrate emissions in the Netherlands (and nitrate is poisoning our groundwater) – the number of cattle farms should be reduced by 50%. This remark sparked intensive farmer's protests culminating in two days of protests by farmers driving their tractors to the seat of the Netherlands Parliament: The Hague. A fundamental solution indeed would be to reduce the number of farms emitting nitrates, especially NH_3. Treating the consequences would focus on installing air washers, removing topsoil of contaminated nature reserves, anticipating new cleaning technologies and the like. Reducing the level of ambition was also suggested, especially by the farmers as other economic sectors (like air transport) should also contribute. Finally, many farmers suggested the problem was overestimated as on their way to the protest manifestations in The Hague they had been passing flowering heather, so the problem could not be as bad as suggested by these politicians.

The aim of the problem specification process therefore also is to obtain clarity and consensus about the intervention aspects of an issue. It is then possible to develop measures that address one or more of these four aspects, depending on the availability and acceptability of means. Figure 2.8 shows the aspects of a problem formulation as a stepping stone for solutions. A final remark on interventions may be useful though. It was suggested that problems can be solved by reducing ambitions, but a strategy may also be to raise the ambition levels. For instance, in its 2020 State of the Union address, the EU Commission raised its climate ambition and proposed a 55% cut in emissions by 2030.[6] So lowering the ambition level may not always be the right way of dealing with a problem! Perceptions may be addressed, but not always to lower expectation but for instance to make people aware of problems. Raising the EU ambitions in this respect is a clear sign and warning to European countries to start implementing measures and to other world players like the USA, China and India to raise their ambitions too.

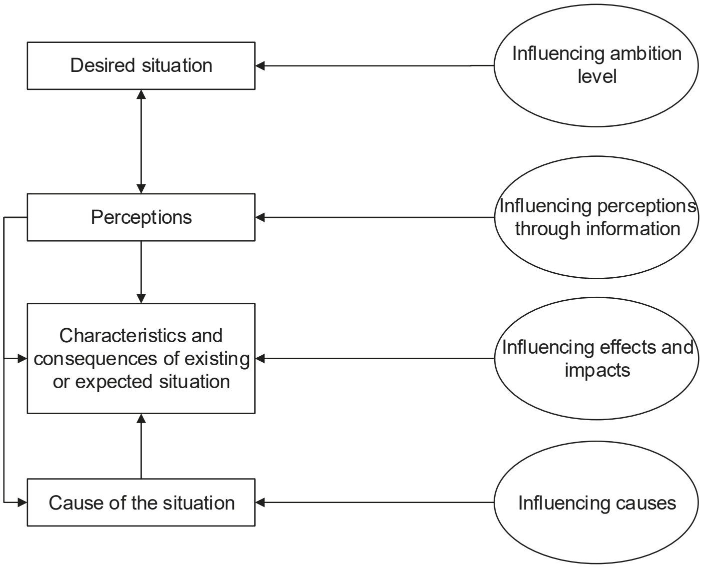


Figure 2.8 Problem formulation and points of intervention (inspired by Koppenjan, 1990)

Summarizing what we said about the activity of problem formulation and intervention a number of functional requirements can be derived from the earlier sections. They are (a) the need for joint problem formulation, (b) the need for accepted knowledge often derived through stakeholder involvement, joint fact-finding and negotiated knowledge, (c) the need for understanding the importance of the political process for creating a coalition of the willing, (d) agreement on the point of intervention.

2.5 Problem Formulation as First Step in Problem Analysis

Problem analysis and problem formulation is an activity that is fundamental to the problem-solving process. Formulating the problem in an adequate manner is a necessary condition for finding good solutions. However, it is easier said than done. As indicated in Chapter 1, the progress of the analysis and problem-solving process is determined to a large extent by choices that are made during the problem formulation process. Therefore,

6 https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1599.

it is of the utmost importance to spend enough time and attention to problem formulation and demarcation. Handbooks suggest that problem exploration may take up 20 to 25% of the total time needed for problem-solving!

In this book we presume multi-actor complexity as previously mentioned. We introduced a situation where the policy analyst is asked by a client (problem owner)[7] to give support and make suggestions for other approaches. The problem will be positioned in a complex multi-actor environment. The role of the analyst is that of policy advisor (see Chapter 1): from the viewpoint of a client or problem owner an analysis is conducted and a strategy is developed aimed at improving the situation that is perceived as a problem by that actor.

In many cases, the analyst's first impressions of the problem come from the problem owner's formulation: 'Traffic safety is affected negatively because a lot of car drivers make telephone calls while driving. We have developed a portable phone which can be used hands-free in a car, eliminating the problem mentioned above' or 'Trucks cause pollution, so we have to try to move haulage transport from the road to the railway network.' It is not advisable though for analysts to uncritically accept the problem formulation of potential clients. This even constitutes a disservice to the client. Experience teaches us that most of these first impressions of the problem do not stand up to criticism. The problem formulation often points too strongly in the direction of a specific solution, and many times other important actors involved in the tackling of the problem turn out to have a different view on it. Sometimes closer analysis shows that the first impressions of a problem are wrong, in part or wholly, or an assessment of the future points to the likelihood of the problem disappearing in time without intervention by the problem owner. Also, we see situations with many different problem perceptions present, where framing and disinformation and even disruptive communication by social media may play a role. Examples are climate change denial, Trump's campaign on the 'stolen elections' or the conspiracy theories on vaccination with microchips during the COVID-19 pandemic.

What then distinguishes good problem formulations from bad ones? Unfortunately, there is no final answer ('good' also depends on the perceptions of actors), but there are a number of characteristics that can be used to distinguish the better (or improved) problem formulation from the not so good ones. A good problem formulation must be convincing because of (a) the scope of the approach that was followed (that made sure that nothing important was overlooked), and (b) the consistency and clarity in the argumentation of the choices that were made. Good problem formulations are characterized by:

– a clear and well-thought-out introduction to the problem (context, history);
– a precise identification of the client and other relevant stakeholders, those that can affect or are affected by the problem or its solution (see: Bryson, 2004);
– a concise description of the problem from a multi-actor perspective (what is the desired situation and how is that measured,[8] what is the present or expected situation and what is the gap between these two situations?);

7 Problem owner is a term that is not used in a tender procedure, instead client or commissioner is used.

8 Also shown in an objectives tree.

- a demarcation of the aspects[9] and factors that are important[10] (what does the problem relate to?);
- an overview of potential solutions;[11]
- a concise description of the main uncertainties in the context of the problem that may influence the problem, its demarcation and/or the effectiveness of proposed solutions;
- an overview of existing knowledge gaps;
- an indication of strategic threats and opportunities (the context of the analysis, how to fit into the whole process of problem-solving);
- a description of the basis of support, sketching what other actors are needed in the process of problem-solving.

From these we determine that a thorough and in-depth problem formulation pays attention to the causes of the problem (factors) as well as to the context of the problem (the views on the problem and the solutions of other actors involved and aspects that the client did not think were relevant). To achieve all of this, a large variety of analytical techniques are available to the analyst. In the next chapters we will present a number of basic techniques which can serve as a starting point for analysing complex problem situations.

In Table 2.4 a sequence of analytical steps is presented that supports problem formulation. This general sequence, although with the premise that it is an iterative and interactive activity, is reported in many scholarly articles and books such as (Checkland, 1985; Thissen, 2000; Thissen & Walker, 2013; van der Lei et al., 2011). These activities may be considered standard procedure for any problem analysis, no matter whether it is a tamed or untamed problem. Beware that during the very first stage of problem analysis in Table 2.4 indicated as 'put into words the problem formulation of the problem owner', our inquiry or research aims at verifying whether the suspicion of a problem is grounded or not (is there a problem that one or more actors experience?); finding out what the most important characteristics of the problem are, both technically or in terms of content, and whether they are socially or actor related; and working out what the best direction is for finding solutions. The final step of this preliminary exploratory research is to reformulate the problem and draft an accompanying plan for further research, including one or more research questions posed by the analyst.

This very first step is aimed at preventing miscommunications between the analyst and the client, by presenting a clear and structured picture of the initial problem formulation. This step is not so much about the verification of a problem (is this problem formulation correct?), but about the exact formulation of words, which reflects the problem perception of the problem owner/commissioner. Even though it may not be possible to pay attention to all these points, the requirements for good problem formulation from the previous section can serve as some form of guideline. This initial problem (re-)formulation by the analyst gives the client something to think about because the initial problem formulation by the client is often one-sided, unclear, incomplete, consisting of contradictory elements and/or conflicting goals and is often aimed at implementing a preferred solution.

9 Aspects = a cluster of coherent factors.

10 Also depicted in a causal map and a system diagram. Note that when a factor does *not* appear in these diagrams, this indicates that this factor is considered to be *not* important. The term 'demarcation' denotes this 'drawing the line' between what is important and what is not (see Chapter 3).

11 Also depicted in a means-ends diagram (see Chapter 3).

The second step consists of an initial, critical analysis and subsequent reformulation and delineation of the problem, using techniques such as objectives trees, causal mapping and means-ends analysis. This critical analysis and problem reformulation stays within the boundaries of the interests and perspective of the client. It is discussed in the next chapter on systems analysis.

However, problems and their owners do not operate in a vacuum. For example, the traffic problem of the container shipper is inextricably connected to the plans of a railway company regarding a new railway to inland areas, the different public authorities whose area the proposed railway will cross, the residential areas that are going to be traversed, the landscape and its inhabitants and so on. All these contextual factors and actors influence in turn the problem situation. The third step therefore is an actor and network analysis, which is aimed at systematically mapping out these relevant contextual factors (particularly the varied perceptions and intentions that exist) and analysing the institutional context and the interdependencies between the problem owner and the other actors. More detailed information about the actor and network analysis can be found in Chapter 4.

Problems, problem situations and actor configurations are not stable but may change over time and most often contextual factors change too. Therefore, the fourth step takes a systematic look at important plausible future developments in the problem context. For more information about dealing with uncertainties in the future, we refer you to Chapter 5.

In the next step, a balance is drawn: to what extent must and can the problem be reformulated, by choosing different objectives, a different demarcation or by considering a larger number of interested actors/stakeholders as joint problem owners? The consequences for the continuation must be formulated: Is the problem worth tackling? Does action need to be taken towards other actors? Is a more detailed analysis necessary, and if so, a more detailed analysis of what, and in which way? Chapter 6 deals with the characterization of the problem and thinking up of follow-on activities.

An overview of the different steps and the most important techniques that can be used in performing a problem analysis are shown in Table 2.4. Note, however, that the heading 'sequence of steps' falsely suggests a logical sequence of these activities. In practice, these activities form part of an iterative process and the steps mentioned do not always have to be followed in the order suggested. Situations may arise in which one or more steps are disregarded. It is important to realize that the sequence is a guideline and nothing more. Specific problems ask for a specific approach.

Table 2.4 Sequence of steps

Step	Techniques, Chapters
Initial problem formulation: put into words the problem formulation of the problem owner	Interviews, literature See: Chapters 1 and 2
System exploration and delineation: Choice of problem definition level and objectives Specify criteria Identify and structure relevant factors Identify possibilities of influence and constraints Synthesis and consistency check	 Means-ends diagram Objectives tree Causal map System diagram See: Chapter 3
Actors and network analysis Institutional and stakeholder analysis	Stakeholder grid, formal chart, etc. See: Chapter 4
Study of the future	Trend-extrapolations and contextual scenarios See: Chapter 5
Synthesis, consistency check and reformulation of the problem	Among others system diagram See: Chapter 6
Draw up a plan of action and a research plan	Various See: Chapters 7 and 8

2.6 Takeaways

- Problem-solving is not a rational activity.
- Problem-solving and (political) decision-making processes at the level of complex systems, networks and chains are not chronological, but rather extremely unstructured.
- Complexity is anchored more often in the multi-actor situation with competing values, political ideas and interests than in the technology.
- Policy analysis may add sense and content to the problem-solving process.
- The political process may not be in need for scientific analysis, rather looking for information or supportive evidence.
- A well-formulated problem is the right starting point for problem analysis.

References

Checkland, P. B. (1985). Formulating Problems for Systems Analysis. In H. J. Miser & E. S. Quade (Eds.), *Handbook of Systems Analysis. Overview of Uses, Procedures, Applications, and Practice*. Elsevier Science Ltd., ISBN: 9780444009180. pp.9-48

Cobb, R. W. & Elder, C. D. (1983). *Participation in American Politics. The Dynamics of Agenda-Building*. Baltimore: John Hopkins University Press.

Cohen, M. D., March, J. G. & Olsen, J. P. (1972). *A Garbage Can Model of Organizational Choice. Administrative Science Quarterly*, 17(1), 1-25. https://doi.org/10.2307/2392088.

de Bruijn, H. (2019) *The Art of Political Framing How Politicians Convince Us That They Are Right*. Amsterdam University Press, Amsterdam.

de Bruijn, H., Heuvelhof, E. ten & Veld, R. in ’t (2002). *Process Management. Why Project Management Fails in Complex Decision Making Processes*. Boston: Kluwer Academic Publishers.

de Bruijn, H. & Porter, A. L. (2004). *The Education of a Technology Policy Analyst – to Process Management. Technology Analysis & Strategic Management*, 16(2), 261-274. https://doi.org/10.1080/09537320410001682919.
Douglas, M. & Wildavsky, A. (1982). *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers*. Berkeley: University of California Press.
Dunn, W. N. (1981). *Public Policy Analysis: An Introduction*. New York: Prentice-Hall.
Durning, D. (1993). *Participatory Policy Analysis in a Social Service Agency: A Case Study*. In: Journal of Policy Analysis and Management v12 n2 (19930401): 297-322
Enserink, B. (2005). *Public Participation in Dutch Watermanagement: Pragmatism in Meeting EU Requirements*. In P. H. Feindt & J. Newig (Eds.), *Partizipation, Öffentlichkeitsbeteiligung, Nachhaltigkeit. Perspektiven der politischen Ökonomie* (pp. 203-227) (Ökologie und Wirtschaftsforschung, Band 62). Marburg: Metropolis Verlag.
Enserink, B. & Koppenjan, J. (2007). *Public Participation in China: Sustainable Urbanization and Governance. Management of Environmental Quality: An International Journal*, 18(4), 459-474. https://doi.org/10.1108/14777830710753848.
Enserink, B., Hermans, L., Kwakkel, J., Thissen, W., Koppenjan, J. & Bots, P. (2010). *Policy Analysis of Multi-Actor Systems*. Den Haag: Boom/Lemma.
Greenwood, R., Raynard, M., Kodeih, F., Micelotta E. R. & Lounsbury, R. (2011). *Institutional Complexity and Organizational Responses. The Academy of Management Annals*, 5(1), 317-371. http://doi.org/10.1080/19416520.2011.590299.
Hendriks, F. & Toonen, T. A. J. (Eds.) (2001). *Polder Politics: The Re-Invention of Consensus Democracy in the Netherlands* (reissued 2018 by Routledge, London).
Hogwood, B. W. & Gunn, L. A. (1984). *Policy Analysis for the Real World*. Oxford: Oxford University Press.
Hoogerwerf, A. (1987). *De levensloop van problemen: definiëring, precisering en oplossing. Beleidswetenschap*, 1, 159-181.
Hoogerwerf, A. (1992). *Het ontwerpen van beleid. Een handleiding voor de praktijk en resultaten van onderzoek*. Alphen a/d Rijn: Samsom HD Tjeenk Willink.
Hoogerwerf, A. (red.) (1998). *Het ontwerpen van beleid. Een handleiding voor de praktijk en resultaten van onderzoek*. Alphen a/d Rijn: Samsom H.D. Tjeenk Willink.
Keeney, R. L. & Raiffa, H. (1977). *Conflicting Objectives in Decisions*. Chichester: John Wiley & Sons.
Kingdon, J. W. (1984/1995). *Agendas, Alternative and Public Policy*. Boston: Little, Brown and Company.
Klijn, E. & Koppenjan, J. (2014) *Complexity in Governance Network Theory. Complexity, Governance & Networks*, 1(1). https://doi.org/10.7564/14-CGN8.
Klijn, E. H. & Koppenjan, J. (2016). The Shift toward Network Governance: Drivers, Characteristics and Manifestations. In Klijn, E.H., & Koppenjan, J. (2016) *Theory and Practice of Public Sector Reform* (pp. 158-177). Routledge, London.
Koppenjan, J. F. M. (1990). *Definiëring van complexe problemen door de overheid: balanceren tussen ruim en precies*. Beleidswetenschap, 4(1), 21-45.
Koppenjan, J. & Klijn, E. (2004). *Managing Uncertainties in Networks*. New York and London: Routledge.
Mayer, I., 1997. Debating Technologies: A Methodological Contribution to the Design and Evaluation of Participatory Policy Analysis (PhD thesis)Mayer, I. S., van Daalen, C. E. & Bots, P. W. G. (2004). Perspectives on Policy Analysis: A Framework

for Understanding and Design. *International Journal of Technology, Policy and Management, 4*(2), 169-191. https://doi.org/10.1504/IJTPM.2004.004819.
Monnikhof, R. (2006) *Policy Analysis for Participatory Policy Making* (PhD thesis TU Delft).
Olson, R. (2019). *Narrative Is Everything. The ABT Framework and Narrative Evolution*. Independently Published ISBN: 9781072232575.
Pauly, S. (2001). *Ambiguïteit in het spel. De casus PolyVinylChloride* (PhD thesis). Delft: Eburon.
Qiu, Y., Chen, H., Sheng, Z. & Cheng, S. (2019) Governance of Institutional Complexity in Megaproject Organizations. *International Journal of Project Management, 37*, 425-433. https://doi.org/10.1016/j.ijproman.2019.02.001.
Rein, M., Schön, D. (1996) Frame-critical policy analysis and frame-reflective policy practice. *Knowledge and Policy* 9, 85–104. https://doi-org.tudelft.idm.oclc.org/10.1007/BF02832235
Rittel, H. W. J. & Webber, M. M. (1973). *Dilemmas in a General Theory of Planning. Policy Sciences*, 4, 155-169. https://doi.org/10.1007/BF01405730.
Sabatier, P. A. (1988). *An Advocacy Coalition Framework of Policy Change and the Role of Policy-oriented Learning Therein*. Policy Sciences, 21(2-3), 129-168. https://doi.org/10.1007/BF00136406.
Sabatier, P. A. & Jenkins-Smith, H. (1988). *Policy Change and Policy-Oriented Learning: Exploring an Advocacy Coalition Framework*. Dordrecht: Kluwer.
Sabatier, P. A. & Weible, C. M. (2007). *The Advocacy Coalition Framework: Innovations and Clarifications. Theories of the Policy Process* (pp. 189-220). Boulder: Westview Press.
Schattschneider, E. E. (1960). *The Semisovereign People: A Realist's View of Democracy in America*. New York: Holt, Reinhart and Winston.
Simon, H. A. (1973). The Structure of Ill-structured Problems. *Artificial Intelligence, 4*, 181-201.
Simon, H. A. (1977). *The New Science of Management Decision*. Upper Saddle River: Prentice Hall PTR.
Simon, H. A. (1991). *Bounded Rationality and Organizational Learning. Organization Science*, 2(1) (Special Issue: Organizational Learning: Papers in Honor of (and by) James G. March), 125-134. https://doi.org/10.1287/orsc.2.1.125.
Teisman, G. R. (1992/1995). *Complexe besluitvorming. Een pluricentrisch perspectief op besluitvorming over ruimtelijke beslissingen*. Den Haag: VUGA.
Teisman, G. (2000) *Models For Research into Decision-MakingProcesses: On Phases, Streams and Decision-Making Rounds*. Public Administration 78(4), 937 – 956. https://doi.org/10.1111/1467-9299.00238
Thissen, W. A. H. (2000). *Issue-Formulation in a Multi-Actor Context: A Five Step Approach*. Proceedings of the IEEE Conference on Systems, Man and Cybernetics (pp. 301-306).
Thissen, W. (Ed.) & Walker, W. (2013). *Public Policy Analysis: New Developments*. (International Series in Operations Research & Management Science). Springer New York Heidelberg Dordrecht London.
van Bueren, E. M., Klijn, E. & Koppenjan, J. F. M. (2003). *Dealing with Wicked Problems in Networks: Analyzing an Environmental Debate from a Network Perspective*. Journal of Public Administration Research and Theory, 13(2), 193-212. https://doi.org/10.1093/jpart/mug017.

van de Graaf, H. & Hoppe, R. (1989). *Beleid en politiek. Een inleiding tot de beleidswetenschap en de beleidskunde*. Muiderberg: Coutinho.

van de Poel, I. & Royakkers, L. (2011). *Ethics, Technology, and Engineering*. Chichester: Wiley-Blackwell.

van der Lei, T. E., Enserink, B., Thissen, W. A. H. & Bekebrede, G. (2011). How to Use a Systems Diagram to Analyse and Structure Complex Problems for Policy Issue Papers. *Journal of the Operational Research Society, 62*(7), 1391-1402. https://doi.org/10.1057/jors.2010.28.

Wildavsky, A. (1979). *The Art and Craft of Policy Analysis*. Hampshire and London: MacMillan Press.

WRR (Netherlands Policy Research Council) (1994). *Besluiten over grote projecten* (Report No. 46). The Hague: SDUB.

Problems

3 Systems Analysis

> *"Systems analysis is to a large extent a craft activity in which skilled persons draw upon the knowledge and tools of many different sciences and technologies to create a product responsive to the needs of the eventual users"*
> (Miser and Quade, 1985: 29)

Systems

In this book, we provide analytical tools and methods to structure multi-actor problem situations that are ill-structured, messy and wicked. Various perspectives and disciplines have put forward analytical tools and methods, but a logical place to start is systems analysis. Systems analysis is the approach that evolved in the 1950s and 1960s from the field of operations research. Systems analysis applied scientific, and often mathematical, approaches to investigate and solve problems in large systems. For many policy analysts the analysis methods and approaches that were developed for systems analysis form an important part of their toolbox. This chapter provides an introduction to analytic thinking and to some of the methods that are most useful to support problem formulation and problem exploration in the early stages of policy analysis: means-ends analysis, objectives trees, causal diagrams and system diagrams. However, we will start with a brief introduction to the field of systems analysis and its use by policy analysts.

3.1 Introduction to Systems Analysis

Systems analysis applies scientific methods to analyse large and complex systems. When applied as part of policy analysis processes, the system under study is typically a certain policy domain, seen from the perspective of a policy-maker, client or, more basically, someone who thinks there is a problem (Findeisen & Quade, 1985). Systems analysis seeks to map and analyse this system, and structure the problem, through a way of working that is open and explicit, empirically based, consistent with existing knowledge and for which the results are verifiable and reproducible (Walker, 2000: 12). In addition to applying scientific methods, systems analysis is scientific in that it seeks to develop and test 'theories': causal assumptions of how the world works. Systems and policy analysts "speak of their theories as models, but the terms are really synonymous" (Miser & Quade, 1985: 19). Another key feature of systems analysis is the recognition that the complexity of the systems that are studied is such that complete certainty is impossible, and that systems analysis is essentially an art and a craft, drawing on tacit and informal methods, in addition to formal and explicit approaches (Miser & Quade, 1985).

The systems analysis approach that we describe in this chapter grew out of the operations research field and historically is connected to the work of institutes such as the RAND Corporation, a US-based think tank, and the International Institute for Applied Systems Analysis (IIASA). This means that we will not be discussing the full range of systems theories such as cybernetics, general systems theory, system dynamics and complex adaptive systems, but will focus on applied systems analysis. An overview of system theories and approaches, including systems analysis, can be found in Jackson (1992), Daalen & Bots (2010) and Slinger et al. (2020).

The primary advantage of using a systems analysis approach is that it helps to put some structure to complex and ill-defined policy fields. It helps analysts to make their own assumptions and expectations explicit, providing a basis for communication with clients, as well as with fellow analysts. Furthermore, the field of systems analysis is rich in useful guidelines, tools and techniques, enabling an analyst to develop detailed and comprehensive models of a policy domain. This in turn can help them in advising their clients about possible courses of action in a particular problem situation. Even if systems analysis cannot provide complete and detailed prescriptions in a particular situation, it can almost always eliminate the really bad alternatives (Miser & Quade, 1985). In this chapter, we focus on the early stages of systems analysis in which a system diagram of the problem situation is developed as part of problem structuring.

A known limitation of systems analysis is that it is necessarily incomplete, not only because of practical limitations in terms of time, money or human resources but also because it simply cannot synthesize all potentially relevant considerations (Miser & Quade, 1985). This means that during problem structuring an analyst must make choices about what to consider, what to include as part of the analysis and what aspects are left outside the scope of analysis. As a result, uncertainties remain. The uncertainties increase even more when we take into account that many policy decisions apply for long periods of time. No-one can know how the system will evolve, what it will look like in two, five or ten years from now. To address this limitation, Chapter 5 discusses some methods for exploring the future. Also, systems analysis generally starts from the perspective of a specific problem owner. Multi-actor considerations are usually accommodated by applying standard methods and then iterating, but standard systems analysis was not specifically developed to function in multi-actor policy systems. If the multi-actor complexities are many and pervasive, additional approaches and reflexive iteration will be needed to incorporate them in a policy analysis. Some of the additional approaches are discussed in Chapter 4, while the reflexive iteration is discussed in Chapter 6.

3.2 Conceptual Framework for Systems Analysis

Meaningful discussion of systems analysis tools and methods requires a basic description of what we mean when we speak of a system. If our aim is to analyse a certain ‘system’, then what is this object of analysis, what are the main concepts involved and how are these structured and related?

3.2.1 The System Diagram and Its Components

A **system** is defined as a part of the reality that is being studied as a result of the existence, or suspicion, of a problem. An analyst makes a **system model** that clarifies the system by (1) defining its boundaries and (2) defining its structure – the main elements and the relationships among them (Walker, 2000: 13). The question of which part of reality, which system, is relevant for further analysis is directly related to the problem perspective that is adopted.

We have seen that a problem implies a perceived gap between an existing or expected situation and a desired situation, and the person who perceives the gap wants to know what can be done about it (see Chapter 1; Checkland, 1985). This means that a system model is actor-specific: it describes the system from the viewpoint of a specific actor. It also implies that a system is relevant only because it influences the realization of a certain desired situation. The desired situation is generally described in terms of **objectives**. The realization of objectives is measured through the use of **criteria** that are linked to the main outcomes of interest of a system (Walker, 2000: 13).

Another part of our definition of a policy problem concerns the possible means to 'do something about it'. A problem owner should have some **means** (e.g. policy instruments) through which she/he can influence the system, improving the degree to which objectives are being realized. Since we are dealing with complex problems, the means generally do not influence the outcomes of interest directly. Instead, the outcomes are influenced indirectly through elements inside the system, which are called **internal factors**. By a **factor** we mean a system property that is taken into account. The influences of the means on the internal factors and ultimately on the criteria are causal influences. In systems analysis, the focus of attention often lies on the internal factors and their interrelationships as these determine how influences propagate through the system.

Finally, there are likely to be some important influences on the system from the external environment, factors from outside the system over which the decision-maker or problem owner has no control (Checkland, 1985; Walker, 2000). These **external factors** are elements that cannot be influenced by the problem owner or by the factors inside the system, but that can have an important influence on the behaviour of the system.

Depicting these elements leads to a system diagram, as shown in Figure 3.1. It consists of the system demarcation, the boundary, with three groups of factors at the boundary: the means of the problem owner, the external factors and the criteria. The direction of the arrows shows that the means and the external factors influence the system, and that these influences propagate through the internal factors of the system, eventually influencing the criteria.

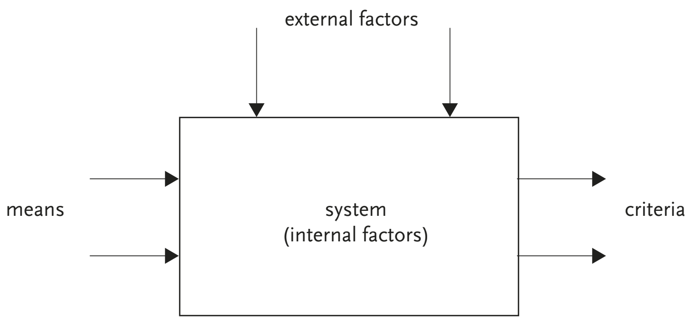


Figure 3.1 General elements of a system diagram

When the system diagram is filled in for a particular problem situation it provides a structured overview of the problem situation. It supports the problem owner in gaining insight into the problem situation and analysing whether his/her objectives can be attained. For instance, the system diagram can be used to explore whether a particular means that leads to desired changes in one criterion also has positive effects on other criteria or not. The sensitivity of the criteria to changes in external factors can also be analysed. Key internal factors can be determined and (additional) means to influence these can be identified. Such a filled-in system diagram is a conceptual model of a problem situation. A conceptual model is a representation of a system that shows relevant concepts and relationships between the concepts. The uses of a system diagram are discussed further in Section 3.5.

3.2.2 Interests, Objectives, Criteria and Means

The terms 'interest', 'objective', 'means' and 'criterion' all have to do with the point of view of one or several actors. Because a lot of confusion exists about the exact meaning of these different terms, we provide working definitions here.

By **interests** we mean the values and desires that an actor finds important, *regardless of the specific situation.* Interests are usually formulated in an abstract way and they are relatively stable over time. They are often referred to as categories: social interests include issues such as equity and social justice, environmental interests include biodiversity and ecosystem health, economic interests include economic growth and competitiveness and so on. There are different organizations and groups in most countries that protect these kinds of interests. Think of human rights organizations, environmental protection organizations, branch organizations of employers and employees, women's organizations, car owner groups and so on. On an individual level interests such as good health, a good income and so on can be categorized as interests. These interests are sometimes called '*fundamental* objectives' (Keeney, 1992).

Objectives differ from interests in that they are specific to a situation. *Objectives belong to a particular problem or project.* Objectives are interests made concrete, which translate to current policy issues. An actor will strive to achieve a situation-specific objective in order to ultimately realize his/her interests. The general interest 'a healthy environment' of an environmental protection organization could translate into the objective 'low nitrate concentration in groundwater' when the organization discusses the problem of polluted groundwater due to over-fertilization. When discussing the planned extension of a highway in a green belt area, the same interest 'a healthy environment' can translate into the objectives 'large area of open meadow landscape' and 'low noise nuisance'. In both cases, the preservation of the environment is the underlying interest, but the objectives differ. In common language use, objectives can be formulated freely, for example, in terms of verbs, nouns or constraints. In systems analysis we formulate objectives using nouns preceded by relative adjectives, such as high or low, large or small, to indicate the direction of the desired situation. Formulating objectives as nouns with relative adjective allows us to use the objectives to determine the relevant criteria.

Criteria are objectives operationalized in terms of *factors* for which a value can be established on a scale, via direct or indirect measurement. Objectives can be fairly abstract, for instance high traffic safety. Operationalization of traffic safety produces criteria such as 'number of casualties per year' and 'number of accidents per year' (measured by counting), 'probability of being involved in an accident' (measured as the ratio of accidents in a year over the total distance travelled by all travellers in that year), 'material damages as a consequence of accidents per year' (measured in Euros per year) and so on. As they can be measured, criteria can be used to determine whether the desired situation has been attained.

By **means**[1] we mean any actions that can be used in order to achieve an objective. This implies that means and objectives are related to each other. Like objectives, in common language use means can be described in global terms, such as 'money' or 'legislation', but they can also be specified more precisely, e.g. 'subsidize biological products' or 'forbid the use of pesticide X'.

Figure 3.2 Meaning depends on perspective

The distinction between objectives and means is not absolute. This ambiguity is similar to that of Figure 3.2: whether the image depicts a bird or a rabbit depends on the perspective one takes. Likewise, what may be a means to one actor can be an objective to another. From a government perspective, subsidizing biological products and forbidding the use of pesticides are possible means to achieve the objective of an ecologically friendly agricultural sector, while from the perspective of an environmental protection organization, low use of pesticide X and high subsidy on bio-products are objectives, since an environmental protection organization cannot itself reduce the use of pesticides. A single actor may also experience this ambiguity: an automobile manufacturer may see the high safety of a car as an objective (and see installing airbags as a means to achieve this), but also as a means for high car sales (combined with other means, such as a publicity campaign that highlights the safety features of the car).

Interests, objectives, means and criteria play an essential part in problem structuring. Knowledge of the interests, objectives and means of actors is necessary in order to reach a meaningful problem description. The example in Text box 3.1 illustrates this.

Text box 3.1 Interests, objectives and means: Bicycle helmets example

The requirement for cyclists to wear helmets: an exploration of a policy problem
In various countries the use of helmets has become mandatory for cyclists. In the Netherlands this is currently not the case. Cyclists are a relatively vulnerable group of road users and it may be possible to improve safety by requiring them to wear helmets. Suppose that, with forthcoming elections in mind, a popular politician has called for it to become compulsory for cyclists to wear crash helmets, and for this measure to take immediate effect.

1 The singular of 'means' is also 'means'; one may look for *a* means as well as for different means to attain a goal.

Systems

What is the problem here? The answer will depend on who is giving it. What possible different perspectives on this problem exist, and which will be useful to elaborate further?
Is the problem an excessively high accident rate among cyclists? Or is it more specifically the number of fatal and serious accidents? A number of factors may contribute to the problem: increased traffic, insufficient attention to road safety in primary education, unsafe road infrastructure, slow and fast (electric) bicycles in the same lanes, youthful overconfidence, use of mobile phones while cycling, an over-representation of vulnerable older cyclists who are somewhat slower to react or other road users who are not careful or not paying attention.
What then is the problem that the analyst is expected to address? He/she must first find out whether the problem actually exists, define it in detail and then investigate whether any policy measures can be found to contribute to a solution of the problem, over which the client has some form of authority. Assuming that the problem does indeed exist, the analyst will wish to establish its true extent and scope. For example, how many accident victims are there per travelled kilometre, and in which age categories are they to be found? How severe are the injuries? How do these statistics relate to those of other groups of road users, using other modes of transport? Such figures will indicate the extent and the boundaries of the problem. For example, is it only the groups of cyclists over the age of 60 who have a higher-than-average accident rate, or only the group aged under 18? Further information on this point and about, say, the development of the issue over time can perhaps be gained by consulting the results of similar or comparable studies.
Another part of the problem structuring will consist of establishing the position and influence of the various individuals and groups concerned. Who is addressing this problem? Why? What are their interests? What influence do they have on policy? In this example, interested parties may include: the politician who raised the issue to win votes, the National Road Safety Organization, police officers with a strong involvement in road safety, medical specialists who wish to prevent serious injuries, insurance companies who wish to reduce treatment expenditure, insured people who wish to pay lower insurance premiums, cyclists who wish to maintain the freedom to ride without a helmet, the manufacturers and retailers of bicycles (who may see their market share decline were helmets to be made compulsory), road infrastructure companies who see a potential demand for reconstruction and perhaps many others, such as school principals, the cyclists' federation, helmet manufacturers, mobile phone companies etc.

The example in Text box 3.1 shows that it is difficult to get a grip on a complex problem situation. Investigating interests, objectives and means in a structured way can contribute to understanding the complex problem. Next, we describe such a structured systems analysis method to investigate a problem situation that results in a system diagram.

3.3 A Method to Develop a System Diagram

There are various ways to develop an adequate system diagram, which includes identifying suitable system boundaries as well as the main factors and the important relations among them. Here, we will use the following steps, each of which is supported by a specific technique:

1. set the initial problem demarcation and level of analysis;
2. specify objectives and criteria;

3. identify potential means, and map the main causal relations with and between internal factors, and their influence on the criteria;
4. provide an overview of the problem situation using a system diagram.

Taken together, these steps help to develop a first system diagram and to perform a first, qualitative systems analysis, supporting a sound problem description. A system diagram is a conceptual model of a problem situation. A model is a simplification of reality, and problem structuring necessarily implies making choices. As an analyst it is important to substantiate these choices and to iterate through these steps, to arrive at a sound problem description.

3.3.1 Problem Demarcation: Means-Ends Analysis

In many cases, problems can be analysed at different levels. Choosing a useful level from which to start the analysis is not always easy. However, the level at which a problem is analysed largely determines the problem demarcation, the spectrum of aspects/factors and possible solutions that are taken into account. Hence it is worthwhile to spend time at the beginning of an analysis looking at the different levels at which problems can be identified.

The first thing to find out is *why* a problem is important for a client. Means-ends analysis therefore starts out by formulating the client's dissatisfaction with the actual situation as a verb sentence that expresses the desired situation. This verb sentence will typically be at the core of the client's problem, for example, 'to have enough water even in dry summers' for a farmer who sees his crops wither after weeks without rain. We call this verb sentence an 'end'. In common language 'objectives' and 'ends' may be used interchangeably to describe a desired situation. However, we distinguish a desired situation formulated as a verb sentence (end) from a desired situation formulated as a noun qualified by a relative adjective (objective). We make this distinction because they are used differently in two different analytic techniques. An 'end' (to have enough water even in dry summers) can be reformulated into an 'objective' (large amount of water in summer) and vice versa. A means-ends analysis uses the verb formulation because it makes use of the change of perspective illustrated in Figure 3.2. A means for one actor may be an objective for another, therefore in a means-ends analysis all elements are formulated in an active sense as verbs.

The question to pose next is *why* this end is worth striving for? Does the end contribute to the realization of a higher end? Asking this question several times, until a meaningful answer cannot be given anymore, will result in a means-ends network[2] (Gregory & Keeney, 1994; Keeney, 1992). This 'why' exercise will reveal that there are fundamental ends, and means-ends. The latter can be seen as ends, but they are also means to realize other, more fundamental, ends. In the drought example, the farmer also wants to 'have a good crop'. If, when asked why this is worth striving for, he answers 'Because I am a farmer!' this would indicate that 'have a good crop' is a fundamental end. If he answers 'To make a living!' this would suggest that switching from farming to another livelihood is conceivable.

Having identified the client's fundamental end, a means-ends analysis continues in the opposite direction. For each end identified so far, the analyst now asks *how* (using which means) this end can be achieved. This may identify additional conditions for the client to

2 Keeney calls this a means-end objective network. In order to avoid confusion with the objectives tree technique which is explained in Section 3.3.2, we do not include the term 'objective' here.

be satisfied (e.g. have sufficient arable land, and fertile soil), and at the same time additional means for attaining an end (e.g. switch to drought-resistant crops and store water during the wet season). Posing the *how* question is important because if nothing can be done to realize a certain end, that end does not provide a very promising starting point for a problem analysis as the problem owner apparently has no means to improve the situation.

By first asking 'why' and then asking 'how', a means-ends analysis can, in principle, cover the whole spectrum from concrete to abstract, from very specific actions up to the fundamental end. The result permits a deliberate choice for a particular problem level. In the drought example, the problem demarcation might range from very broad ('ensure that the client has sufficient income') to very narrow ('create an efficient water storage facility'). The example in Text box 3.2 provides a complete illustration of this process and of how the resulting diagram helps in choosing the level of problem structuring.

Text box 3.2 City metro – Example of means-ends analysis

Suppose that the mayor of a city asks you to help her make more people use the metro. As an analyst, you will first ask the *why* questions, and then the *how* questions.

Q: Why do you want to stimulate the use of the metro?
A: To reduce congestion in the city centre!
Q: Why do you want to reduce congestion in the city centre?
A: To make the city more attractive!
Q: Why do you want to make the city more attractive?
A: Are you daft? Because I am the mayor of the city!

Here you have reached a fundamental end, as it is essential for your client. So now you start asking how questions:

Q: How can you make the city more attractive? Only by reducing congestion?
A: No, there are other ways. We are also considering renovating some of the older city districts, and upgrading parks and other public spaces, but congestion hinders both business and tourism, and therefore should have priority.
Q: Supposing that this is true (but you might want to have this checked!), is the metro line the only means for reducing congestion? Some cities have effectively implemented congestion levies, or have reduced congestion by regulating freight delivery, barring trucks during rush hours.
A: No, but it might be worth investigating. We are considering creating additional park and ride facilities in the city's peripheral zone.

You can summarize this dialogue in the means-ends diagram of Figure 3.3. It shows that the problem of getting more people to use the metro is embedded in another problem (the congested city centre), which in turn is part of a larger problem (the city being unattractive for business and tourists). It might be that some of the other means are more effective than stimulating the use of the metro system. In general, it is sensible to choose an objective on a more fundamental level because then the analysis will include a broader spectrum of important objectives, and hence a broader spectrum of means will be taken into account.

Please note that the means-ends diagram is split into an upper and lower part here only for ease of reading. This is not standard practice; a means-ends diagram should consist of one diagram. The rectangles represent means-ends, and arrows denote causal relations in Figures 3.3 and 3.4.

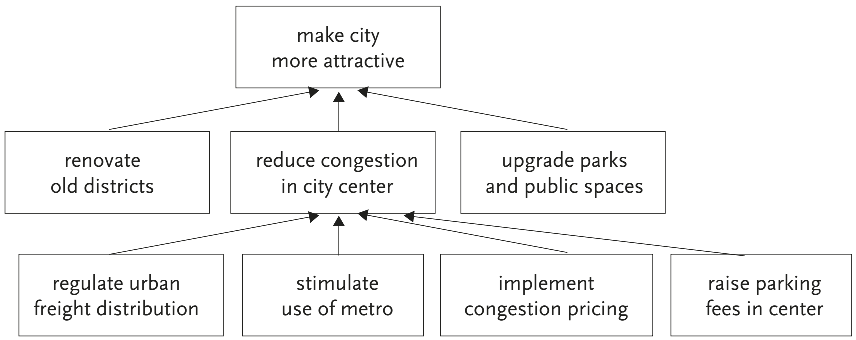


Figure 3.3 Upper part of the means-ends diagram

For a complete means-ends analysis, you would now ask the *how* question for the other two second-level means-ends, and for each of the four third-level means-ends. But assuming that your client (the mayor of the city) prefers to focus on the objective 'stimulate use of metro', repeatedly asking the question '*How* can you realize that goal?' could lead to the part of the means-ends diagram in Figure 3.4.

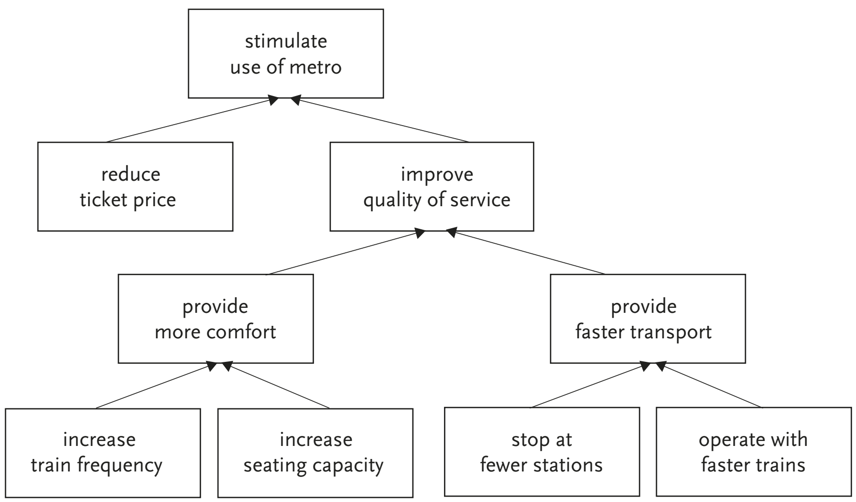


Figure 3.4 Lower part of the means-ends diagram

Systems

Rules for Constructing a Means-Ends Diagram

All diagramming techniques require that the analyst obeys certain notational rules. Only when this convention is followed will the diagram be meaningful to other analysts and permit logical interpretation. For means-ends diagrams, the following rules apply:

1. Rectangles denote means-ends. The text in a rectangle should be a verb phrase ('stimulate ...', 'improve ...', 'reduce ...') because this preserves the ambiguity of a means-ends: a verb phrase can be read as a means ('*we can* improve the quality of service') and also as an end ('*we want to* improve the quality of service').
2. Arrows denote causal relations: it should be possible to read each arrow X → Y as in 'if we do X, this will help to Y', or (if the causal relation is less certain) 'if we do X, this will probably Y' or 'if we do X, this may Y'.
3. Arrows should point upwards. This rule guarantees that the most fundamental ends are at the top of the diagram.
4. More than one arrow may proceed from the same rectangle. This rule is useful because it may be that one means can contribute to the realization of several ends.
5. Each rectangle should have either none or more than one ingoing arrow. This rule prohibits that the diagram suggests that an end Y can be realized by only one means X. If that were the case, Y could be replaced by X, as the client has no choice. This rule forces the analyst to keep the diagram as simple as possible.
6. The diagram should not contain redundant arrows. An arrow X → Z is redundant if the diagram also contains some indirect path X → Y → ... → Z. Combined with rule 3, this rule forces the analyst to place elements at the correct level, and to keep the diagram as simple as possible.

Interpreting Means-Ends Diagrams

A means-ends diagram can help to choose the appropriate level for analysis by selecting one particular end in the means-ends hierarchy and reformulating this as the *focal objective*. For example, the means-end verb phrase 'reduce congestion in the city centre' can be reformulated as the focal objective 'low congestion in the city centre' since objectives are expressed as nouns with a relative adjective. In general, a focal objective should be fundamental enough to enable the problem owner to undertake different actions to solve a problem without introducing considerations that are clearly irrelevant and that will add unnecessary complexity to the analysis. Note that this implies that you cannot choose one of the lowest means-ends for the focal objective. If you do want to focus on one of these, then you should identify additional means. This is usually possible. For instance, looking more closely at even the most straightforward means (e.g. 'reduce ticket price' in Figure 3.4) for an objective will still reveal a diversity of means for achieving it (lower fares only outside rush hour, provide city passes for tourists, provide free transport for students, etc.).

One way to test whether a particular end Z is suitable for a focal objective is to ask the problem owner the following questions:

– 'Do you agree that it is desirable to Z? And that when you succeed in achieving Z, your main problem is solved?'
– 'Do you agree that Z can be achieved by doing M_1, M_2, ... (the means immediately below Z)? And that you indeed have the means to do this?'
– Do you agree that at this moment you lack the knowledge to decide whether you should either M_1 or M_2 or ... , or a combination of these means?

These questions test whether the conditions for a policy problem mentioned in Section 1.2.3 are met: (1) is there a gap between an existing or expected situation and the desired situation (the objective Z)? and (2) is there a dilemma, that is, a difficult choice between possibilities that can (partly) close the gap, but also have undesirable outcomes? If the problem owner disagrees on some of the questions, you shift the focus to finding another objective in the means-ends diagram.

It is important to realize that even an elaborate means-ends diagram is only a 'quick scan' of the client's problem. Even when you agree on what should be the focal objective, it is wise to also make problem statements based on the goals on the immediately adjacent levels because this will bring out the dilemmas involved. The arrows in a means-ends diagram represent only the desirable causal relations; potential side effects of means are ignored. A problem statement of the form 'How can the client achieve [end Z related to focal objective] without [undesirable side effects of the means immediately below Z]?' makes the dilemma explicit. Taking the end 'stimulate use of metro' in Text box 3.2 for the focal objective, a problem statement results in something like:

> 'How can metro use be stimulated *without* incurring operating losses?'

or, if the mayor is concerned with the safety of passengers:

> 'How can metro use be stimulated *without* people getting crushed during rush hour?'

Choosing the end on the next higher level in the means-ends diagram for the focal objective would produce different dilemmas. Considering the side effects of regulating freight traffic, a possible problem statement could be:

> 'How can the traffic congestion in the city centre be reduced without hampering commercial transport?'

The idea of congestion levies may raise concerns regarding the high investments needed to implement large-scale congestion-mitigating measures:

> 'How can the traffic congestion in the city centre be reduced without incurring large financial costs?'

As raising the parking fees in the city centre may lead drivers to look for parking space in the peripheral districts, this means introduces yet another dilemma:

> 'How can the traffic congestion in the city centre be reduced without causing nuisance in other parts of the city?'

Discussing the different problem statements with the client will be helpful in deciding which problem to focus upon.

Other Aspects of Problem Demarcation

The problem demarcation is more than choosing the relevant level of analysis on the basis of the objectives to be considered. Demarcations in space and time are also necessary in determining the system boundary of the problem to be analysed.

Spatial demarcations focus on the physical scope of the problem situation. The geographical area affected by the problem is relevant when it comes to deeper analysis. For example, is it wise to consider only the traffic congestion in the city centre? Here, again, a critical attitude is desirable: has the question of whether the problem is local, regional or national been considered; which spatial scale is most appropriate for the best solutions? Could it be that the causes of the problem lie outside the area where the problem is felt? Then that is where the most interesting solutions can be found, so the geographical area should be widened. And even if only local measures are taken, do these have consequences for a larger area? If so, this would also call for a wider spatial demarcation.

Temporal demarcations focus on the time frame within which one analyses the problem. This demarcation is not always as clear because there is strong interdependence between the different choices in problem structuring. The time frame is not only determined by the question of when the problem arises but also by the characteristics of the solutions that are being investigated. For example, changing the metro fares can be done within months whereas constructing a new metro line is a matter of five years or more.

The problem demarcation results in an initial choice for the level of analysis on the basis of the means-ends analysis and a specification of the spatial and temporal scales relevant to the problem. In effect, the problem demarcation defines the boundary between what is internal to the system and what is external to the system. We specify here that this represents an initial choice that can be iteratively refined as each of the steps in the problem structuring process is executed.

3.3.2 Specify Objectives and Criteria: Objectives Tree

The means-ends analysis will have helped to determine the focal objective for the problem analysis. When this objective is abstract or encompasses multiple aspects, it needs to be defined in more specific terms. For this, a method for analysing objectives is used: the objectives tree.

Objectives trees help analysts to find, in a relatively simple way, an answer to the question: *what exactly* does the problem owner want? It helps the analyst to define a high-level, abstract objective in terms of more specific lower level objectives. The lowest-level objectives in the tree provide the criteria to be used for measuring the degree to which the problem owner's objectives are being met. These criteria can then be used to compare and evaluate different means and combinations of means.

Constructing an objectives tree begins by considering the focal objective selected using the means-ends diagram and then making one or more problem statements that make the client's dilemmas apparent. The next step is to define both the desired change (the focal objective) and the undesirable side effects (the 'without' part of the problem statements) as objectives. Since the aim is to obtain criteria, these objectives should be defined in such a way that they show what *factors* are concerned (see Section 3.2.1). Taking again the example of the problem of the mayor who would like to see more people use the metro (see Text box 3.2), we could decide to define only one objective: 'many passengers', which would then give us a single criterion: the number of passengers, measured in number of passengers per year. However, the problem statements we made revealed that the mayor not only wants to see many passengers on the metro but also wants to keep the operating loss within limits and avoid the metro becoming so crowded that people get crushed during rush hour. The objectives tree in Figure 3.5 reflects that these three objectives together define the mayor's main objective: *good* use of the metro line in her city.

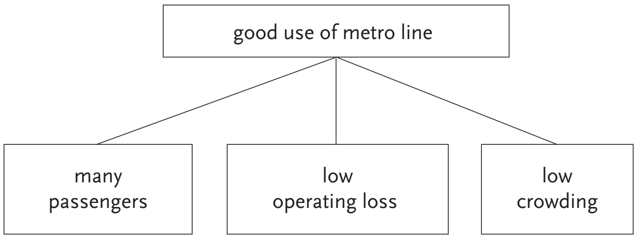


Figure 3.5 An objectives tree with two levels

This rather simple objectives tree illustrates how the abstract qualification 'good' is defined in terms of targets for concrete, measurable factors: the number of passengers (should be high), the operating loss (i.e. the cost of operating the metro minus the revenue from tickets, measured in Euro per year; this amount should be relatively small) and the occurrence of crowding (e.g. the number of times per year that there are more than 3 people per m^2 on a train; this number should be low).

If we apply the same method to the mayor's higher level objective to reduce traffic congestion in the city centre, we might again settle for a single objective: low traffic congestion. This would produce the simplest objectives tree possible: a single rectangle. We would then still need to operationalize the factor 'traffic congestion', for example, by measuring it as the total time (in hours per year) for all main streets that the traffic in these streets moves at less than 15 km/h. By doing so we would have properly defined the single criterion for measuring the extent to which the congestion problem has been solved. But here, too, the different problem statements we made revealed several dilemmas, and these should be articulated in the objectives tree. The upper part of the tree in Figure 3.6 summarizes that the mayor wants to reduce congestion, but without restricting commercial traffic and causing nuisance in other city districts, and with low financial risk. Note that the main objective now does not mention the factor 'congestion'; this is because the four second-level objectives span a much broader range of factors. As the objective 'low nuisance for other city districts' is still rather abstract, it has been elaborated further.

Systems

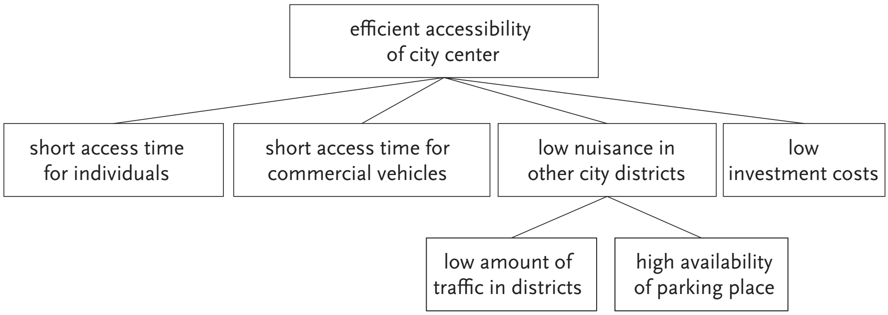


Figure 3.6 An objectives tree with three levels

Constructing an objectives tree is a process of 'finding the right words'. Having expressed the client's dilemmas in one or more problem statements, the analyst defines an initial level of objectives that represents what the client wants to achieve and what the client wants to avoid. The next step is to define a more abstract objective that encompasses all of this, and yet is as specific as possible. This then becomes the 'root objective' for the objectives tree. The analyst then checks whether each objective at the lower level is operational, i.e. that the factor it entails can be measured and expressed on some unit scale. If so, then this factor is a usable criterion, and no further elaboration of the objective is needed. Otherwise the analyst tries to formulate two or more objectives that clarify its meaning. If new objectives have been added in this way, the procedure is repeated.

Rules for Constructing an Objectives Tree

For objectives trees, the following rules apply:

1. Rectangles denote objectives. The text in a rectangle should be a noun phrase that indicates a desired state (e.g. 'high ...' or 'good ...'). To avoid confusion with means (i.e. actions the client can take), verbs should *not* be used.
2. Connecting lines denote definition relations: lower level objectives specify the meaning of the higher level objective to which they are directly connected.
3. Each objective should have either zero or more than one sub-objective. If an objective Y can be defined in terms of a single sub-objective X, then Y should be replaced by X. This rule forces the analyst to keep the diagram as simple as possible.
4. The lowest-level objectives should be operational: the noun phrase in these rectangles should make clear which factor is to change (or not change) as well as the direction of the desirable and undesirable changes, and the factor concerned should be measurable on some scale (preferably ISO standard units).

Objectives Tree ≠ Means-Ends Diagram!

As both diagrams relate to goals, and both consist of rectangles that are arranged in levels and linked by lines or arrows, the objectives tree is easily confused with a means-ends diagram. However, the two serve very different purposes: a means-ends diagram is used to decide which problem to focus on; an objectives tree is then used to define the criteria for evaluating alternative solutions for this problem. Given these different functions, the diagrams must be constructed and interpreted following different principles.

Because means-ends can also be seen as ways to realize some higher level means-end, a means-ends diagram can be read in two directions. When read from top to bottom, a means-ends diagram clarifies for each means-end *how* that means-end can be achieved. Reading a means-ends diagram from bottom to top clarifies *why* it is desirable to realize a means-end. The relation denoted by the arrow X→Y is a *causal* relation: it is a *directed* relation (up!) to reflect that X leads to Y, and not the other way around.

In contrast, an objectives tree should only be read from top to bottom, and then it clarifies the meaning of a still abstract objective by specifying two or more concrete objectives that can be considered as 'component elements'. The relation denoted by the lines is a *definition* relation: a cluster of lines departing from a higher level objective X to two or more lower level objectives Y_1, Y_2, ... reflects that the extent to which objective X is realized can be measured by measuring the extent to which Y_1, Y_2, ... are realized.

Interpreting an Objectives Tree

The main function of an objectives tree is to define the objectives of an actor (the client or some other stakeholder in the policy problem) in such detail that the analyst can infer the set of criteria that need to be considered when evaluating alternative solutions. In essence, the interpretation of an objectives tree consists of compiling this set of criteria. Assuming that the objectives tree has been properly constructed (i.e. following the rules mentioned earlier), all of the 'leaves' of the tree (i.e. the objectives that are not defined in terms of more concrete sub-objectives) each produce one criterion, while the 'internal nodes' of the tree (i.e. all objectives that are not 'leaves') can be ignored. Interpreting an objectives tree thus consists of listing the criteria that should be used in the problem analysis. For each criterion, a suitable unit scale should be specified. These units are usually denoted between brackets. Text box 3.3 shows the criteria lists derived from the objectives trees in Figures 3.5 and 3.6.

Text box 3.3 Different problem demarcation ⇒ different criteria

Criteria derived for the problem of inadequate use of the metro:
– number of metro passengers [passenger/day];
– operating loss [€/year];
– number of crowding incidents [crowding incident[a]/day].

[a] A crowding incident is defined as a situation in which the density of passengers in a metro train exceeds 3 persons per m^2.

Criteria derived for the problem of traffic congestion in the city centre:
– access time for individuals [minute[b]];
– access time for commercial vehicles [minute[b]];
– number of vehicles entering/leaving a district [vehicle/day];
– availability of parking space [% vacant places[c]];
– estimated investment costs [€].

[b] Average time needed to cover the last 2 km to destination in city centre.
[c] Average of vacant places/total parking places, measured at 11 a.m.

Being a factor, a criterion should be denoted by a noun phrase that refers to a specific system property. For typical objectives like 'low nitrate emissions to groundwater', 'high crop yield' and 'high profit', the criteria are easily obtained by omitting the words like 'low' or 'high'. For objectives such as 'many passengers' and 'few drop-outs', the factors are tallies (i.e. they count discrete entities), in which case the word 'many' or 'few' should be replaced by 'number of' to obtain a well-defined criterion. An objective that needs a little more translation effort is 'few power failures'. The criterion would then be 'frequency of power failures' (measured in failures per year), but one could also opt for 'mean time between power failures' (measured in days). Note that for the first criterion, low values are better than high values, whereas for the second criterion, high values are better than low values. The commonly made mistake of operationalizing 'traffic safety' by measuring it in terms of casualties per year highlights that the analyst should take care in choosing an appropriate unit of measurement for a criterion.

While interpreting the objectives tree, the analyst should also pay specific attention to the *independence* of the criteria. When criteria are not independent of each other (e.g. 'NO_x emission' and 'NO_x concentration in the air', or 'average duration of traffic jams' and 'length of traffic jams'), or when a criterion is included in another, broader criterion (e.g. 'concentration of aerosols' and 'concentration of small particulate matter'), this system characteristic will 'count double' when alternative solutions are evaluated using the list of criteria. In that case, a choice will have to be made between accepting the aggregated criterion 'quality of air', or elaborating the quality of air into a number of suitable parallel criteria. Such problems of overlapping criteria, or criteria that are causally related, are less likely to occur when the objectives tree has been properly constructed.

Using Proxies as Criteria

Some criteria are intrinsically difficult to measure. In such cases, it can be useful or even necessary to work with proxies. A proxy is a measurable factor that is believed to give a good indication of the realization of the actual objective.

Text box 3.4 Using proxies as criteria
The use of fertilizers in agriculture constitutes a problem for the environment because the residues of fertilizers seep into surface waters, degrading the environment. In this case, one might suggest as a criterion the quantity of fertilizer that seeps into the surface water yearly. However, this factor will be hard to measure or observe directly, as this would require the installation of monitoring equipment next to every agricultural plot. Alternatively, the quantity of fertilizer that is introduced onto the land could be used. This would be justified under the assumption that the quantity that seeps into the system is proportional to the amount of fertilizer applied.
A similar choice for a proxy as criterion can be made when analysing the problem of environmental damage as a consequence of freight transport by road. In principle, indicators for the eventual environmental consequences of freight transport – for example, respiratory problems for humans – should be used as criteria. Knowing that respiratory problems correlate with the concentration of certain substances in the air (aerosols, nitrogen oxides), the yearly emission of these substances may be chosen as a proxy for environmental damage.

The examples in Text box 3.4 clarify that the use of a proxy as a criterion leads to a narrower demarcation of the system that needs to be analysed, and therefore to a less complicated analysis: the mechanisms in the natural environment do not have to be taken into account. The danger of using proxies is that they may not be representative of the degree to which the objectives are actually achieved. For example, death rate could well serve as a proxy for the status of public health. The death rate gives a fair indication, but there are many more factors at stake in public health. When the death rate is taken as proxy for public health, the analysis will overlook increases in health risks that are not immediately fatal (e.g. obesity). A similar problem occurs when the chosen proxy reflects the degree to which certain means have been put to use, rather than the degree of achievement of the objective. Consider, for example, using the number of doctors or hospitals per 1,000 persons as an indicator for public health. These kinds of faulty substitutions produce misleading results and occur more often than you would think!

The Multi-Actor Situation
We often find ourselves in the situation where we have to take into account *several* actors who may have different interests, and possibly conflicting objectives. This multi-actor aspect is addressed in detail in the next chapter, but we should mention here that its importance has also been recognized by systems analysts. For instance, Ralph Keeney indicates in his book '*Value-Focused Thinking*' (1992), which is almost entirely devoted to the analysis of objectives and means, how a so-called 'overall objectives hierarchy' can be deduced by combining and structuring the criteria from the objectives trees of different actors in a problem context. This kind of joint hierarchy of objectives allows the analyst to evaluate alternatives while considering the objectives of all stakeholders involved.

The following small example illustrates this approach. Three actors are stakeholders in the issue of further developing a local airport A near city C. The management of airport A wants to construct a second runway in order to improve its turnover and its competitive position. The city council of C wants high employment, but also a good living environment for its inhabitants, more specifically, low noise nuisance and good air quality. The envi-

ronmental organization E wants to protect the bird species that breed in the area, and therefore wants low noise nuisance and low air pollution. An operationalization of these objectives could result in the following list of criteria:
– turnover of airport A [€/year];
– number of new jobs near C [job];
– number of houses exposed to more than 70 dB(A) [house];
– emissions of small particulate matter [kg/year].

The environmental organization is hardly interested in the effects on the first two criteria. As a firm, the airport is interested in the last two criteria only because neglecting these aspects is bound to lead to lengthy legal procedures that would cause delays. The municipality will be interested in the last three criteria. By working with the whole set of criteria, the analyst can perform research and prepare evaluations that are interesting and acceptable to all three actors.

3.4 Mapping Causal Relations

Now that it is clear what we want to achieve, through the identification of objectives and the specification of associated criteria, we should investigate the elements that influence the realization of these objectives. The means-ends diagram constructed at the beginning to support the initial problem demarcation and identify an appropriate level of analysis provides a starting point. However, in almost all cases, it is sensible to develop a 'map' of the causal chains in the system that link means to criteria.

A causal map depicts the causal relations between the factors that are relevant to the problem. It represents the internal structure of the problem, supporting a qualitative form of 'what if?' analysis that helps in understanding the effects of means and/or external factors on other factors, notably the criteria (Montibeller & Belton, 2006). Furthermore, a causal map can provide a good starting point for quantitative models that might be developed later in the process of policy analysis. Another term for a causal map is a causal (relation) diagram. A reason for using the general term 'map' here is to distinguish it from a system diagram, which will be discussed in the next section.

The basis for a causal map is a 'theory' about how a system works. Usually, this theory is a mental model produced by the researcher/analyst, complemented with knowledge from literature research, interviews and experts about the essential causal mechanisms of the system that are relevant to the problem. The criteria resulting from the objectives tree offer a good starting point for the construction of the causal map. Potential solutions are aimed at changing the criteria in the desired direction, and by doing so closing the gap that is at the heart of the problem. Reasoning backwards from the list of criteria is therefore a sensible approach when elaborating a causal map. Next we reason backwards from the criteria, asking the same question over and over again: which factors influence X?

During the problem structuring, a causal map should remain limited to those factors that are most relevant to the problem and its solution. It is easy to get carried away while drafting a causal map, trying to represent all aspects of the problem in detail. However, excessive detail renders the map ineffective as a tool for clarification and communication. It is therefore advisable to choose a rather high level of aggregation. A general rule of thumb is that a causal map becomes difficult to interpret when it contains more than twenty elements. If the system is so complex that more factors are really needed to capture its main elements and structure, it is advisable to develop different causal maps for different 'subsystems' and for different levels of aggregation.

When thinking about which factors to include in a causal map, keep in mind that causal analysis is about understanding how changes in one factor result in changes in other factors. This implies that you should focus on factors that can change; constants can be ignored. A second consideration is that only those factors that have a significant influence on one or more criteria need to be included.

The causal map in Figure 3.7 shows the intermediate result of starting a causal map from the criteria derived from the objectives tree in Figure 3.5, and then for each of these factors X repeatedly asking the question 'what factors can cause X to change?' Each newly identified factor Y is then added to the map, and the causal relation Y→X is depicted by an arrow. This arrow is then labelled with a sign: a '+' to denote that if the value of Y increases, the value of X will also increase (positive relation), or a '–' to denote that if the value of Y increases, the value of X will decrease (negative relation). This process is repeated for all factors that are *not* directly influenced by some means of the client.

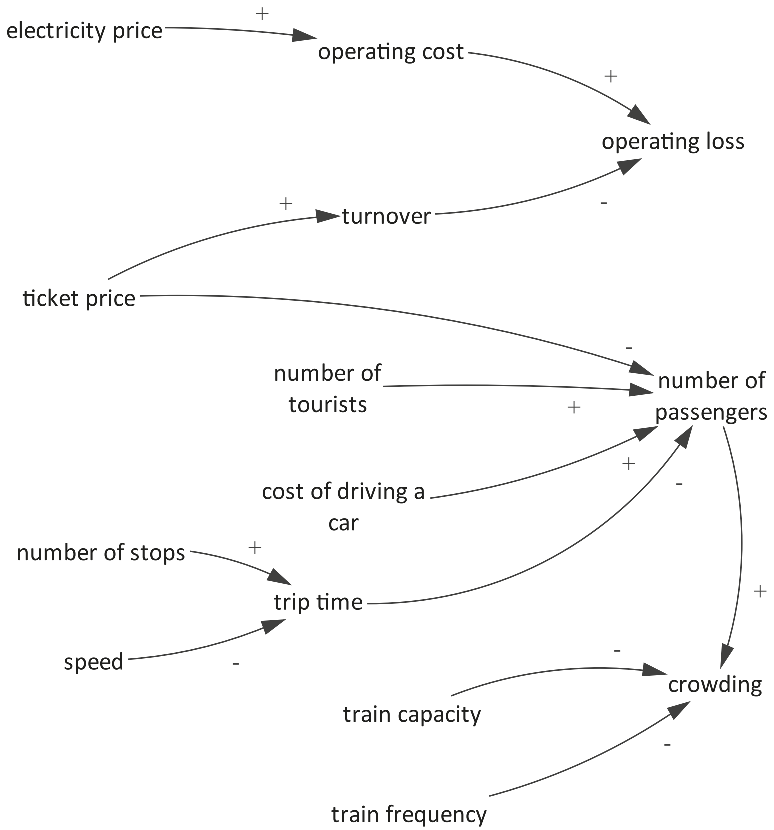


Figure 3.7 Intermediate result of causal mapping

The process of 'backward reasoning' is then followed by a process of 'forward reasoning' by asking for every factor X 'what other factors change when X changes?' As can be seen in Figure 3.8, this leads to adding new causal relations. Thinking in this way may also reveal additional side effects (new factors), and if these turn out to be of interest to the client, they should be added to the list of criteria. When constructing a causal map, it is advisable to document the underlying assumptions, because causal assumptions that may seem self-evident to the analyst may not be obvious to others.

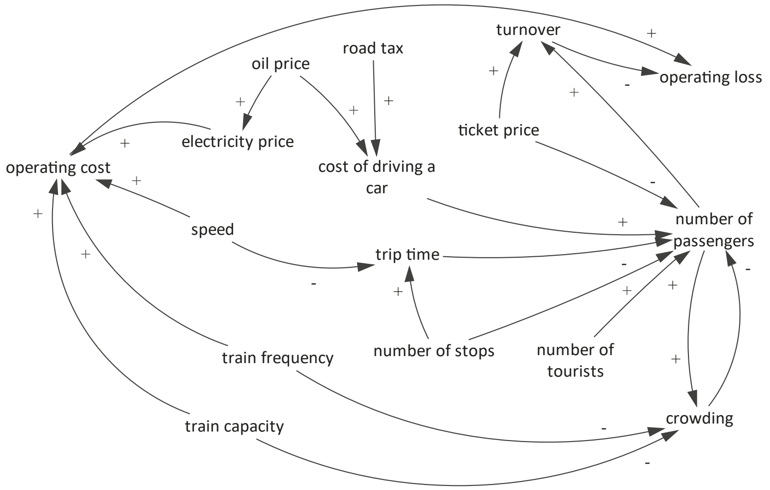


Figure 3.8 A completed causal map

Rules for Constructing a Causal Map

For a causal map, the following rules apply:

1. Each of the factors should be a noun phrase that denotes some variable system property. Each noun phrase F should be such that the sentence 'F increases' is grammatically correct and meaningful.
2. Arrows denote first-order causal relations. Each arrow X→Y should signify that a change in X will result in a change in Y.
3. Each arrow X→Y should be labelled with either a plus (to denote that the values of X and Y are positively related) or a minus (to denote a negative relation).
4. Each factor should be connected to at least one other factor.
5. To enhance legibility of the diagram, crossing arrows should be avoided as much as possible.
6. If the diagram contains an arrow X→Z and also some indirect path X→Y→ ... →Z, then the analyst should justify this multiple causality by explaining that the two paths have different underlying causal mechanisms. This rule forces the analyst to keep the diagram as simple as possible.

Interpreting a Causal Map

The main function of a causal map is to provide an overview of the factors and causal relations that are relevant to the client's problem and therefore need to be considered in the problem analysis. The analyst uses the diagram first to find out to what extent the client distinguishes the same factors and interrelationships, if not, what the differences are and whether this has implications for the problem formulation and associated initial system demarcation.

Having established that all elements of the causal map (factors and relations) make sense, the analyst should verify whether the causal relations denoted by the arrows occur within the time frame set by the problem demarcation. If an effect is expected to occur so slowly that it is not significant on the time scale selected for the analysis, it is advisable to remove the arrow involved.

The next step is to scan for loops: causal paths that start from some factor X and eventually join this same factor X again. Figure 3.8 contains one such loop, involving only two factors: 'number of passengers' and 'crowding'. Such loops denote a dynamic feedback mechanism. The type of feedback can be determined by multiplying the signs along the cyclic path to determine the net effect. An even number of minuses (this includes 0 minuses) indicates positive feedback, and an odd number indicates negative feedback. Positive feedback means that over time the effects of changes that affect any of the factors involved in the loop may be amplified; negative feedback means that these effects may be reduced. The loop in Figure 3.8 suggests the latter: when more people start using the metro, this increases crowding, and this is expected to deter people from using the metro, which in turn reduces crowding.

Having checked for loops, the analyst should also check whether the causal map contains factors X and Y linked by more than one causal path X→ ... →Y. If these paths have opposite signs (as is the case for the two paths between 'number of stops' and 'number of passengers' in Figure 3.8), this raises the question of which influence is stronger.

Besides providing an overview of factors and relations, a causal map facilitates the search for means to attain objectives. The set of means identified while constructing the means-ends diagram is usually incomplete. The causal map permits a more systematic search: for each factor X, the analyst poses the question 'How can the client change X?' For some factors, this may reveal several means, for others none. Some factors may be affected by the same means. The resulting list of means needs to be integrated consistently and iteratively with the results of the other analyses (criteria, causal map) in the system diagram.

3.5 Overview of the System and Its Boundaries: The System Diagram

The primary function of a system diagram is to summarize the systems analysis by showing the boundary and the elements relevant to the problem analysis. The boundary represents the system demarcation (the level and spatial and temporal scales of analysis). The elements come in four categories: **criteria** (the factors whose values indicate to what extent the problem has been solved), **external factors** (factors that cannot be influenced by the client, but do affect one or more criteria), **means** (actions of the client that affect one or more criteria) and **internal factors** (all other factors within the boundary that play a role in the causal chains that affect the criteria). The first three categories (criteria, external factors and means) are often said to be *on* the system boundary, as they are depicted as such in the system diagram. As mentioned at the start of this chapter, the means are placed on the left-hand side of the diagram, external factors at the top and criteria on the right-hand side of the diagram. Whereas means and external factors cannot be influenced by internal factors, the criteria are influenced by internal factors and can themselves also influence internal factors. So although the criteria are located on the right system boundary they may be connected to internal system factors.

As it synthesizes the results of the exploratory systems analysis, the system diagram is a conceptual model of the system. It constitutes the basis for further analysis, but also forms a useful tool for communicating about the system demarcation and the structure of the problem with the client, fellow analysts or other actors.

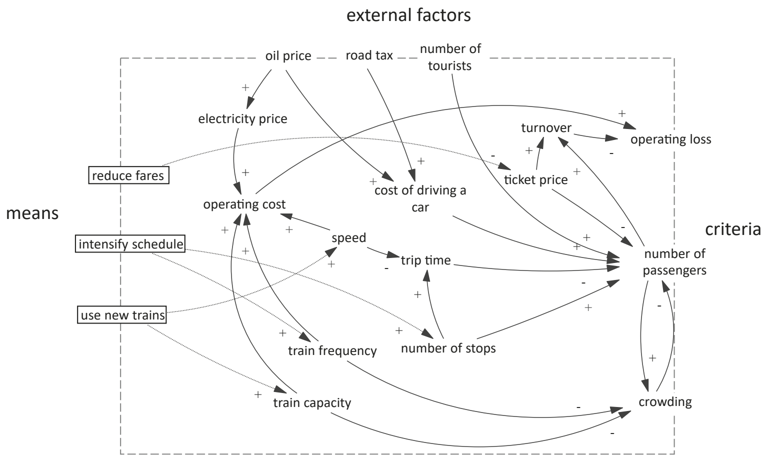


Figure 3.9 A system diagram

Figure 3.9 depicts a system diagram that summarizes the results of the city metro example. It shows that three means have been identified, and that these allow the client to directly affect the factors 'ticket price', 'number of stops', 'train frequency', 'speed' and 'train capacity', and so indirectly influence the criteria.

Rules for Constructing a System Diagram

For a system diagram, the following rules apply:

1. The means are located at the left boundary. To be relevant to the problem, there must be a causal route from a means through the internal factors to at least one criterion. Means seldom connect directly to a criterion. If the system diagram has such direct connections, check your logic carefully.
2. Criteria, located at the right-hand boundary, must have incoming arrows, and can have outgoing arrows (if they connect back to an internal factor).
3. Every internal factor must have an incoming arrow. Every internal factor must have an outgoing arrow, except if it forms a criterion.
4. Means and external factors do not have incoming arrows.
5. External factors are located at the upper boundary. For an external factor to be relevant there must be a route through the internal factors to at least one criterion.
6. Arrows must be accompanied by a '+' or '–' sign.
7. Means are formulated as verb phrases.

8. All factors are formulated as noun phrases and can be measured and expressed on some unit scale.
9. The outer dashed boundary depicts the system demarcation, representing the spatial and temporal scales chosen for the systems analysis and the level of aggregation. Which factors are internal or external to the system needs to be consistent with the choice of system boundary.

Because the system diagram also represents means, and because the placing of factors is more constrained than for a causal map (means on the left, criteria on the right, external factors at the top), it can become unclear due to crossing lines. For complex problems, with many internal factors, it is advisable to hide clusters of internal factors by depicting them as 'subsystems' as shown in Figure 3.10. With unsigned arrows, as the '+' and '–' only make sense between two factors. The factors and relations that remain hidden in this 'upper level' system diagram should be shown in separate diagrams, one for each of the subsystems.

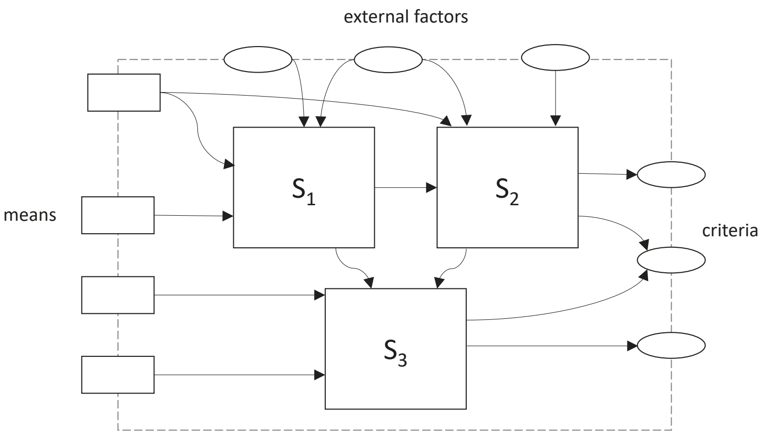


Figure 3.10 A system diagram with subsystems

Interpretation of a System Diagram

A system diagram is used in the first place to summarize the findings from the means-ends analysis, the client's objectives tree and the causal analysis. It can also be used for qualitative analysis of the effect of using particular means, or of changes in external factors, on the criteria. To do this, the analyst selects a means or external factor X, and investigates, by following the causal path(s) from X, which criteria are eventually affected, and in what way. For each affected criterion Z, the effect (an increase or decrease of the value of Z) is assessed by taking into account the multiplication of the signs along the arrows as discussed in the previous section. Doing this allows for the identification of the desirable effects as well as the undesirable side effects of the means employed. It facilitates identifying intrinsic dilemmas, means that are good for some objectives but not for others, and whether the problem owner can potentially attain all the objectives.

Alternatively, the question 'how can we increase criterion Z?' can be answered by following the causal chains back to specific means and/or external factors. This can indicate whether criteria are sensitive to external influences, giving insight into how much control the problem owner has over the criteria and whether the objectives might be attained without action having to be taken.

In tracing causal pathways from the means and/or external factors through the internal factors to the criteria, key internal factors can be identified. This may lead to a search for (additional) means to influence the key factors, and even the identification of actors who may be able to help in influencing these key factors and attaining the problem owner's objectives, or who share similar objectives.

For a particular problem situation, it can be useful to tabulate the findings in a consequences table like the one in Table 3.1, to get an impression of which means affect which criteria in which ways.

Table 3.1 Qualitative consequences table indicating the effects of different means on criteria

		Criteria			
		C1	**C2**	**C3**	**C4**
Means	M1	+		–	
	M2	+	+		
	M3	–			+
	M4		+	+	
	M5		+/–	–	
	M6			+	+
	M7				–

In a similar fashion, the effects of changes in the external factors on the criteria can be explored (Table 3.2). The effects of combinations of changes in external factors and means can also be analysed, as discussed further in Chapter 5.

Table 3.2 Qualitative consequences table indicating the effects of changes in external factors on criteria

		Criteria			
		C1	**C2**	**C3**	**C4**
External	E1		+		
	E2	+		–	
	E3	–			+

3.5.3 The Multi-Actor Situation

In Section 3.3.2, we showed how a broader set of criteria can be defined by taking into account the problem perceptions of several actors, typically the client and a selection of stakeholders. This broader set may of course also be used as the starting point for making a causal map, and eventually result in a system diagram that comprises the means and criteria of all of these actors. This multi-actor system diagram can be constructed and interpreted using the same principles. However, the following points are worth noting.

When a system is viewed from a single actor's perspective, all actions of all other actors are represented using factors and causal relations. For example, when the client is a local water authority that considers enforcing anti-pollution laws more strictly, other actors, such as the industry that discharges its wastewater into the river, are assumed to comply, for example, by installing filters. In a causal map, this would typically be represented as a minus-labelled causal link 'enforce more strictly' → 'emissions'. When the analyst also wants to include the perspective of the industry in the system diagram, the criteria and possible actions of this new actor (e.g. installing filters) should be added. To properly represent the interplay between the local water authority and the industry, the rationality of the industry should be made explicit. The extended diagram should reflect that installing filters costs money and hence negatively affects the industry's main criterion: profit. There is a direct negative causal link from 'install filters' → 'profit'. So why would the industry install filters? The answer could be that the local water authority can fine the industry if it does not comply with the anti-pollution act. To articulate that the industry is sensitive to this financial incentive, the diagram could be extended further by adding the factor 'compliance with norms' and a positive-labelled causal link from the industry's means 'install filters' → 'compliance with norms', followed by a positive-labelled link from this factor to the industry's profit criterion to reflect that compliance will avoid fines. Phrased differently, non-compliance will cost money. Adding a link from the means 'enforce more strictly' → 'compliance with norms' then reflects that when the local water authority uses this means, the industry's profit will be affected indirectly and will only increase if the industry installs filters.

In a single-actor system diagram, actions of other actors (or rather, the immediate effects of these actions) will typically be represented as external factors if the client has no means to control these other actors. When the system diagram is extended to include the perception of such an actor, the actions of this actor become means (and hence should be represented at the left side of the diagram), while the factors that represent the effects of the actions move 'inside' the system: they change from external factors to internal factors.

Clearly, shifting from a single-actor system diagram to a multi-actor system diagram will change the system demarcation – the system boundary – with the means of other actors now being included as means, or factors that were considered external potentially becoming internal factors, or the causal map becoming more complex, or the criteria becoming more numerous. When interpreting a multi-actor system diagram, it is important to keep track of which actor takes an interest in which criterion, as different combinations of means may distribute the costs and benefits differently across actors. The methods for identifying and dealing with this multi-actor aspect will be discussed in detail in the following chapter.

3.6 Takeaways

– Systems analysis is used to arrive at a conceptual model of the problem situation, depicted in a system diagram.
– The system diagram provides a structured overview of the problem situation, from the perspective of the problem owner, and can be extended into a multi-actor system diagram.
– A system diagram is based on a causal map of the problem situation.
– A system diagram consists of a boundary, with three groups of factors at the boundary: means, external factors and criteria.
– Means-ends analysis is a tool that can be used to support system demarcation.

- An objectives tree is a tool to support the identification of outcomes of interest for the problem situation which are formulated in the form of measurable criteria.
- The means and the external factors influence the system, and these influences propagate through the internal factors, eventually influencing the criteria.

References

Checkland, P. (1985). A Development of Systems Thinking for the 1990s. *Journal of the Operational Research Society, 36*(9), 757-767. https://doi.org/10.2307/2582164.

Daalen, C.E. van & Bots, P.W.G. (2010). Using a Systems Perspective to Design a Problem Solving Process. *Journal of Design Research, 8*, 301-316. https://doi.org/10.1504/JDR.2010.035674.

Findeisen, W. & Quade, E. S. (1985). The Methodology of System Analysis: An Introduction and Overview. In H. J. E. Miser & E. S. Quade (Eds.), *Handbook of Systems Analysis, part I. Overview of Uses, Procedures, Applications, and Practice* (pp. 117-150). Amsterdam: Elsevier Science Publishing.

Gregory, R. & Keeney, R. L. (1994). Creating Policy Alternatives using Stakeholder Values. *Management Science, 40*(8), 1035-1048. https://doi.org/10.1287/mnsc.40.8.1035.

Jackson, M. C. (1992). *Systems Methodology for the Management Sciences.* Boston: Kluwer Academic Publishers.

Keeney, R. (1992). *Value-focused Thinking. A Path to Creative Decision Making.* Cambridge, MA: Harvard University Press.

Miser, H. J. & Quade, E. S. (Eds.) (1985). *Handbook of Systems Analysis, Part I. Overview of Uses, Procedures, Applications, and Practice.* Amsterdam: Elsevier Science Publishing.

Montibeller, G. & Belton, V. (2006). Causal Maps and the Evaluation of Decision Options – A Review. *Journal of the Operational Research Society, 57*(7), 779-791. https://doi.org/10.1057/palgrave.jors.2602214.

Slinger, J. H., Taljaard, S. & d'Hont, F. (2020). *Complex Coastal Systems. Transdisciplinary Learning on International Case Studies*. Delft: Delft Academic Publishers.

Walker, W. E. (2000). Policy Analysis: A Systematic Approach to Supporting Policymaking in the Public Sector. *Journal of Multi-Criteria Decision Analysis, 9*, 11-27. https://doi.org/10.1002/1099-1360(200001/05)9:1/3<11::AID-MCDA264>3.0.CO;2-3.

4 Actor Analysis

An actor is a social entity, a person or an organization, able to act on or exert influence on a decision. This book places policy analysis in a multi-actor environment. From this perspective policy problems and policy processes involve multiple actors ('parties') because we presume that no single actor will be able to unilaterally impose its desired solution onto the others. Some form of cooperation, coordination or congruence between actors is required; the actors are interdependent. In such circumstances knowing who are the 'others' and understanding their objectives and motivation for participating is a crucial part of problem structuring. This chapter presents a method for analysing actors to help structure a complex policy issue.

4.1 Introduction: Why Actor Analysis?

The system diagram presented in Chapter 3 presumes that policy analysis revolves around the perspective, interests and the policy instruments or means of one problem owner. This approach suffices when the problem owner himself has sufficient means to solve a policy problem. In practice, however, such situations are rare. Therefore, the problem owner has to be aware of the interests and objectives of the other actors who are in some way involved with the policy problem, will be affected by the solutions or have means that are essential for solving the problem.

Sometimes these interests and/or the others' objectives may be aligned with those of the problem owner, but very often they are not fully aligned or even conflicting; knowing friends and foes; anticipating their concerns and issues; maybe engaging them in problem analysis and problem-solving activities might enrich the process and lead to better solutions, legitimate decisions and reduce resistance. Thus it is of great importance that a problem analysis provides insight into the range of actors involved as well as their networks.

As indicated this insight can support policy analysis in various ways. Presupposing that we are dealing with untamed or ill- or unstructured problems as discussed in Chapter 2 actor and network analysis will help to choose the fitting style of policy analysis for the current problem (see Figure 2.1). Mayer et al. (2004) describe six so-called 'styles of policy analysis' that describe a specific way of dealing with problems adapted to the character of the problem. According to Mayer et al. (2004), whose work will be discussed extensively in Chapter 6, actor analysis can help to support various policy analysis activities; it can mobilize knowledge, clarify values, help generate new ideas, map areas of potential conflict or mobilize support (see Table 4.1).

Table 4.1 Possible contributions of actor analysis to policy analysis activities

Policy Analysis Activity	Actor Analysis Can Help to ...
Research and analyse	Mobilize (scientific) knowledge and information from a broad actor base, which is likely to improve the quality of the problem analysis.
Design and recommend	Create ideas for alternative strategies and tactics by mapping options and interests of different actors. This helps to identify common ground and shared fundamental values, to identify ways in which different actors can contribute to these shared values and to identify needs and possibilities for compensation or mitigating measures to satisfy particular actors.
Advise strategically	Assess the feasibility and potential to implement policy options, by mapping the positions, interests, resources and relations of actors, providing insight into the opportunities and threats that actors pose for problem-solving.
Mediate	Map conflicts, identify potential coalitions of actors and propose a road map for a negotiation process, including agenda items and participants in various stages of discussion.
Democratize	Ensure that all the important actors are included in the policy process, and/or that their views and concerns are incorporated in the problem analysis. From a normative point of view, this supports a more legitimate and inclusive problem analysis.
Clarify values and arguments	Include the full range of values and arguments in a problem analysis, which aids a problem analysis that is recognized and accepted by different parties, offering a better basis for agreement and cooperation concerning policy options.

4.2 Conceptual Framework for Actor Analysis

Before sketching the main steps involved in actor analysis, it is useful to reflect on the object of analysis: what is an actor and what are the main concepts that are needed to describe actor interactions in policy processes? This helps to identify the main concepts and dimensions that one should cover in a first scan of the multi-actor context of a policy problem.

In this chapter, we define an actor as "individuals, organizations, or groups capable of autonomous and intentional actions that have an impact on a problem or system of interest" (Hermans & Cunningham, 2018: 13-14). Actors are those parties that have a certain interest in the system and/or that have some ability to influence that system, either directly or indirectly. Note that we use the term 'actor', and not 'stakeholder'. In practice, the terms are often interchanged. However, sometimes the term 'stakeholder' is used to refer to those groups that are mostly involved because they have an interest, or *stake*, in decision-making processes, while the term 'actor' is used to refer to those with the capacity to influence the decision-making or to *act* on decisions and their outcomes.

Beyond a direct description of the term 'actor', further insight into what an actor is can be gained by discussing the key attributes of actors in relation to policy-making and policy analysis. What characterizes an actor? For this, we turn to theories of the policy process, many of which have been presented in Chapter 2.

Public policies are generated within decision arenas: "a dedicated social space for strategic decision-making" (Hermans & Cunningham, 2018: 14). These arenas may have clear formal boundaries or they may be more virtual spaces in which actors interact (Ostrom, 2005). These arenas set the stage for actor interactions, whereby the network relations and the institutions provide key conditions for actor's behaviour (see Hermans & Cunningham, 2018: 19). Looking only at the networks and institutions, however, has a limited potential to explain policy changes if it is not complemented by an analysis at a lower level in terms of actor properties (Rhodes & Marsh, 1992: 196). At this actor level, most theories converge around three basic dimensions that help explain actor behaviour: perceptions, values and resources (Jobert, 1989; Mitroff, 1983; Sabatier, 1988; Scharpf, 1997).

If one takes the arena level and the actor level into account, the behaviour of actors in policy processes can be described using the following conceptual dimensions (Hermans, 2005):

Arena level:

1 Networks: 'More or less stable patterns of social relations between interdependent actors, which take shape around policy problems and/or policy programmes' (Klijn, 1997: 30). Policy networks may coincide with arenas, or they may offer the larger social context for a decision arena.
2 Institutions: In networks, the institutions provide an important influence for the relations in the network and for the behaviour of actors. Institutions are defined here as the 'rules of the game' (North, 1994). These include formal and informal rules, explicit and implicit (Ostrom, 2005).

Actor level:

3 Perceptions: The image that actors have of the world around them, both of the other actors and networks, and of the substantive characteristics of a policy problem (Bots et al., 2000; Scharpf, 1997). Perceptions may also be labelled causal beliefs, cognitions or frames of reference. Perceptions here refer only to 'neutral' theories of how the world operates, and not to normative beliefs about what is good and desirable. The latter are discussed under the dimension of 'values'.
4 Values: These provide the directions in which actors would like to move; they describe the internal motivations of actors. Related concepts such as 'norms', 'interests' and 'purposes' function on a more abstract level, whereas 'objectives', 'goals' and 'targets' express values in more specific terms. 'Preferences' and 'positions' translate values into a preference ordering over specific solutions or policy outcomes. Variables on this dimension are closely linked to actors' perceptions (see also Sabatier, 1988: 131-133).
5 Resources: The practical means that actors have to realize their objectives. Resources are the 'things over which they have control and in which they have some interest' (Coleman, 1990: 28). Resources enable actors to influence the world around them, including other actors, relations and rules in a network. As such, resources are closely related to power and influence.

4.3 Methods for Actor Analysis

There are several methods available to support actor analysis. In practice, most use is made of approaches for stakeholder analysis, which are rooted in strategic management literature (see, e.g. Bryson, 2004; MacArthur, 1997; Freeman, 1984; Grimble & Chan, 1995; Mitroff, 1983). The popularity of stakeholder analysis methods is explained by the fact that they are relatively easy to use and can be applied in a wide range of situations. Furthermore, these methods are flexible enough to cover a wide range of conceptual dimensions. These qualities also make stakeholder analysis methods very useful for an initial problem exploration. Hence, they provide the basis for the actor analysis approach described in this chapter.

However, it should be kept in mind that in many cases it may be worthwhile to carry out an actor analysis that goes beyond an initial scan or exploration. In such cases, a more focused and detailed actor analysis method is required. In these cases, several methods are available depending on the concepts that are of most interest. These include for instance methods that focus specifically on the structure of social networks (Scott, 1991), methods that map actor perceptions (Bots et al., 2000) and methods that analyse conflicts between actors (Hipel et al., 2008). An overview of different actor analysis methods for policy analysts is provided in Table 4.2. More background information on the methods in this overview and their use can be found in Hermans and Thissen (2009) and in Hermans and Cunningham (2018).

Table 4.2 Overview of methods for actor analysis

Method	Focus	References
Network Analysis	**Networks**	
Social network analysis	Structural characteristics of actor networks	Kenis and Schneider (1991); Scott (1991)
Stakeholder Analysis	**Resources and Interdependencies**	
Stakeholder analysis	Stakeholder environment to maximize cooperative potential and minimize threat of obstruction	Freeman (1984); Bryson (2004)
Motivation and ability analysis	Stakeholder setting and influence of (policy) triggers to motivate or enable actors to support action	Phi et al. (2015); Nguyen et al. (2019); Korbee et al. (2019)
Game Theory Models	**Resources and Interdependencies**	
Metagame analysis	Structure of policy 'game' to help identify stable outcomes and advise on strategies for negotiation and coalition building	Howard (1971, 1989); Fraser and Hipel (1984)
Hypergame analysis	Structure of policy 'game' and role of (mis)information and strategic surprise	Bennet et al. (1989)
Transactional Analysis	**Resources and Interdependencies**	
Transactional process models	Potential for exchange of control between different actors, to facilitate policy process	Coleman (1990); Timmermans (2004)
Vote-exchange models	Predicted shifts in actors' positions and outcomes of collective decision-making	Stokman (1994); Thomson et al. (2003)
Discourse Analysis	**Perceptions of Groups of Actors**	
Argumentative analysis	Different chains of reasoning used in policy debate and underlying values and assumptions	Toulmin (1958); Mitroff (1983)
Narrative policy analysis	Opposing views of controversial problems and possible meta-narratives to reformulate those problems	Roe (1994); van Eeten (2006)
Q-methodology	Groups of actors with shared perspectives and their underlying basis	McKeown and Thomas (1988)
Cognitive Mapping	**Perceptions of Individual Actors**	Axelrod (1976)
Self-Q interviews	Possibilities to address policy problems through actors' rationale	Bougon et al. (1990)
Dynamic actor network analysis (DANA)	Perceptions of actors to enable comparative analysis of agreement, conflict etc.	Bots et al. (2000)

Preference Elicitation	Values of Actors	
Value-focused thinking, analytic hierarchy process (AHP), multi-attribute assessment	Structure and hierarchy in various attributes and alternatives	Keeney (1992); Saaty (1990); McDaniels and Thomas (1999) etc.

Source: Hermans and Cunningham (2018); Hermans and Thissen (2009)

4.4 Steps in Actor Analyses

The following sections of this chapter discuss and clarify the steps that need to be followed in general actor analyses. The core of the method described here is in line with the guidelines for stakeholder analysis that are available in various documents. However, whereas stakeholder analysis methods typically focus on the dimensions of power and interests of actors, our initial scan of the actor network will also cover the network structure and perceptions of actors. This results in a basic procedure for actor analysis that covers six steps:

1 Formulation of a problem and associated decision arena as a point of departure.
2 Identification of the actors involved.
3 Mapping the formal institutional playing field: Chart the formal institutions and relations of actors.
4 Identifying actor characteristics: Determining the interests, objectives, perceptions and resources of actors.
5 Summarizing the interdependencies between actors using overview tables or diagrams.
6 Determining the consequences of these findings with regard to the problem formulation.

These steps are further explained in the following sections. These explanations are supported by a case example of New York City drinking water supply, introduced in Text box 4.1.

4.4.1 Step 1: Use Problem Formulation and Associated Decision Arena as Point of Departure

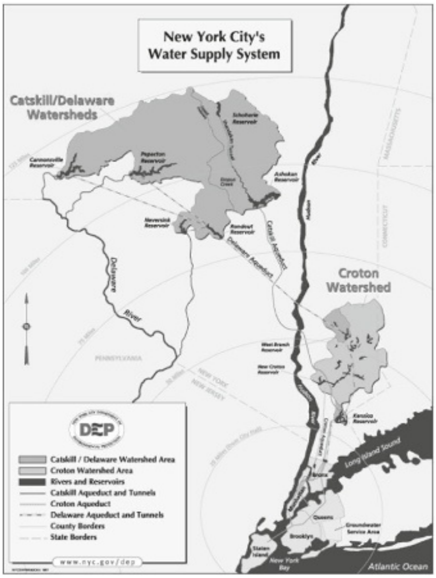
There needs to be an initial problem formulation which can serve as a point of departure for the actor analysis. There are two possible alternatives:

1 The problem formulation as viewed by the problem owner, which is mapped out by the analyst as a first research activity.
2 The problem formulation as formulated by the analyst, based on a first substantial problem exploration.

A good problem formulation includes a clear description of the gap and the dilemma of the main problem owner. What is the gap between the desired situation and the current/expected situation? And what is the action dilemma for the main actors involved when it comes to closing this gap?

For further requirements and examples of good problem formulations, refer to Chapter 2. However, for an actor analysis, this problem formulation needs to be linked to a decision arena. There might be multiple arenas you can consider, and it is important to be explicit about those. Where are actors deciding about this problem? These decision-making processes might be formal or informal and they might be simultaneous and coordinated, or asynchronous and piecemeal. Bringing into vision the decision arenas is necessary for the next steps in the actor analysis, but might also cause you to modify your initial problem formulation. It is the expectation that an actor analysis yields new insights that help the analyst to further complement or sharpen the initial problem formulation, and that might already start with this very first step in an actor analysis.

Text box 4.1 Problem formulation for the case of New York City drinking water supply
Throughout this chapter, we will use one example as a means of illustration. The example concerns the drinking water supply for New York City and the associated New York City watershed agreement. The specifics discussed here are dated around the turn of the millennium, but are described in present tense for illustrative purposes. As with many wicked or untamed problems, also this case and the watershed agreement are still relevant (see for instance New York Times, 2018). The specifics, however, may have changed. More details on this example can be found for instance in Hermans et al. (2003) and NRC (2000). A short introduction to the problem will help to understand the case.
The inhabitants of New York City depend on upstream rural watersheds for their drinking water supply. Water is collected in several surface water reservoirs located in New York State. It is not filtered before distribution to the users and New York City wants to maintain this situation because filtration is very costly. Avoiding filtration is only possible if the water in the reservoirs meets certain quality standards that ensure that public health is not endangered. The quality of the water in one particular watershed, located in Delaware County, does not meet the required standards. Based on the prevalent watershed rules, this watershed has a 'restricted status'.



Location map of the New York City watersheds (Source: https://www.dec.ny.gov/docs/water_pdf/nycsystem.pdf accessed June 2022)

Actors

The problem owner in this case is the local government of Delaware County. The 'restricted status' of the watershed prohibits the addition of polluting substances to water streams in the area, which in turn severely restricts economic growth. The problem that Delaware County faces is essentially the problem of how to reduce the pollution loads in the watershed in order to create room for further economic growth. Pollution reduction could be achieved for instance by reducing pollution from farms and other businesses, from the rural households that are not yet connected to the sewerage grid or by upgrading the existing wastewater treatment plants. Whatever the solution, it is likely to put local economic development at risk and it is likely to be costly, stretching the resources of an already underdeveloped rural community.

4.4.2 Step 2: Make an Inventory of the Actors Involved

Identifying actors that are possibly involved in the problem and its solution is an iterative process. By acknowledging the existence of other actors with different problem definitions, shifts can occur in the problem definition and configuration of actors, specifically in the exploration phase, which makes it possible that other actors become relevant for the solution of the problem. Also later in the policy process, unforeseen shifts can take place in the problem definition and configuration of actors, for example, when new solutions are thought of, new parties appear on the scene or new technology becomes available.

Actor Identification Techniques

There are different methods that complement each other and that help analysts to make a first selection of actors that may be involved. The different actor identification approaches discussed by Mitroff (1983) and Bryson (2004) offer a useful starting point. The resulting techniques are complementary, if partly overlapping, and their joint use is likely to result in a list that has less risk of omitting important actors. They can be used by the analyst, preferably in dialogue with the problem owner, and one or more key informants, persons knowledgeable about the policy field.

- The *interest-based* or *imperative* approach identifies actors who feel strongly enough about a certain policy problem or issue to act on their feelings. More generally, one could ask 'Who has an interest in or feels the consequences of the issues around which the problem revolves, or the solutions that are being considered?'
- The *institutional* or *positional* approach reviews the existing policy-making structures to identify actors with a formal position in policy-making. Studying the formal legislation, procedures, policy documents and so on provides a first indication of the parties that are possibly involved.
- The *reputational* approach uses key informants related to the policy problem and asks them to identify important actors. The resulting list of actors may be further expanded by asking each of the actors on the list to nominate additional actors. The latter technique is known as 'snowballing' (Wasserman & Faust, 1994). A variation to this technique is for the analyst to ask for any of the seemingly important actors who have important relationships with that actor.
- The *social participation* approach identifies actors to the extent that they participate in activities related to a policy issue. For instance as part of committees, by attending meetings or as part of platforms.

- The *opinion leadership* method identifies actors who tend to shape the opinions of other actors. For instance, the opinions of certain universities or research groups, certain international organizations or certain individuals may be highly influential.
- The *demographic* approach identifies actors by such characteristics as age, sex, occupation, religion, level of education, residence etc. This is relevant when policy problems and policy options have a different impact on different demographic groups. Also, this can be particularly helpful to specify the types of 'citizens' or 'voters' that are involved. Being more specific on this will be more useful than just including a generic label for all citizens, voters or consumers.
- Finally, the system diagram and the causal map offer important leads. Relevant actors can be identified by asking the questions: 'Who *influences*, directly or indirectly, relevant system *factors*?' and 'Who is *impacted* by changes in these *factors*?' Attention needs to be given here to the actors and factors *inside* the system, as well as in the *environment* of the system.

Some Specific Points of Attention

Dealing with Composite Actors
A problem occurs when we have to deal with a *composite* actor. An organization can be involved in the problem situation with more than one of its parts. For instance, a government ministry typically consists of different directorates, departments and sections, each with its own mandate and mission. The question is then which organization level we have to appoint as an actor: the ministry as a whole, or one or more specific units within the ministry.

When different units of an organization are involved with a problem based on their own distinctive objectives and responsibilities, it is wise to include all these units as separate actors.

When there is only one unit of an organization involved, then the question remains: is that specific unit or the whole organization the actor? The rule here is: choose an organization level as high as possible, without losing information in the process or involving objectives that are irrelevant to the problem situation. However, *avoid the inclusion of actors on the level of 'government' or the 'trade and industry'.* Such a high level of aggregation limits the usefulness of the analysis.

Text box 4.2 offers an example for the New York City drinking water case.

Text box 4.2 Composite actors in the New York City drinking water problem
In our example of Delaware County's problem with New York City's drinking water supply, several composite actors play a role. For instance, the government of New York City is organized in several bureaus and departments. However, only one department is responsible for the City's water supply: the Department of Environmental Protection. Therefore, this department can be identified as the actor representing New York City's interests. For Delaware County, two distinct organizational units should be included as they have clearly different interests and roles in the problem: the Department of Soil and Water Conservation, which is concerned with environmental protection, and the Department of Planning and Economic Development.

Setting Boundaries to Decision Arena or Actor Network

Depending on the problem, it may be difficult to identify the boundaries of the decision arena or the actor network. Where to draw the line between actors that are important and those that are not? The first general advice is not to be too restrictive in the identification of actors to prevent premature focusing on a limited number of actors (Brugha & Varvasovszky, 2000: 341). Although this is good advice for drawing up an initial long list of actors, keeping the remainder of the analysis feasible means that one subsequently needs to limit the number of actors to keep the time and resources required for the analysis within reasonable limits (cf. Grimble & Chan, 1995: 119).

Suggestions for how to do this streamlining of the initial long list of actors are not easy to find. However, three general guidelines may help:

- *Ensure that the actor network is in line with the chosen level of problem analysis.* For instance, if the problem is on the regional or local level, there is often less need to involve national level actors who often set relevant boundary conditions without active involvement in local policy-making. Often, not always. If the problem analysis focuses on the national level, there is less need for actors that are predominantly active on the regional or local level. For instance, one could include the National Association of Municipalities, but there will be little need to include individual municipalities.
- *Ensure that the list of actors covers a balanced set of interests and roles.* Ideally, all the important interests and roles within a policy-making situation should be represented in the initial actor selection. If possible, at least *two or three* actors with different roles should be identified for each interest. For instance, if agriculture is an important interest, one could identify the Ministry of Agriculture, the national association of farmers' cooperatives and an agri-business branch association as important actors. In this regard, the categorization of actors using two or three different classification schemes, as illustrated in Text box 4.3, offers a useful tool.
- Finally, a simple rule of thumb: experience indicates that a useful actor analysis often includes anywhere *between ten and twenty different actors*. Taking less than ten actors into account will increase the risk that important actors are being overlooked. Taking more than twenty actors into account increases the risk that the analysis is insufficiently focused to be useful. This may be the case when the network boundaries are too broad or when an unnecessary level of detail is employed.

Changing Roles of Actors

In determining arena boundaries and identifying actors, one has to keep in mind that the inventory of actors who are actively involved at the moment of the analysis does not have a predictable value for the future: new actors may participate and parties that play an important role now may 'exit the stage' later on. For instance, climate change and energy transition have the interest of many more actors now than it did some years ago. The same applies to public health and pandemic disease control. This means that the list of actors involved in policy problems that involve climate change will have changed dramatically in the past years or so.

Furthermore, from the earlier descriptions it will be clear that, throughout the actor analysis, one needs to check at regular intervals whether or not the initial list of actors is still appropriate, or if new insights require new actors to be added or existing actors to be removed from the list.

Problem Owner as an Actor in Actor Analysis
Make sure to include the problem owner in the list of actors and the subsequent steps in actor analysis. In order to produce a complete overview of an actor network, it is important to include the problem owner explicitly in the analysis – at least in those steps where comparisons and overviews are made of the characteristics of various actors. This helps to understand the position of the problem owner vis-à-vis the other actors. This is not possible when the problem owner is excluded from the analysis.

Structuring the List of Actors
The clarity of the list of actors can benefit from dividing actors into categories. This can be done in various ways, as illustrated in Text box 4.3. A first classification can be based on the role and position in a governance system: government authorities on various levels; companies (utilities and enterprises, both private and semi-public); non-governmental organizations (NGOs); local interest groups (e.g. local community organizations); non-organized interests or individuals.

Another complementary classification of actors can be made by looking at their interests in the problem or their position in a production chain. For instance, in relation to a policy problem in the field of energy, such interest categories could include: energy provision, energy consumption, environmental conservation, economic development and so forth. Use of this second classification logic will be helped by a specific assessment of each actor's individual interests. This is done in Step 4 of the actor analysis, so it will be worthwhile to revisit and reconsider the initial categorization in a later stage of the analysis – as part of an iterative process.

Text box 4.3 Actors involved in the New York City drinking water problem
The table below contains the actors identified for the New York City drinking water problem, using two different classifications. The first column uses a classification based on their role in governance, the second column contains the same actors, but grouped based on their main interests.

Actors' roles in governance		Actors' issues of interest
Federal government		*Environment*
US Environmental Protection Agency		US Environmental Protection Agency
US Department of Agriculture		NYS Dep. Of Environmental Conservation
New York State (NYS) government		Delaware County Soil & Water Conserv. District
NYS Dep. of Environmental Conservation		Catskill Watershed Corporation
NYS Dep. of Health		*Health: Water supply and sanitation*
NYS Dep. of Agriculture and Markets		NYS Dep. of Health
Local government		New York City Dep. of Environmental Protection
New York City Dep. of Environmental Protection		Health interest groups in NY City
Delaware County Soil & Water Conserv. District		Wastewater treatment plant operators
Delaware County Dep. of Planning & Econ. Dev.		*Agriculture*
Towns and villages in Delaware County		US Department of Agriculture
Non-governmental organizations		NYS Dep. of Agriculture and Markets
Cornell Cooperative Extension Association		Farmers
Catskill Watershed Corporation		Watershed Agricultural Council
Watershed Agricultural Council		Cornell Cooperative Extension Association

Organized local interests		*Local economic development*
Delaware County Chamber of Commerce		Delaware County Dep. of Planning & Econ. Dev.
Companies and non-organized interests		Towns and villages in Delaware County
Farmers		Small and Medium sized Enterprises
Small and Medium sized Enterprises		Delaware County Chamber of Commerce
Wastewater treatment plant operators		
Health interest groups in NY City		

4.4.3 Step 3: Mapping Formal Institutions and Relations

Characteristics and positions of actors and their mutual relations have a formal and an informal side. Knowledge about both sides is essential in order to understand actors and their environments. The analysis should begin by mapping out the formal institutions and relations because these are mostly easy to reconstruct using available documents. Mapping those formal institutions offers a good starting point to understand the background against which other, informal, relations take shape, and to sketch the formal playing field within which actors interact in a policy process. A 'formal chart' can be used as a means of orientation in this.

The formal institutions offer a good basis to subsequently investigate the informal institutions and relations. Although formal authorities and formal hierarchical relations do not fully determine the informal relations between actors, it would be wrong to assume that hierarchical relations do not matter. On the contrary, they have a strong shaping influence and they do limit the informal interaction processes. It is clear that legislation and formal procedures strongly shape the interaction and influence the behaviour of parties. Therefore it is good to know which laws and procedures actors have or will have to deal with.

Formal task settings determine to a large extent the identity of public organizations. They derive formal rights and duties from these tasks, as well as associated authority and resources to enforce those rights and act on their duties. Therefore, often their interests and resources can be related back to these task settings. So it is a good thing to systematically map out those formal tasks. Formal authorities are also a type of resource, to which we will turn later in the analysis when we map out the interdependencies between parties. Drafting the 'formal chart' produces not only context information for the analysis of the informal relations but also information about resource dependencies between actors in a network.

Inventory of Relevant Formal Rights, Responsibilities and Relations

Formal relations can be described by:

– *Describing the formal positions of actors and their rights and responsibilities.* Actors' rights and responsibilities are often formalized in laws and regulations. Especially for government organizations, these positions and responsibilities are likely to be defined in specific laws and regulations. Information about the position and tasks of non-government actors, although often more 'fuzzy' and somewhat less formal, can often be found on websites, annual reports etc. Also, their room for manoeuvre will be limited by the prevailing legislation, see third point of this list.
– *Specifying formal relations between actors, when possible, by exhibiting an organization chart* with clarification. Do certain organizations or departments have a hierarchical relationship? Is there a formal membership of representational arrangement? Who

bears final responsibility, or acts as coordinating agency? Who has a formal advisory role in a decision-making process?
– *Describing in short the most important laws, legislation, procedures and authorities* that play a role in the problem situation. This is likely to provide information in support of the previous items, but also may yield additional information that is useful for getting an idea of the position, interests, influence and 'solution space' of actors.

Drawing a Formal Chart

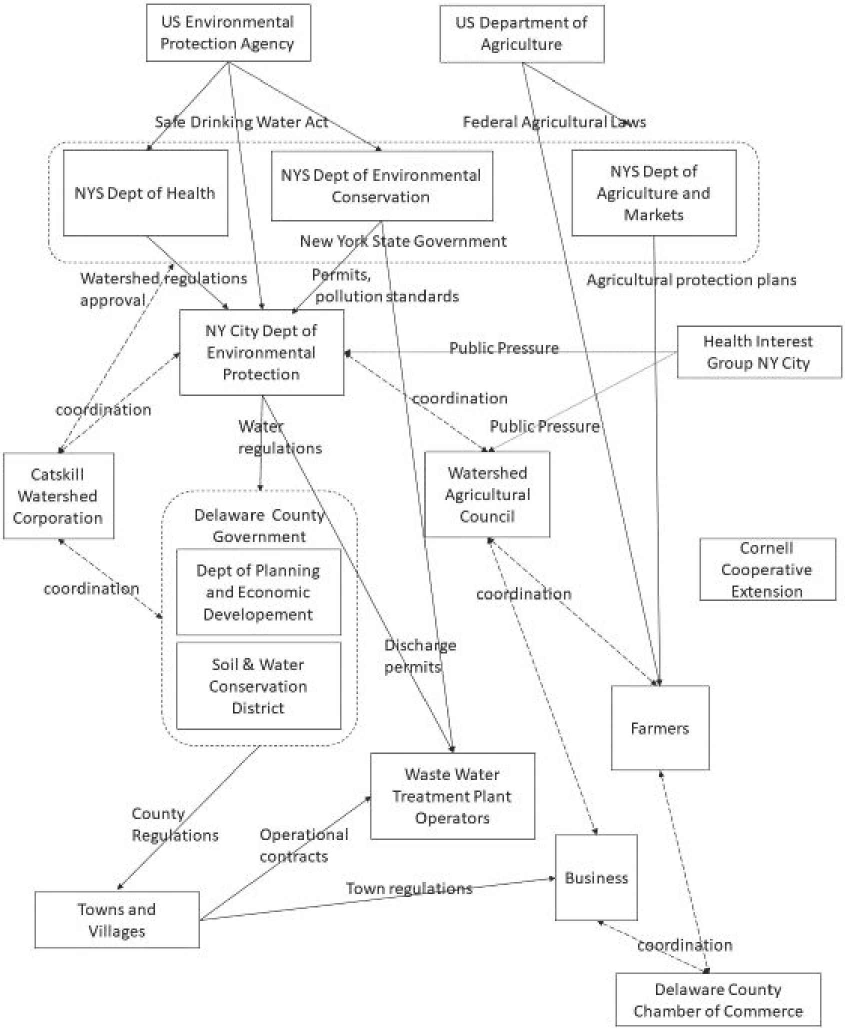
Parts of the information on formal positions and relations between actors can be presented using a so-called 'formal chart'. Usually, such diagrams do not depict all the existing formal relations, but those deemed most important for the problem analysis. Note that in fact each arrow in this formal chart represents a resource needed for analysing dependencies. The construction of a formal chart is a matter of sound judgment. The following guidelines apply:

1 Use the key legislation and formal agreements that apply to your specific problem and decision arena as a first starting point.
2 Position the actors mentioned therein while preserving some intuitive vertical hierarchy (typically state-level actors such as ministries on top and local level actors such as municipalities or executive branches more at the bottom).
3 Draw arrows only if they depict a specific formal relation between two actors. The hierarchy flows from the actor with the outgoing arrow to the actor with the incoming arrow. It therefore indicates some kind of formal hierarchy, control or influence.
4 Each arrow needs to be labelled. Use a short label to explain the formal relation.
5 You may use dotted rectangles to indicate clusters of actors that are all subject to a similar type of law or formal rule.
6 Limit the formal chart to only show the most important formal relations – to avoid cluttering of your diagram.
7 Provide a clear explanatory text with your formal chart, which includes reference to the formal acts, laws and agreements that provide the basis for the formal relations depicted in the diagram.

Text box 4.4 gives an example.

Text box 4.4 Formal chart for the New York City drinking water problem

The next figure shows the most important formal relations between the actors. It should be noted that not all the informal influence relations have been included. As a result of this, the non-governmental actors may seem less connected or less influential than they may actually be.



Formal chart for the New York City drinking water problem

Single-sided arrows indicate a hierarchical relationship, two-sided arrows indicate formal representation relationships/membership.

Actors

This figure shows that the US Environmental Protection Agency (USEPA) is 'on top' of the hierarchy, according to the Safe Drinking Water Act (SDWA). Based on this Act, USEPA determines whether or not New York City should filter its drinking water. The State agencies have some influence over NY City Department of Environmental Protection (NYCDEP), as their approval or permits are needed for some of the NYCDEP's activities. NYCDEP and the NY State Department for Environmental Conservation are jointly responsible for permits and determining acceptable pollution loads. As a water supplier, NYCDEP is authorized to develop and implement rules and regulations to protect the water quality in the City's watershed, including those in Delaware County, provided that NY State Department of Health approves of these rules. This gives NYCDEP a strong position vis-à-vis the Delaware County agencies.
To protect New York City's reservoirs from pollution while maintaining the economic viability of the Catskill and Delaware watershed region, an agreement was signed between New York City and the watershed communities. Part of this agreement was the establishment of several programmes to support pollution reduction. The Catskill Watershed Corporation (CWC) was established to administer and manage some of these programmes. The CWC is a non-profit organization and its members consist of twelve representatives of West of Hudson communities (of which six are from Delaware County), two members appointed by the State Governor and one New York City employee. Since agriculture is the main economic activity and the main source of pollution in the New York City watersheds, specific arrangements were made concerning agriculture. This resulted in a Watershed Agricultural Programme, which is implemented by the Watershed Agricultural Council (WAC), a farmer-led non-profit organization. Its board consists of farmers, agri-business representatives and the Commissioner of NYCDEP. The WAC has contracted the local Soil and Water Conservation Districts (SWCD), the Cornell Cooperative Extension Association (CCE) and other parties to assist in implementing its programme (note that these contractual relations are not depicted to maintain a certain level of clarity in the diagram).

4.4.4 Step 4: Identifying Key Actor Characteristics

For a better understanding of actor networks, we also need to zoom into the level of the individual actors. This means we want to analyse the values, perceptions and resources of the different actors.

Problem situations are complex because different problem formulations co-exist and because different actors are capable of influencing the resolution of these problems. The initial problem formulation by the problem owner is just one of the possible formulations of the problem that is faced in the initial situation. In the first parts of this analysis step, the problem formulation of the different actors is systematically assessed by looking at their interests, objectives and causal beliefs or perceptions. This is followed by a closer look at the resources that different actors control.

Specify Interests of Actors

Interests are the issues that matter most to an actor, and usually interests have a clear direction. Interests are not directly linked to a concrete problem situation, as opposed to objectives, and are relatively stable. A company typically has an interest in making an economic profit, whereas the direction will be to increase profits. Another typical company interest will be continuity of business. For the Directorate General for the Environment of the Netherlands Ministry of Infrastructure and Water Management, the main issue of interest will be the environment, which needs to be conserved or protected (and remember that this can be seen from the formal chart in Step 3). For a politician the main interest may be re-election. An assessment of the interests of an actor helps to estimate to what extent certain objectives or solutions will be acceptable for the actor involved. Interests can be found out by asking questions such as: *Why is the problem situation of importance to an actor? How are actors affected by the problem and why do they care?*

Specify Objectives of Actors

Objectives indicate what actors wish to achieve in a certain situation, which changes they would like to realize (or what they would like to maintain). All actors that are involved in a problem have their own more or less clearly formulated objectives. They use these objectives as a measure to judge the existing situation. The gap between the objectives or the desired situation and the perceived existing or expected situation determines the nature and seriousness of the problem. Objectives are the translation of an actor's interests into specific, measurable terms.

An actor usually has multiple objectives, some of which may have nothing to do with the problem. Clearly, in our problem analysis we are first and foremost interested in the objectives that are directly related to the problem situation. These objectives can be found by asking the questions: *What does the actor want to achieve when it comes to the problem situation? When does the actor want to achieve this?* And: *Which specific costs and benefits are associated with the problem situation or the proposed solutions for a certain actor?*

Specify Perceptions

Most actors have their own, unique perceptions of a problem situation and these perceptions can differ significantly. When dealing with complex policy problems, it is neither easy nor useful to determine 'who is right' (see Chapter 2). Thus, instead of looking for who is right, we try to map out the similarities and differences between problem perceptions in the actor analysis. After all, even if 'wrong' problem perceptions arise, they exist, they are a part of the problem situation and they will influence the behaviour of the actors who hold them! Therefore, all perceptions should be mapped in a problem analysis, staying as close as possible to the way the actor sees the system – whether we as analysts believe they are right or wrong.

The specific problem perceptions of actors can be specified in causal maps for individual actors, as is done for instance in Dynamic Actor Network Analysis (Bots et al., 2000). Actors may distinguish different factors and may have different assumptions of the main causal relations between those factors: Is there a causal relation? What is the direction and intensity of the relation? Is there a direct relation between factors A and B, or is factor A mainly influenced by factor B via factor C? However, for our purposes we need not map these detailed diagrams, but we can get a useful impression by addressing the following questions:

– What is the actor's perception of the problem? What is the core of the problem: which factors are central in the system and what are the causal relations between factors?
– What are the main causes of the problem according to an actor? (Rule in this course: limit to a maximum of 3)
– What possible solutions do they distinguish with regard to the problem situation and its causes? (Rule in this course: limit to a maximum of 3)

Make a Systematic Comparison

With the help of the previous steps, a table can be completed that summarizes the problem formulation for each actor. The result will be an overview table as depicted in Table 4.3. Note that the complete overview table may be quite large.

Table 4.3 Overview table of actors' problem formulations

Actors	Interests	Desired Situation/Objectives	Existing or Expected Situation and Gap	Causes	Possible Solutions
Problem owner					
Actor 1					
Actor 2					
...					
Actor N					

The summary table supports a systematic comparison of the problem formulation of the problem owner and the other actors. This helps to identify the similarities and differences, as well as common objectives and shared interests, or potential conflicts. These insights can be used to complement the initial problem formulation and problem analysis. Also, they can help to formulate recommendations for the problem owner related to the interaction with other actors, and on how to influence other actors.

Text box 4.5 Problem formulations of actors in the New York City drinking water case

Actors	Interests	Desired Situation/Objectives	Existing or Expected Situation	Causes	Possible Solutions
Delaware County Department of Planning and Economic Development	Regional economic development, welfare of citizens of Delaware County	Healthy businesses, sustained economic growth, good employment opportunities	Income levels among lowest in the country, decline in local businesses, high levels of unemployment	Rural economies have difficulties nationwide, environmental rules impose further restrictions	Diversify economy (tourism, IT services), soften environmental regulations
Delaware County Soil & Water Conservation District	Protection of human and ecosystem health	Good score on various soil and water quality parameters (for instance phosphorus, giardia and cryptosporidium)	Current levels may be high for drinking water purposes, but do not pose a direct health problem for Delaware County inhabitants	Farmers, especially dairy farmers, emit polluting substances, as do wastewater treatment plants, storm water events and old septic tanks of households not connected to the sewerage	Among others: improve on-farm management through implementation of the Watershed Agricultural Programme
NY City Department of Environmental Protection	Protection of human and ecosystem health, provision of safe drinking water to NYC inhabitants at an affordable price	Good water quality in the upstream watersheds that feed the NYC reservoirs (in this case: low levels of phosphorus, giardia and cryptosporidium)	Levels are too high, endangering current water supply arrangements, threatening need of costly investments in filtration techniques	Communities in the upstream watersheds emit too high levels of polluting substances, especially phosphorus, giardia and cryptosporidium	Impose strict environmental regulations on watershed communities, purchase the lands around the reservoirs to stop polluting activities there
US EPA	Environmental protection	Good water quality and safe drinking water supply sources for New York City	Currently, the NYC drinking water supply system does not meet the national standards	Emission levels in watersheds are too high in relation to the existing supply system that does not include filtration	Ensure sustainable lowering of emission levels in watersheds or invest in filtration
Farmers Delaware County	Agriculture	Good income from farming and good future prospects for farming business	Income from farming is low and prospects are bleak – and worsened by restrictive environmental regulations	Structure of agricultural markets, combined with unreasonable demands from New York City for pristine watersheds	Improve on-farm management with help of Watershed Agricultural Council
Health interest groups for NYC citizens	Public health and costs of living	Safe drinking water supply at an affordable cost	Current arrangements are costly and still leave too many uncertainties regarding public health risks now and in the future	Pollution loads in watersheds are too high and current measures taken to reduce them are not sufficient	Impose strict environmental regulations on watershed communities, purchase the lands around the reservoirs and restrict access to these lands
Etc.					

Actors

The above table shows that water quality in the reservoirs downstream of Delaware County does not meet the drinking water standards. This is a problem for New York City and its Department of Environmental Protection because it means they cannot use this water for public drinking water supply without treating it. Restricting the pollution levels in the watersheds is a solution to New York City DEP, but creates a problem for the actors in Delaware County: it would damage the economy in a region that is already lagging behind in terms of economic development. The health interest groups in New York City consider the current efforts of the New York City government and the local watershed actors as a problem. They are altogether sceptical about the effectiveness of pollution reduction by the watershed communities and they claim that New York City should enforce a strict ban on all economic activities in sensitive areas, by buying up lands and restricting access to it. Otherwise they will be forced to build a filtration plant for its drinking water supply in the near future anyway.

Resources of Actors

In this sub-step, we investigate the dependency of the problem owner on the actors in his environment. This relationship is determined by three things: the importance to the problem owner of resources of other actors, the extent to which those resources are replaceable and the degree to which the interests and objectives of other actors are similar (Hanf & Scharpf, 1978). Furthermore, it is important to know how important and urgent the problem is to other actors: this will determine whether or not actors are likely to be willing to play an active role in the debate and resolution.

The degree to which a problem owner depends on an actor is related to the resources of that actor. Critical actors are those on whom a problem owner critically depends for solving his problem. Identifying critical actors is an important part of actor analysis, and logically starts with an inventory of the resources of the various actors.

The resources of actors are the formal and informal means that are available to the actors to realize their objectives. Formal means are for instance authority (power of decision) and instruments (subsidies). An example of an informal resource is information. The following resources can be distinguished (adapted from Kok, 1981):

- information;
- knowledge (and skills);
- manpower (including often skilled manpower);
- money (or access to money through loans or credit facilities);
- technology, equipment, infrastructure;
- authority/formal power (as per the laws and regulations in Step 3);
- position in the network: support from or access to other actors;
- legitimacy;
- organization (ability to mobilize and use resources effectively and efficiently);
- (social) media platform or access;
- others, such as ....

In this step we find out which resources are available to various actors. Since every actor has a spectrum of resources, actor analyses often do not benefit from an exhausting overview. Only the resources that are most relevant to the problem situation need to be included. Make sure to be specific when listing resources. So do not simply 'select' from the earlier list, but if you do so, specify what kind of knowledge an actor has that is of relevance to the problem, or what kind of authority an actor has that is of importance in the arena.

Resource Dependency and Critical Actors
The resource dependency of one actor in relation to a second actor depends on the importance of the resources held by the second actor and the degree to which these resources can be replaced by other resources. For instance, most Western countries heavily depend on oil imports to sustain their economies. Thus, they are highly dependent on OPEC countries. However, as alternative fuel technologies are being developed, such as biofuels, hydrogen and solar energy, this resource dependency is decreasing. Schematically, the issue of resource dependency can be illustrated as in Table 4.4:

Table 4.4 Resource dependency

	Limited Importance	Great Importance
Limited options to replace	Medium dependency	High dependency
Can easily be replaced	Limited dependency	Medium dependency

Using Table 4.4 helps to assess resource dependency but tends to overlook resource dependency related to blocking power. As Hanf and Scharpf (1978) back in the days argued, the problem owner not only depends on actors with the resources to support problem-solving, or to sustain existing systems, but he also depends on actors with resources to hinder the activities of the problem owner, or to prevent the successful implementation of a solution. Actors that are either important for their 'power of realization' or for their 'blocking power' are the *critical actors* – the actors that a problem owner cannot ignore (Table 4.5) (Enserink, 1993).

Table 4.5 Overview table for determining critical and non-critical actors

Actors	Important Resources	Replaceable?	Dependency Limited, Average, High	Critical Actor? Yes/No
Actor 1:				
Actor 2:				
Actor N:				

4.4.5 Step 5: Summarizing Interdependencies

Assess the Criticality, Dedication and Support of Actors
The previous step shows you the '*critical actors*'. Your problem owner is to an important extent resource dependent on those actors. Resource dependency of your problem owner on another actor is determined by the extent to which the realization of your problem owner's objectives depends on the resources controlled by that other actor.

Interdependency is slightly different. It reflects a two-way relationship, and is influenced not only by the resources of actors but also by their interest in the problem and their dedication to act on it. Two actors that both take a high interest in a problem, and that both control critical but different resources to influence this problem, can be said to be interdependent. The importance of a problem to an actor will appear from his problem formulation and the extent to which his core interests are affected by the problem or by possible solutions. In addition, it can help to assess whether an actor will be affected by clear costs or benefits. If he is affected, he will probably be a '*dedicated actor*', or he may become one in time. If an actor does not experience any clear costs or benefits, or if costs and benefits seem to negate each other, this actor will be less likely to try to influence the problem analysis and the choice and implementation of a particular solution. This means that such actors are less likely to pose a threat to the problem owner, but also that it will be more difficult for a problem owner to mobilize their active support. In such cases, we are dealing with a '*non-dedicated*' actor.

Dedicated actors do not necessarily share the same interests and objectives. The previous step of the actor analysis, in which the interests and objectives of actors have been assessed, enables the analyst to assess if actors have interests that are similar to the interests of the problem owner, or if actors have interests that conflict with the interests of the problem owner. Actors with interests and objectives that are well-aligned or similar to those of the problem owner are more likely to offer *support*. Actors with conflicting interests are more likely to offer *opposition*. Adding this information to the results of the previous identification of critical and non-critical actors, and of dedicated and non-dedicated actors, enables one to complete an overview of dependencies of the problem owner on the different actors.

Overview Table for Classification of Actor Dependencies

Completing the cells of Table 4.6 provides an overview of the different types of actors on whom the problem owner depends to a larger or lesser degree. Table 4.6 offers the problem owner an impression of the possible reactions of actors in his environment to his problem formulation and the intended solution.

Table 4.6 Overview table for classification of interdependencies

	Dedicated Actors		**Non-dedicated Actors**	
	Critical Actors	**Non-critical Actors**	**Critical Actors**	**Non-critical Actors**
Support: Similar/ supportive interests and objectives	Actors that will probably participate and are potentially strong allies	Actors that will probably participate and are potentially weak allies	Indispensable potential allies that are hard to activate	Actors that do not have to be involved initially
Opposition: Conflicting interests and objectives	Potential blockers of certain changes (biting dogs)	Potential critics of certain changes (barking dogs)	Potential blockers that will not act immediately (sleeping dogs)	Actors that need little attention initially (stray dogs)

Visualizing Interdependencies

The information contained in the overview table for interdependencies (Table 4.6) can also be visualized in 'alignment-interest-influence' diagrams (ODI, 2010) or 'power-interest grids' (Figure 4.1) (Bryson, 2004; Eden & Ackermann, 1998). In some cases, such maps may have certain advantages over tables, especially when they provide a quick illustration of important patterns in the actor environment of the problem owner. In these maps, the power and interests of actors are used to classify different actors, whereas pluses and minuses are used to indicate if an actor supports or opposes the main interests and objectives of the problem owner. Critical actors are those with a high level of power – i.e. important resources – while dedicated actors are those with a high level of interest in the problem. Such maps may be used to characterize actors (Bryson, 2004) and to formulate a generic advice regarding the types of relationships a problem owner typically might establish with actors in different quadrants (Johnson et al., 2005).

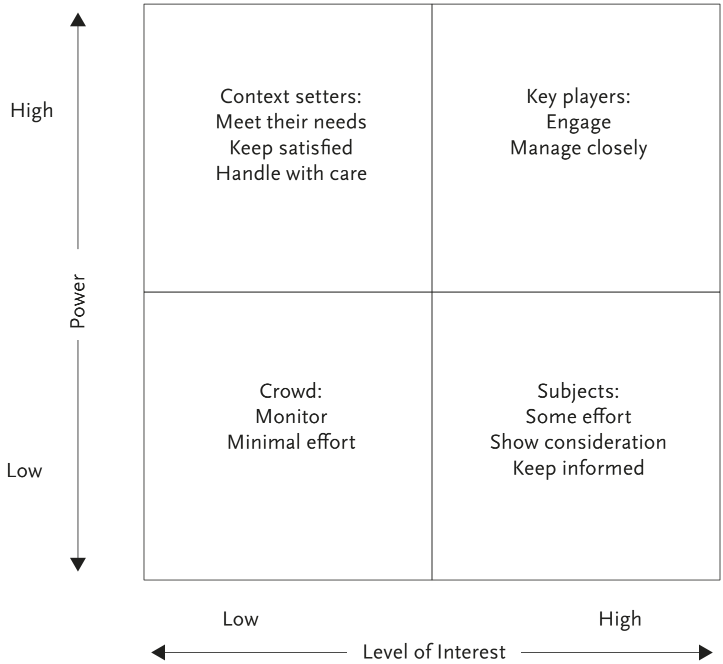


Figure 4.1 Mapping actor dependencies: Power/interest matrix

Drawing Conclusions from Overview Tables and Maps
The insights contained in overview tables or dependency maps can be translated into different types of conclusions. The diagrams depict the current position of actors. This will hold important information. At the same time, because actors are interdependent, it is also possible to think of ways to change the current picture, and to influence the position of actors. That way, one can think of actors that could be 'moved' around in the grid. Especially the power-interest grid or similar diagrams are useful to trigger thinking about the latter (see ODI, 2010).

The overview of actor dependencies can be a reason to iterate in your problem structuring steps and modify the problem formulation. For instance by identifying key interests in addition to those of the problem owner, that need to be taken into account – i.e. it is wise to at least ensure that the problem formulation recognizes the key interests of critical and dedicated actors.

The overview can also be used to identify existing or potential coalitions and alliances that might need to be established, encouraged or discouraged, mainly in relation to the dedicated and non-dedicated critical actors (compare Koppenjan, 1993). Thought needs to be given to the fact that seeking support and coalition building is not necessarily a remedy for

Actors

the presence of dedicated critical actors that may potentially block certain changes. Their status of critical actor gives them the power of veto to oppose majorities. Therefore the analyst also needs to indicate what opportunities there are to overcome differences and to avoid or defuse conflicts.

Another approach to coalitions and alliances may be to think about the actor constellation as a strategic game where the action (activation of the actor's means) by actor A may induce a re-action by actor B. The latter re-action might be either supportive or a counter-action, which in turn may seduce other actors in the arena to choose position and/or employ their means to support or counter the initiatives by A and B. Playing these kinds of virtual games may lead to the insight that only if special conditions are met, for instance only if critical actors A and B cooperate and both put in their means, a policy has a fair chance to succeed.

Finally, the analyst can reflect on possibilities to change the position of actors in the power/interest matrix. Are there ways to mobilize supporting 'context setters'? What could turn 'biting dogs' into 'sleeping dogs' or 'barking dogs' to prevent 'sleeping dogs' from waking up, or to raise the dedication from critical non-dedicated actors with supportive interests and objectives? The latter is typically done through education and awareness-raising activities or maybe even active engagement, participation and co-design. This line of thinking is similar to that discussed by Quan et al. (2019) to see where actors' abilities or power could be strengthened and where actors' interests or motivations need attention.

Difficulties and Pitfalls in Mapping Actor Interdependencies

Whether one uses a table or a matrix, one has to be aware of a number of difficulties and pitfalls when making and using a power-interest grid.

First, make sure that the overview table or power-interest grid is indeed consistent with the earlier tables and diagrams. This may sound obvious, but too often, power-interest grids show actors as 'low' on power that, according to the resources tables, are critical, or the other way around. The same applies to the problem formulation table and the depicted level of interest or support of actors. Action groups for instance may be very loud but lacking a real constituency and may have little means or actual influence. Therefore, make sure to use these tables to build your final overview table and power-interest grid.

Sometimes the actors have not determined their position yet, or they are internally divided. If this is the case, they should not be included in the table. The solution can be to distinguish between different units within composed actors, or to put question marks behind the positions of the actors and to include them, if necessary, with question marks in two cells. Assigning them a preconceived position might turn into a self-fulfilling prophecy and may be counter-productive.

The tables and maps were initially developed to be used for stakeholder analysis in relation to project design and implementation. In those cases, it is often easier to assess who is likely to support a specific project, and who is likely to oppose it (or parts of it). However, when the focus is on a policy problem, rather than a specific project, a range of solutions is still possible, and assessing support and opposition is likely to be conditional on the specific types of solutions one has in mind, and is linked to the level at which one looks at interests and objectives. At a higher level, interests may be similar among actors (e.g. in the case of New York, many actors may share an interest in good water quality in the watershed), but at the level of specific objectives, conflicts may arise (e.g. the objective of fewer agricultural activities in a specific part of a watershed). Therefore, when used to analyse policy problems, these tables and maps require a clear explanation of why certain actors are believed to be opposing or supportive.

Related to the previous point of attention, it is not uncommon that a first actor analysis results in an overview table with no critical opposing actors. If this is the case, it needs to trigger another, deeper, look at actors' objectives and perceptions. Because if really all critical actors would be in agreement, solving the problem at hand should be easy; all agree on what needs to be done and how. If you are facing a truly complex problem, this will not be the case.

4.4.6 Step 6: Confront the Initial Problem Formulation with the Findings

The last step of an actor and network analysis consists of the confrontation of the findings with the problem owner's problem formulation. The logical starting point here is the conclusion you have drawn based on the overview tables and power/interest diagram in the previous step. Use these as your basis. However, in addition to this summarizing step, also each of the previous contributing steps offers potentially interesting new insights. Therefore it is necessary to list the conclusions and insights from the different analysis steps, translating them into a list of potential threats and opportunities stemming from the characteristics of actors and networks. These conclusions, threats and opportunities may have consequences for:

- the content of the problem analysis,
- the interaction with actors,
- the system diagram and
- research activities.

Consequences that Relate to the Content of the Problem Analysis of the Analyst

This actor and network analysis will often be a reason for reformulating the problem. Possibly the core of the problem is different from the original one, a different demarcation is needed, other factors are noticed and causal relations are different.

Consequences that Relate to Dealing with Other Actors

The actor and network analysis can be used to inform the problem owner about the consequences of his problem formulation. Will it provoke resistance or support? Regarding which points? With which actors? It can indicate with which actors a fruitful cooperation is possible and from which actors opposition can be expected. The advice can also include involving actors with the further problem analysis or even to set up a future course interactively.

Consequences that Relate to the System Diagram

When a different problem demarcation is needed the system diagram may need to be adapted accordingly. The same is true when the analyst judges that major concerns of other, critical actors need to be taken into account. The latter may imply that additional outcomes of interest/criteria might need to be added. When means of those other critical actors are essential to reach the objectives these new means may need to be added to the diagram too. In this iterative way the system diagram is adapted to match the new insights. We will come back to this in Chapter 6.

Consequences Regarding Research Activities
Thirdly, knowledge gaps and new research questions may have been discovered that relate to the causal, substantial aspects of the problem situation, as well as to the social dimensions. These need to be specified at the end of the actor and network analysis. They are possible ingredients for the research approach that is presented in the plan of approach at the end of the issue paper.

Text box 4.6 has an example of consequences of the actor analysis for Delaware County, as the problem owner in the New York City drinking water problem.

Text box 4.6 Consequences of the actor analysis for Delaware County
The actor analysis for the New York City drinking water supply problem suggests that the problem owner, Delaware County, indeed faces a dilemma. However, the dilemma is not so much what specific pollution-reducing alternatives to implement and how to bear the costs of those. In fact, costs may be less of a problem than effectiveness. Money has been made available by New York City and New York State to support the implementation of measures. The sums available through various funds under the watershed agreement are considerable and may even help to improve the local farming system. However, health interest groups in New York City worry about the adequacy of pollution reduction measures to meet the water quality standards – and they may have a point. Nevertheless, given the apparent power and influence of the government coalition of New York State and City actors that favour pollution reduction, it will be difficult for Delaware County to object to the need for pollution reduction as something that is a questionable exercise. The current agricultural activities are not very profitable economically, and are still at risk of being further impaired by the pollution restrictions. This suggests an important knowledge gap. The problem owner should consider widening its problem formulation to look not only for means to reduce pollution but also for opportunities for economic development.

4.5 Points of Attention in Actor Analysis

Risks and pitfalls are manifold when executing stakeholder or actor analyses. Below we highlight some of the main points of attention, limitations and ways to cope with those.

4.5.1 Trustworthy Sources of Information

Real-world actor networks can be characterized as messy, dynamic and ill-defined systems. The task of an analyst is to provide some structure in this mess that allows him to extract some useful lessons for the problem formulation and interaction strategies of the problem owner. In this task, the analyst requires sound and trustworthy information on the characteristics and relations of the actors. Unfortunately, such information sources are not always easy to come by.

Information for an actor analysis can be obtained through *text analysis*: finding out perceptions, resources and objectives from written documents. On a generic level – and for an analysis of formal positions of actors – websites, annual reports and official policy statements may be available. However, when it comes to assessing actor perceptions and their informal relations and means of power, useful written sources of information are generally rare. This means that analysts will have to complement the information from written sources with interviews with the most important actors and with some key informants. This means that data collection often has to be done 'on-site', and is likely to require a substantial amount of time and resources.

Furthermore, getting access to actors and ensuring their collaboration, poses additional challenges – not everyone is willing to share their ideas with an analyst, or respondents may provide strategically distorted or desirable answers to questions, rather than speaking their minds truthfully.

To counter the risks and limitations inherent in any single source of information about actors' characteristics, the reliability of the information should be improved by comparing and cross-checking information from different sources, by expanding the number of interviews and questioning actors about each other's positions.

When there is a lack of data, problem perceptions, objectives, interests and/or dependencies can be *estimated* by the researcher, using logical reasoning based on the information that is available. However, here the researcher needs to be very careful. Estimations may be wrong, and there are many examples where problem owners or analysts hold the wrong assumptions about other actors' objectives or resources. In those cases, a problem owner might be in for a very unpleasant surprise, for instance when an alleged supporter turns out to be a fierce opponent, or when a 'sleeping dog' turns out to be wide awake.

Therefore, it is sometimes better to indicate that information is lacking. This means that there is a knowledge gap, which leads to the formulation of a research question for future research. But in any case, it is very important to indicate the sources of information used for an actor analysis, to indicate which information is based on estimations and to identify key assumptions that underlie the final conclusions and recommendations. When these are not specified, it has a negative impact on the reliability of the whole analysis – and it makes an analyst vulnerable to the justified criticism of a disappointed problem owner once he finds out the recommendations from an actor analysis are counter-productive!

Also remember that parties do not always have crystallized opinions and that these opinions can change. This information is especially interesting because it shows that there are possibilities to influence the realization of problem formulations and courses of solutions.

4.5.2 Actor Analysis Tries to Hit a Moving Target

The findings of the actor analysis result in a snapshot. Actors' problem perceptions change continually, as do their objectives, strategies and mutual relations. Actually the mere exercise of executing an actor analysis may influence the position and attitude of actors, for instance when they become aware of their (limited) power position in the game. This continual dynamic causes strategic and institutional uncertainty. This uncertainty needs to be taken into account. The possibility to discount this uncertainty in the analysis itself is limited. That is why it is important to be aware of the fact that the validity of the findings from an actor analysis is limited in time. The most important remedy is to re-execute the analysis after a period of time.

4.5.3 Some Important Limitations of Actor Analysis

The actor analysis classification is static, but actors are changing constantly. Allies today can be opponents tomorrow and vice versa. Furthermore, limits in access to information about actors may result in incorrect assumptions or black spots in the analysis. Therefore the problem owner can be thrown off guard by the results. As said before there is a risk that the actor analysis will work as a '*self-fulfilling prophecy*': because actors are carelessly earmarked and therefore treated as an opponent by the problem owner, they may feel left out and may start acting as an opponent.

The table and dependency maps can have a polarizing effect: they divide the field into actors that support or oppose the objectives of the problem owner as if there are no positions in the middle and as if the problem has only two extreme positions (for instance an environmental interest versus an economical interest). In reality there are often several potential positions which make it possible to bridge conflicts that focus on one dimension by focusing attention on other dimensions (van Eeten, 2006). Sustainability for instance might bridge the gap between environment and economy in the earlier example.

Finally, Scholes (1998) points out that analysing dependencies, with its focus on resources and power, entails a risk of losing sight of ethical considerations. For instance, dependency analysis may suggest minimal effort is required in relation to non-critical actors. However, these may well be disadvantaged groups in society for whom public policymakers have some responsibility in terms of improving their involvement; taking into account their interests and creating opportunities. This limitation can be addressed by using some other actor analysis methods, such as an 'ethical analysis grid' (Bryson, 2004), but it also helps if the analyst is aware of this, and pays special attention not only to the critical actors but also to those that are dedicated but non-critical.

4.6 Takeaways

- You cannot formulate a problem, and you cannot play a policy game, if you do not know who the players are and what the main rules of the game are.
- In policy analysis, games take place in arenas, where the players are called actors and where the rules are provided by institutions.
- Understanding actors starts with understanding the network and institutions and each actor's objectives, perceptions and resources.
- Actor analysis offers methods to investigate the actor characteristics to make explicit their interdependencies, and to support problem structuring.
- The described method provides a basis for problem structuring, but should not be treated as 'stable truth'. Caution is needed among others around information limitations and self-fulfilling prophecies.

References

Axelrod, R. (Ed.) (1976). *Structure of Decision. The Cognitive Maps of Political Elites.* Princeton: Princeton University Press.

Bennet, P., Cropper, S. & Huxham, C. (1989). Modelling Interactive Decisions: The Hypergame Focus. In: Rosenhead, J. (Ed.), *Rational Analysis for a Problematic World* (pp. 283-314). Chichester: John Wiley & Sons.

Bots, P. W. G., van Twist, M. J. W. & van Duin, J. H. R. (2000). Automatic Pattern Detection in Stakeholder Networks. In J. F. Nunamaker & R. H. Sprague (Eds.), *Proceedings HICSS-33*. Los Alamitos: IEEE Press.

Bougon, M. G., Baird, N., Komocar, J. M. & Ross, W. 1990. Identifying Strategic Loops: The Self-Q Interviews. In: A. S. Huff (Ed.), *Mapping Strategic Thought*. Chichester: John Wiley & Sons.

Brugha, R. & Varvasovszky, Z. (2000). Stakeholder Analysis: A Review. *Health Policy and Planning, 15*(3), 239-246.
Bryson, J. M. (2004). What to Do When Stakeholders Matter. Stakeholder Identification and Analysis Techniques. *Public Management Review, 6*(1), 21-53.
Coleman, J. S. (1990). *Foundations of Social Theory*. Cambridge: Harvard University Press.
Eden, C., & Ackermann, F. (1998). *Making Strategy: The Journey of Strategic Management*. London: Sage Publications.
Enserink, B. (1993). *Influencing Military Technological Innovation*. Delft: Eburon.
Fraser, N. M. & Hipel, K. W. (1984). *Conflict Analysis: Models and Resolutions*. New York: North-Holland.
Freeman, R. E. (1984). *Strategic Management. A Stakeholder Approach*. Boston: Pitman Publishing Inc.
Grimble, R. & Chan, M. (1995). Stakeholder Analysis for Natural Resource Management in Developing Countries. Some Practical Guidelines for Making Management More Participatory and Effective. *Natural Resources Forum*, *19*(2), 113-124.
Hanf, K. & Scharpf, F. W. (1978). *Inter-Organizational Policy Making*. Thousand Oaks: Sage Publications.
Hermans, L. M. (2005). *Actor Analysis for Water Resources Management. Putting the Promise into Practice*. Delft: Eburon.
Hermans, L. M., Beroggi, G. E. G. & Loucks, D. P. (2003). Managing Water Quality in a New York City Watershed. *Journal of Hydroinformatics, 5*(3), 155-168.
Hermans, L. M. & Cunningham, S. W., with contributions by M. de Reuver and J. S. Timmermans (2018). *Actor and Strategy Models. Practical Applications and Step-Wise Approaches*. Hoboken, NJ: John Wiley & Sons.
Hermans, L. M. & Thissen, W. A. H. (2009). Actor Analysis Methods and Their Use for Policy Analysts. *European Journal of Operational Research, 196*(2), 808-818.
Hipel, K. W., Fang, L. & Kilgour, D. M. (2008). Decision Support Systems in Water Resources and Environmental Management. *Journal of Hydrologic Engineering, 13*(9), 761-770.
Howard, N. (1971). *Paradoxes of Rationality: Theory of Metagames and Political Behavior.* Cambridge, MA: The MIT Press.
Howard, N. (1989). The Manager as Politician and General: The Metagame Approach to Analysing Cooperation and Conflict. In Rosenhead, J. (Ed.), *Rational Analysis for a Problematic World* (pp. 239-261). Chichester: John Wiley & Sons.
Jobert, B. (1989). The Normative Frameworks of Public Policy. *Political Studies, 37*, 376-386.
Johnson, G., Scholes, K. & Whittington, R. (2005). *Exploring Corporate Strategy*. Essex: Prentice Hall/Financial Times.
Keeney, R.L. (1992). *Value-Focused Thinking. A Path to Creative Decisionmaking*. Cambridge, MA: Harvard University Press.
Kenis, P. & Schneider, V. (1991). Policy Networks and Policy Analysis: Scrutinizing a New Analytical Toolbox. In Marin, B., Mayntz, R. (Eds.), *Policy Networks. Empirical Evidence and Theoretical Considerations*. Frankfurt am Main: Campus Verlag.
Klijn, E. H. (1997). Policy Networks: An Overview. In W. J. M. Kickert, E. H. Klijn & J. F. M. Koppenjan (Eds.), *Managing Complex Networks. Strategies for the Public Sector* (pp. 14-34). Thousand Oaks: Sage.

Korbee, D., Nguyen, H. Q., Hermans, L. M. & Phi, H. L. (2019). Navigating the Bureaucracy: An Analysis of Implementation Feasibility for the Mekong Delta Plan, Vietnam. *Journal of Environmental Planning and Management*, 62(9), 1545-1561.

Kok, W. (1981). *Signalering en Selectie*. Achtergrondstudie nr. 3, uitgebracht aan de Commissie Hoofdstructuur Rijksdienst, Den Haag.

Koppenjan, J. F. M. (1993). *Management van de beleidsvorming. Een studie naar de totstandkoming van beleid op het terrein van het binnenlands bestuur*. Den Haag: VUGA.

MacArthur, J. (1997). Stakeholder Analysis in Project Planning: Origins, Applications and Refinements of the Method. *Project Appraisal, 12*(4), 251-265.

Mayer, I. S., van Daalen, C. E. & Bots, P. W. G. (2004). Perspectives on Policy Analyses: A Framework for Understanding and Design. *International Journal on Technology, Policy and Management, 4*(2), 169-191.

McDaniels, T. L., & Thomas, K. (1999). Eliciting Preferences for Land Use Alternatives: A Structured Value Referendum with Approval Voting. *Journal of Policy Analysis and Management, 18*(2), 264-280.

McKeown, B. & Thomas, D. (1988). *Q-Methodology*. Newbury Park: Sage.

Mitroff, I. I. (1983). *Stakeholders of the Organizational Mind. Toward a New View of Organizational Policy Making*. San Francisco: Jossey-Bass.

National Research Council (NRC). (2000). *Watershed Management for Potable Water Supply: Assessing New York City's Approach*. Washington, D.C.: National Academy Press.

New York Times. (2018). *A Billion-Dollar Investment in New York's Water*. By Winnie Hu. New York Times, 18 January 2018. www.nytimes.com/2018/01/18/nyregion/new-york-city-water-filtration.html

Nguyen, H. Q., Korbee, D., Ho, H. L., Weger, J., Thanh Hoa, P. T., Thanh Duyen, N. T., Manh Hong Luan, P. D., Luu, T. T., Phuong Thao, D. H., Thu Trang, N. T., Hermans, L., Evers, J., Wyatt, A., Chau Nguyen, X. Q. & Phi, H. L. (2019). Farmer Adoptability for Livelihood Transformations in the Mekong Delta: A Case in Ben Tre Province. *Journal of Environmental Planning and Management, 62*(9), 1603-1618.

North, D.C. (1994). Economic Performance Through Time. *The American Economic Review*, 84(3), 359–368.

Ostrom, E. (2005). *Understanding Institutional Diversity*. Princeton: Princeton University Press.

Overseas Development Institute (ODI). (2010). *The Alignment, Interest and Influence Matrix (AIIM) Guidance Note*. Prepared by Enrique Mendizabal. Overseas Development Institute (ODI).

Phi, H. L., Hermans, L. M., Douven, W. J. A. M., Van Halsema, G. E. & Khan, M. F. (2015). A Framework to Assess Plan Implementation Maturity with an Application to Flood Management in Vietnam. *Water International, 40*(7): 984-1003.

Quan, N. H., Patino Guerro, J. D., Korbee, D., Luan, P. D. M. H., Dung, T. D., Hung, D. Q, Loc, H. H. & Hermans, L. (2019). *Manual for Application of the MOTA Framework*. Centre of Water Management and Climate Change (WACC) Vietnam National University, Delft University of Technology and IHE Delft. https://strategic-delta-planning.un-ihe.org/sites/strategic-delta-planning.un-ihe.org/files/quan_mota_manual_-_version_1.pdf.

Rhodes, R. A. W. & Marsh, D. (1992). *Policy Networks in British Government*. Oxford: Oxford University Press.

Roe, E. (1994). *Narrative Policy Analysis: Theory and Practice*. Durham: Duke University Press.
Saaty, T. L. (1990). How to Make a Decision: The Analytic Hierarchy Process. *European Journal of Operational Research, 48*, 9-26.
Sabatier, P. A. (1988). An Advocacy Coalition Framework of Policy Change and the Role of Policy-Oriented Learning Therein. *Policy Sciences, 21*, 129-168.
Scharpf, F. W. (1997). *Games Real Actor Play. Actor-centered Institutionalism in Policy Research*. Boulder, CO: Westview Press.
Scholes, K. (1998). Stakeholder Mapping: A Practical Tool for Managers. In V. Ambrosini, G. Johnson & K. Scholes (Eds.), *Exploring Techniques of Analysis and Evaluation in Strategic Management* (pp. 152-168). Essex: Prentice Hall/Financial Times.
Scott, J. (1991). *Social Network Analysis: A Handbook*. London: Sage.
Stokman, F. N. (1994). Besluitvormingsmodellen binnen beleidsnetwerken (Decision making models in policy networks, in Dutch). In Huberts, L. W. J. C. & Kleinnijenhuis, J. (Eds.), *Methoden van Invloedsanalyse*. Amsterdam: Boom uitgevers.
Thomson, R., Stokman, F. & Torenvliet, R. (2003). Models of Collective Decision-Making: Introduction. *Rationality and Society, 15*(1), 5-14.
Timmermans, J. S. (2004). *Purposive Interaction in Multi-Actor Decision Making*. The Netherlands: Eburon, Delft.
Toulmin, S. E. (1958). *The Uses of Argument*. Cambridge: Cambridge University Press.
van Eeten, M. J. G. (2006). Narrative Policy Analysis. In F. Fischer, G. J. Miller & M. S. Sidney (Eds.), *Handbook of Public Policy Analysis: Theory, Methods, and Politics* (pp. 251-269). Boca Raton: Taylor & Francis CRC Press.
Wasserman, S. & Faust, K. (1994). *Social Network Analysis: Methods and Applications*. Cambridge: Cambridge University Press.

5 Exploring the Future

'Prediction is very difficult, particularly if it is about the future.'
Nils Bohr

'My interest is about the future, because I am going to spend the rest of my life there.'
C.F. Kettering

'If you have to forecast, forecast often.'
E.R. Fiedler

The quotes, derived from a website about forecasting,[1] illustrate the key dilemma of exploring the future: 'we can't know the future'. It is not possible to predict the future accurately, but at the same time exploration of the future is extremely relevant because most of our actions are aimed at what lies ahead. The second quote indicates why exploring the future is relevant. As we and next generations will be living this future, it is interesting and necessary to continuously think about what lies ahead as indicated by the third quote. One of the most urgent demonstrations of the above are of course the IPCC Climate Change Scenarios, which are updated continuously. Moreover, the need for change to happen to save the world for future generations could not have been expressed more urgently than by the then sixteen-year-old climate activist Greta Thunberg with her *'How dare you'* speech at the U.N.'s Climate Action Summit in New York City in September 2019. Starting from various analytic methods for exploring our uncertain future, this chapter gives you the basic tools to start building scenarios.

5.1 Introduction

In the context of policy analysis, we deal with *expectations* and *explorations* of the future as opposed to *predictions*. Predictions are attempts to make absolute statements about the future, while expectations and explorations are judgements about plausible future developments. When it comes to the problem analysis, we mostly speak about explorations of the future as a way of dealing with uncertainties. It is the objective of exploration of the future not to predict *the* future, but to explore *plausible* futures, so analysts and problem owners become aware of the *uncertainties* of and around their policy problem. This exploration can relate to the development of the nature and seriousness of the problem, the effects of possible solutions in the future, as well as to the possible futures and environments of the problem.

Meijer and Korving (2001) cover these different uncertainties succinctly in their research of maintenance and improvement of sewer systems. They sketch different types of uncertainty: uncertainty about the behaviour and volumes of existing sewer systems and sewer

1 For the hobbyists: https://blogs.cranfield.ac.uk/cbp/forecasting-prediction-is-very-difficult-especially-if-its-about-the-future/; https://www.brainyquote.com/quotes/charles_kettering_163122 ; https://www.brainyquote.com/quotes/edgar_fiedler_130302 (all visited June 2022).

drains, and uncertainty about the future situation: rainfall volumes, size of the catchment area, volumes of effluent as well as changing environmental norms. The first category of uncertainties (behaviour and volumes) can be addressed through extensive measurements, modelling and simulation studies. The second category of uncertainties in the wider context of the sewer system can be studied by using other (climate) models and more qualitative scenarios. But all these models and research will not remove all uncertainty because uncertainties will continue to arise in the future. Figure 5.1 depicting the so-called uncertainty trumpet (Rosenhead, 1989) illustrates this phenomenon.

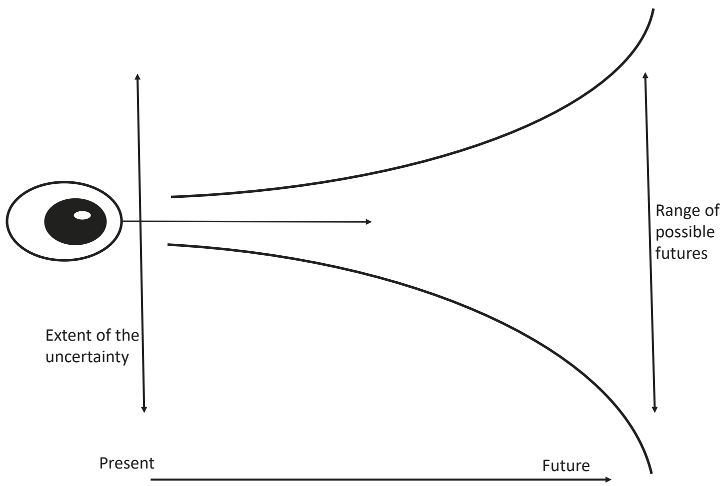


Figure 5.1 The Trumpet of Uncertainty, inspired by Rosenhead (1989)

Considering the relevance of exploring the future to problem-solving, it is not surprising that a whole spectrum of approaches is available for exploring the future. Short-term and long-term uncertainties differ strongly in character and therefore ask for different approaches. In this chapter, we limit ourselves to exploring the middle and long term and start with a brief discussion of two classes of methods, namely formal methods (often based on models) and expert methods. Thereafter, we discuss the design and use of scenarios for policy analysis. Different classifications of scenario methods are presented, a process for developing context scenarios is introduced and an illustration of this process is given.

5.2 Analysing and Classifying Uncertainties

The notion of uncertainty has taken different meanings and emphases in various fields, including the physical sciences, engineering, statistics, economics, finance, insurance, philosophy and psychology. Broadly speaking, uncertainty means limited knowledge about future, past or current events. With respect to policy-making, the extent of uncertainty clearly involves subjectivity, since it is related to the satisfaction with existing knowledge, which is coloured by the underlying values and perspectives of the policy-maker (and the various actors involved in the policy-making process).

One thing to emphasize is that uncertainty is not simply the absence of knowledge. Uncertainty is a situation of inadequate information, which can be of three sorts: inexactness, unreliability and bordering on ignorance (Funtowicz & Ravetz, 1990). However, uncertainty can arise also easily in situations in which ample information is available (van Asselt & Rotmans, 2002). For example, despite thirty years of research into the extent of future climate change, the estimated range of possible future global mean temperatures has only increased. Furthermore, new information can either decrease or increase uncertainty. New knowledge on complex processes may reveal the presence of uncertainties that were previously unknown or were understated. In this way, more knowledge illuminates that our understanding is more limited or that the processes are more complex than previously thought (van der Sluijs, 1997).

Uncertainty as inadequacy of knowledge has a very long history, dating back to philosophical questions debated among the ancient Greeks about the certainty of knowledge and perhaps even further. Its modern history begins around 1921, when Knight made a distinction between risk and uncertainty (Knight, 1921). According to Knight, risk denotes the calculable and thus controllable part of all that is unknowable. The remainder is the uncertain, incalculable and uncontrollable. Since Knight, a wide variety or researchers have adopted, adapted or extended this distinction between risk and uncertainty.

More recently, Walker et al. (2003) suggested understanding uncertainty as a multidimensional concept. They distinguish three dimensions: level, location and nature. The 'level' of uncertainty has to do with the severity of the uncertainty and extends the distinction made by Knight. The level of uncertainty ranges from complete certainty to total ignorance and Walker et al. (2003) distinguish between the levels of statistical uncertainty, scenario uncertainty and recognized ignorance. Statistical uncertainty we know best from the natural sciences; it is about measurement uncertainty, inaccuracy, sampling errors and probabilities in stochastic models. Scenario uncertainty deals with the external environment beyond the system that is studied, as scenarios do not forecast or predict the future but indicate what might happen. Recognized ignorance is uncertainty about the system and mechanisms being studied; we know that we do not know how the system works. The 'location' dimension is used to specify what the uncertainty is about. Often case-specific operationalizations of the location dimension are used because of this. For example, the system diagram (see Chapter 3) can be used to specify whether one is uncertain about external factors, relationships within the system, the outcomes or their relative importance, or factors within or outside the control of the decision-maker. Finally, the 'nature' dimension is a bit more philosophical and has to do with whether the uncertainty is intrinsic to the world itself or due to imperfections in our knowledge of the world. Uncertainty intrinsic in the world includes for example the uncertainty about the toss of a coin or the roll of a die. Uncertainty due to imperfections in our knowledge can arise either due to not knowing enough or due to conflicting information and knowledge.

This multidimensional understanding of uncertainty has proven to be very fruitful. It for example underpins the guidance for dealing with uncertainty used by the Dutch National Institute for Public Health and the Environment (RIVM) when discussing COVID-19 infection-spreading models or the Netherlands Meteorological Institute (KNMI) when making climate models. For more detailed discussions, see for example Kwakkel et al. (2010), Walker et al. (2013) or Marchau et al. (2019).

5.3 Overview of Methods for Exploring the Future

There are many ways to structure the field of futures studies. For reasons of simplicity, we will distinguish formal methods, expert consultation and scenario studies. The latter will be treated to a larger extent as we find them fit better when analysing complex problems. The final section will be on studies 'beyond scenarios' and showcasing more recent developments like exploratory modelling and adaptive policy pathways.

5.3.1 Formal Methods

Formal methods are methods where a formal, verifiable and, in many cases, a mathematical approach is used. Formal methods presume an often causal relation between two or more factors of social, economic or technical nature. Most formal methods for exploring the future are based on some form of extrapolation: past trends, based on time series or theories about underlying mechanisms, are identified and extrapolated. Although this approach faces many potential pitfalls (we know that the future will bring changes, just not which ones), it is often one of the least bad alternatives (we often do not know enough about future changes to be able to make some sensible statements about them). The simplest approach is to presume that the near future will be like the present: 'Tomorrow's weather will probably resemble today's'. However, if we have insight into certain trends or mechanisms behind changes, it is wise to also base the extrapolation on these insights. This means building a model, assuming that the mechanisms that are part of the model will also be valid in the future.

The models can be very diverse in nature depending on the existing insights into, and knowledge, and theories of the phenomenon of interest and the objectives of the exploration. Take for example weather and climate forecasting. Very complex atmospheric models are used for daily weather forecasting. But when dealing with long-term expectations (such as forecasts for temperature and sunshine on 21 July in ten years' time), those complex models are pointless, and a simpler approach can be used: the long-standing statistical average. This expectation is based on the 'model' of the yearly season cycle, and the – questionable – presumption that no large climate changes will occur within this time frame. Climate changes forecasts over an even longer term (e.g. 50 or 100 years); others again use sophisticated mathematical models to explore possible climate changes because of, for instance, global warming. However, these models are not used to describe the weather at a particular location on a particular point in time, but rather to understand the aggregate patterns at country or even larger scales.

We will limit ourselves here to several methods that are relevant in policy analysis, of which you need to know the principles, their uses and their limitations. In policy analysis, these methods are mostly used for investigating social developments, and environmental and technological changes, for gaining insight into how the severity of the problem might change or how possible policies might play out. In short, it is about exploring the gap between the present and desired situation or about the gap between the desired and expected future situation. We discuss four classes of formal methods. With an increasing complexity of the underlying assumptions, these are:

– trend extrapolation and regression analysis;
– analogies;
– causal modelling;
– trend impact assessment (TIA).

Trend Extrapolation

The basic concept of trend extrapolation is simple: past trends, based on time series or theories about underlying mechanisms, are identified and extrapolated. In mathematical terms, a relationship between independent variables ($X_1, X_2 \ldots X_n$) and the dependent variable (Y) is developed:

$$Y = f(X_1, X_2 \ldots X_n)$$

This correlates well with past performance. This formula is then extrapolated to obtain a figure for the year under examination. The result should be realistic, based on the latest available data, reflect the current conditions of the system concerned, supported by other information in the study, and provide an adequate justification for further analyses.

How is a trend extrapolation done? The first step is to identify the dependent variables (the Ys) that are to be estimated through extrapolation. The next step is to gather and analyse the data on the related independent variables (the Xs), which are assumed to influence the variables of interest. The data should be analysed to see whether they are appropriate and not 'contaminated' by unique events. For example, when estimating the potential future traffic at an airport, major sport events like the Olympics, which create a temporary boost to air traffic, contaminate the data.

The third step is to select a method for extrapolation. Potential methods include regression and trend analysis and share analysis. Share analysis is a straightforward method where a higher level trend extrapolation is translated, based on historical data, into an extrapolation for a smaller area. Regression analysis is more complicated, but the basic concept is that the variables of interest are estimated based on other variables that explain the estimated value. Historical data are used to develop a 'best fit' formula. Trend analysis relies on projecting historic trends into the future; it is a type of regression analysis with time being the independent variable.

After applying the selected trend extrapolation method, the results must be evaluated. Evaluating the results is essential. The outcomes should be reasonable, and unexpected outcomes should be justified and explained. For example, in regression analysis, the signs of the coefficients in the equation should make logical sense.

The last step in forecasting is to summarize and document the results. The report should explain the trend extrapolation method used, highlight the relevant assumptions, present the outcomes of the trend extrapolation, and evaluate both the outcomes of the extrapolation and the extrapolation process.

Trend extrapolation is commonly used, especially for making a reasonable case for the expected occurrence of shortages or overspills in the future. An example of a trend extrapolation can be found in Figure 5.2, which illustrates how the Food and Agriculture Organization (FAO) of the United Nations uses extrapolation to illustrate the expected development in the world's feed use of cereals and oilcakes. The graph nicely shows the historical data till 2007 and their extrapolation into the future, suggesting that the growth in use of cereals can be expected to be steeper than the one in oilcakes. Trend extrapolation is based on the idea of identifying trends and underlying mechanisms, based on the past and the present, and extrapolating them forward. However, it might be that the phenomenon to be extrapolated has recently undergone changes or is expected to undergo changes soon (e.g. trend breaks). In such situations, it is unwise to simply extrapolate based on past trends and known underlying mechanisms. In such cases, Trend Impact Assessment (generally known as TIA), which is discussed later, might provide a way out.

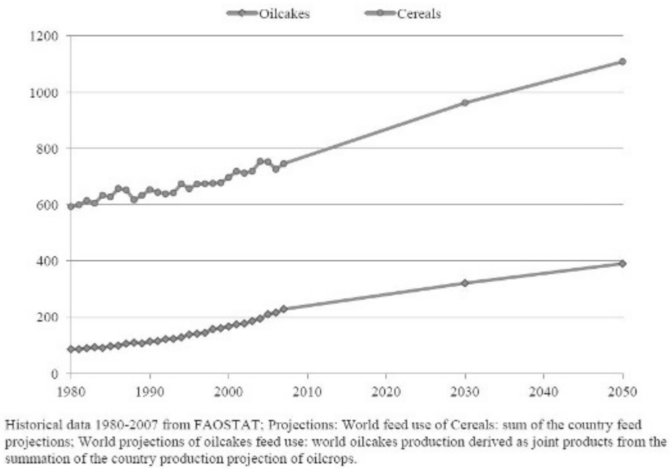


Figure 5.2 World feed use of cereals and oilcakes (million tonnes) (Source: Nikos Alexandratos and Jelle Bruinsma, World Agriculture Towards 2030/2050 The 2012 Revision. ESA Working Paper No. 12-03 June 2012 Agricultural Development Economics Division Food and Agriculture Organization of the United Nations www.fao.org/economic/esa)

More elaborate descriptions and examples of these methods can be found in, among others, Porter et al. (1991), Bell (1997), van Daalen et al. (1999), and Guess and Farnham (2000).

Extrapolation with the Help of Analogies

Analogies are deeply rooted in our culture and language. For example, horsepower is still used to describe engine power. A car model introduced in 1948 at the Parisian car-salon, and still popular today, got its name from this: the *deux chevaux*. The use of analogies is strongly interwoven with our ability to reason and is a consciously or unconsciously applied learning strategy. Examples and experiences from other fields help us to find a way to understand new challenges and/or to come up with solutions.

Extrapolation with the help of analogies is based on the assumption that a development in the future will run analogically to a development in the past – and that similar mechanisms will occur. Analogies presume that the world is less simple than often assumed in linear trend extrapolations. Analogies try to make a statement about the structure behind the changes. A distinction can be made between historical and growth analogies. Historical analogies presume that historical processes run analogically. An example is the way of thinking about the rise and fall of the contemporary world powers, such as the former Soviet Union and now the United States, by comparing them with, for example, the decline and fall of the Roman Empire, or the collapse of British Empire. Growth analogies make an analogy between, for example, the development of technologies with biological and other processes (evolutionary, quasi-evolutionary processes). The analogy between the growth patterns of biological systems and technological functions was formulated for the first time by Ralph Lenz in 1962 (Lenz, 1962). He used the so-called 'Pearl's growth law'. Pearl based his law on his observations of the growth speed of yeast cells and the weight gain of pumpkins and other biological processes. These Pearl growth curves are also known as the S-curve and are often used in economics, as substitution curves (life cycle of subsequent products), to deduce learning curves (Marchetti, 1980) and to describe the course of innovation processes.

More specifically, in economics the Gompertz curve, a variant of the Pearl curve, is often applied to explain increases in product sales. In the literature, you can find different mathematical expressions for the Gompertz law. Examples are:

$\ln y_t = p + qr^t$ or:

$$y_t = e^{p+qr^t}$$

with $0 < r < 1$ and $q < 0$, where $\ln y_t$ is the natural logarithm of the variable that needs to be explained, t is the value of the time variable and p, q and r are the constants that need to be determined. The limit value L of the variable that needs to be explained is given in: $L = e^p$. Just as in the biological growth analogy, the increase is a function of the achieved state and of the difference between the limit and the achieved state, because:

$$\frac{dy_t}{dt} = -y_t \ln|r|(\ln L - \ln y_t)$$

In Figure 5.3, the result of the formula above is exhibited for p = 3, q = −3 and r = 1/4.

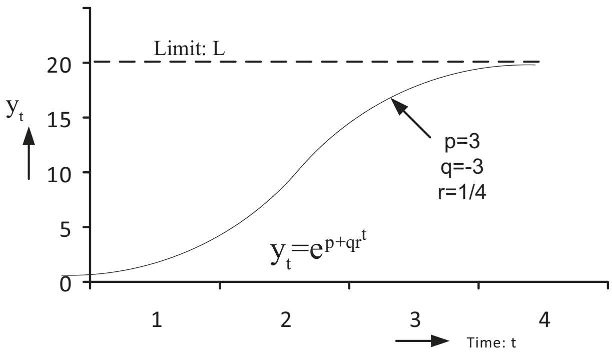


Figure 5.3 Graphic representation of a Gompertz curve

A modern and frequently used analogy is the quasi-evolutionary theory of technology development, where processes of variation and selection occur in the 'wild' nature, analogous to the evolution of species. Here a technology is placed in a selection environment, where it looks for a niche to develop further. Analogies can also be used in the context of trend extrapolation. The structure of the function is then derived from an analogy. There are, however, dangers with such an approach. For example, there are the pitfalls of false causality and false analogy. In addition, why would we assume that processes that in the past appeared to be analogous will continue to be analogous in the future? These kinds of deductions have no verifiable value, especially according to philosopher of science Karl Popper. On the contrary! Let this be a warning. There is no evidence to presume that the apparent correlation between the intensity of solar radiation and the stock exchange will continue in the future, or even that changes in solar radiation could be the cause of fluctuations in the stock exchange (see Figure 5.4). That is why the Dutch Financial Authority obligates product suppliers to mention in all their advertising that 'results from the past are by no means a guarantee for future results'.

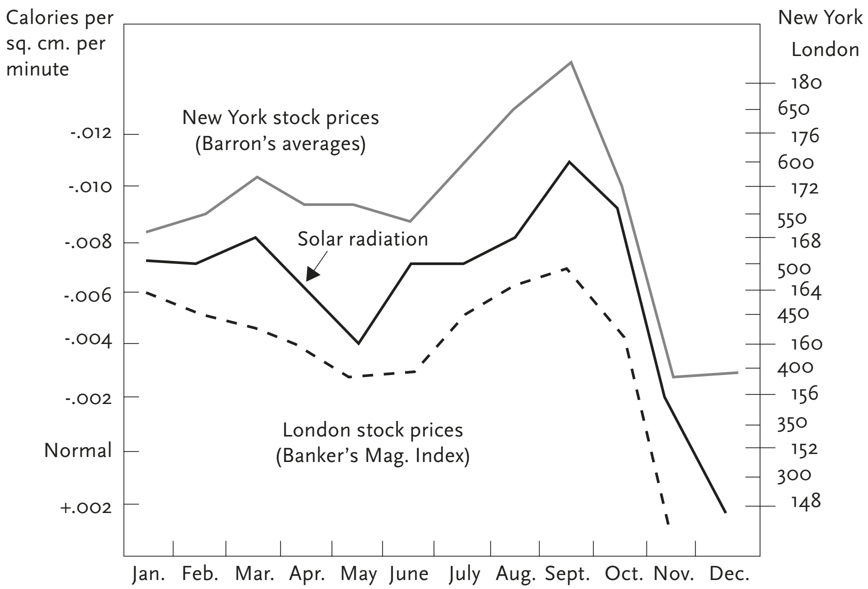


Figure 5.4 New York stock prices and solar radiation (Source: Garcia-Mata & Schaffner, 1934)

Analogy has a strong symbolic meaning, but it also has its limitations. Wise (1976), who investigated the use of explorations of the future in the United States, reached the following conclusions:

> Analogies cannot prove relationships but they can suggest them 'and' some analogies have proved prophetic.... Television as predicted followed a course of public acceptance analogous of that of radio. And both electricity and electronics had social effects analogous to that of the steam engine.... However, past predictions also indicate clearly two main defects of analogy as a predictive technique. Frequently, the items chosen for comparison are inappropriate; and frequently analogy is carried too far.

Even when areas seem to be similar, it can be dangerous to presume an analogy. An example is the revolutionary change in warfare by the introduction of the atom bomb at the end of the Second World War. After Hiroshima and Nagasaki, it was clear that this was a category of weaponry that was not suited for operational use on the battlefield. It took almost ten years, however, before the American Air Force (USAF) also reached the conclusion that the character of strategic warfare had changed fundamentally and that atom bombs were not the same as conventional bombs. Until Eisenhower came forward with his 'New Look' doctrine in 1953, the USAF stuck to the massive use of heavy bombers for 'carpet bombing', as their leading strategic concept and many air force generals viewed nuclear weapons as 'just another bomb' (Enserink, 1993).

Yet the use of analogies is still popular, mainly when it comes to technological innovation and introducing new products onto markets. Here, the aforementioned S-shaped introduction/acceptance curve is often used, where the curve is adapted to the inherent nature of the product or market that is being explored. Marketing lifespans play an important role here. For many technologies, a lifespan of five to ten years is characteristic from the basic prototype to complete market penetration. However, this lifespan can be twenty to twenty-five years from the time the first idea originated to and widespread social application, particularly in the case of so-called 'large technological systems'. An example of a product type with a high rate of circulation is the computer chip. Every two to four years, a new generation penetrates the market. In contrast, the development of a new type of airplane takes easily ten years and market penetration even longer. There are many examples varying from large-scale public traffic and energy supply systems to technologically complex systems such as bombers or high speed trains, with extremely long lifespans of twenty-five years or more.

Causal Maps

Technology forecasting is usually based on the simple extrapolation of historical developments based on a presumed (often simple) connection with historical data. In the United States, technology forecasting started in the 1950s and 1960s to develop policies regarding strategic technologies. In retrospect, the approach seems rather primitive because the uncritical extrapolation of trends leads to serious misconceptions. The technological lead of the Soviet Union in missile technology combined with extrapolated numbers about the composition of the Soviet weapon arsenal caused in the United States to the so-called defence panics: the 'bomber gap' and the 'missile gap'. This panic in turn caused gigantic financial injection in the American defence industry, which in turn became a driving force for the arms race in the following decennia (Enserink, 1993).

More advanced statistical models are open to the same criticism. They implicitly assume that all relevant information about future developments is present in historical data, and with that they ignore insights and knowledge about factors that can have an important influence on the variable that needs to be explored (e.g. changes in average household size that influence the use of drinking water per household), but that are overlooked because no data are available, or data are not included.

In general, development is a complex process, where social, economic, political, technical and normative factors play a role. Objections to trend extrapolation can be countered to an extent by using causal maps (instead of statistical models or simple analogies), where available insights into the causal mechanisms behind changes are included. Since the end of the 1960s, computer technology has offered more and more opportunities to build and analyse complex non-linear mathematical models. Since then, we have witnessed an increasing use of causal mathematical models to support the exploration of the future. The type of models used depends on the objective, available knowledge and the type of causal mechanisms that are presumed to be crucial. For this, we refer to related literature. Suffice it here to mention some examples typical of causal modelling used to support the exploration of the future.

A first example is the development of long-term 'global models' at the beginning of the 1970s, inspired by the 'Club of Rome'. By using the 'System Dynamics' modelling approach, under development back then, the causal connections between economic growth, population growth, food production, exhaustion of natural resources, and harm to the environment were described in a complex simulation model and extrapolated far into the future (until 2100). This led to projections that warned about exhaustion of natural resources, harm to the environment, and famine because of unrestrained economic and population growth. The results received a lot of attention in the media and were used mainly by environmental pressure groups. When it became clear that the model was not predicting accurately, heated discussions about the degree of reality of the underlying model erupted. After this, more long-term models were built, often more detailed and aimed at one specific aspect. For example, in the last decennia, large investments were made in the development of long-term climate models that serve as a base for the exploration of possible climate changes because of greenhouse gas emissions.[2] These models are extremely complex simulation models that consist of many thousands of equations. A second example, in a completely different area, is the Netherlands Bureau for Economic Policy Analysis (in Dutch CPB). They make extensive use of mathematical models to support the economic exploration of the future. Almost every area has its own interpretation of the use of mathematical models for the exploration of the future. In general, these kinds of long-term explorations of the future are very vulnerable to criticism. For example, an evaluation of experiences with global modelling using System Dynamics was given the title 'Groping in the Dark' (Meadows et al., 1982).

Causal mathematical models have the advantage that a wide range of knowledge can be included. However, there are also significant disadvantages: the mistaken impression of preciseness and reliability (the results are quantitative, and computers do not make mistakes). Furthermore, a crucial implicit assumption in these models is that the mechanisms that have been dominant in the past will also be dominant in the future. Moreover, mathematical models can quickly become so complicated, opaque and incomprehensible that it becomes hard even for experts to make statements about their reliability.

Trend Impact Assessment

An important point of criticism on the foregoing methods is the assumption of continuity. TIA (sometimes also called cross-impact assessment) builds on the above-mentioned methods. However, the explicit point of departure is that future happenings (such as policy changes, but also technological breakthroughs or changes in social norms and values) could lead to trend breaks. TIA tries to estimate:

– which factors or sudden events could lead to changes;
– what the probability is of these kinds of factors or events;
– how large their impact could be on the central outcomes of interest.

2 See also IPCC Working Group I Fourth Assessment Report 'The Physical Science Base' (2007).

TIA combines predictable extrapolation with judgements about the probability and the possible effects of trend-breaking events. Identifying these plausible and influential events is usually done using literature studies, and brainstorming, or a *Delphi* setting (see Section 5.3.2).

For instance, in the example below, the authors of the Millennium Project report 2008 State of the Future use trend impact analysis to sketch how the State of the Future Index (SOFI) may develop over the coming years (see Figure 5.5). SOFI is a measure of the ten-year outlook for the future based on the previous twenty years of historical data. SOFI is based on a set of twenty-nine variables that was identified by an international panel of experts. The global SOFI indicates that the future over the next ten years keeps improving although not as rapidly as it did over the past twenty years. The alternative projections are based on the potential occurrences of events, such as ethnic wars, diseases, changing energy demands, democratic and women's rights and other events that can alter trends.

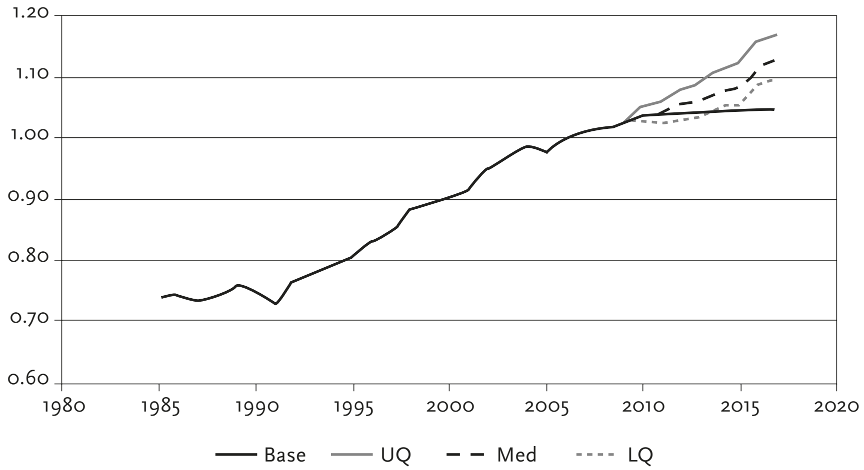


Figure 5.5 SOFI 2007 with alternative projections by trend impact analysis (Source: Glenn et al. 2008. See: https://www.researchgate.net/publication/265071438_Futures_Review_Looking_at_Previous_Global_Futures/figures?lo=1)

In TIA, the analyst is forced to think about plausible important events in the future, which obligates the analyst to make the assumptions explicit. A discussion with policy-makers can then take place at a more detailed level. TIA provides a range of possible results instead of one single result, which makes it possible to take future uncertainties explicitly into account. TIA can be used for a quantitative support of scenarios; we return to this later in this chapter.

5.3.2 Consulting Experts

Formal methods are based on fixed data and they use approaches that are seen as objective. This perceived objectivity, however, is, limited because personal judgement of the model builders plays a major role and different experts produce different models and results. That is why direct consultation with experts is often used as an alternative way to gather information about possible future developments. The knowledge and insights of experts can be collected in different ways, depending on the objective and the means (time and money) of the researcher. The first question that needs to be asked is which experts need to be consulted and subsequently what the most suitable research method is considering its objectives and essential preconditions. Frequently used methods are interviews, questionnaires, meetings, nominal group technique, the Delphi method and workshops. All of these may be supported by computer processing for analysis. This section deals with the choice of experts and the method of questioning that needs to be followed. The *Delphi* method, which is specifically developed to support explorations of the future, is explained in detail.

Selection of Experts

To make strategic decisions aimed at the future, it is crucial to gather information about the existing condition of a system and about plausible future developments of the system and its environment. Therefore, fundamentally different kinds of knowledge and expertise are necessary to be able to take an informed decision. Schnaars (1989) labels these two kinds of expertise as *fact* and *opinion*. It is about knowledge of the actual situation on the one hand, and informed ideas about plausible developments on the other hand. Although bias may exist in collecting knowledge about the existing situation, this effect can be partially compensated by *cross-checking* of opinions (although in group situations the danger of *groupthink* remains). When formulating ideas about the future, diverging opinions are inevitable and consensus is actually not desirable! Selecting the right experts is of crucial importance to the task at hand. A suitable expert is someone who:

– has substantial knowledge of a certain field;
– is not afraid to deal with the uncertainty and to explore the boundaries of his or her area of expertise;
– has the power of imagination.

Relevant here is the table with criteria for self-evaluation for experts, where Lipinski and Loveridge (1982) indicate how someone can assess for himself whether he is an expert or just an informed layman.[3] This can also be a useful lead for the analyst who needs to select the experts. Porter (1991), for example, uses this classification within his own comparative research of technological development and the innovative ability of countries to be able to weigh the judgements of the experts in his international panels. Table 5.1 is based on Lipinski and Loveridge (1982).

Table 5.1 Criteria of self-evaluation: manual for self-judgement of expertise

1. Unfamiliar	You are not familiar with the subject when mentioning it does not recall any memories or it does not give lead to saying something sensible about it.
2. Accidentally familiar	You are accidentally familiar with the subject when you know what it is about, you have read something about it or you heard or saw something about it on the radio or television.

3 See also Porter et al. (1991).

3. Familiar	You are familiar with the subject when you know most arguments pro and contra the most controversial elements of the subject, when you have read a lot about it and when you have formed an opinion. However, were someone to attack your opinion, you would have to quickly admit that you do not know enough.
4. Former expert	You used to be an expert on the subject some time ago, but your knowledge is somewhat outdated because other activities came up. But you are still reasonably well informed about recent developments, which provides you with a broad overview of the subject as opposed to deep detailed knowledge.
5. Expert	You should consider yourself as an expert when you belong to the small community of people who, at this moment, study, work on and are dedicated to this subject. You typically know who else works on this subject, you know the domestic literature and probably also the international literature about this subject; you go to conferences and seminars and when possible you publicize about the subject. Other experts can differ in opinion about this subject with you, but that does not make you nervous.

The choice of the technique for the consultation of experts depends on the objectives and the means of the researcher. The following factors play a role in choosing the technique (see Porter et al., 1991: 205):

– Logistics – the available time and finances determine to a large extent the possibilities. Financial restrictions mean that only a few interviews, a single small workshop, or a simple questionnaire without feedback to the respondents is possible.
– The degree to which feedback and interaction are desired. When regular exchanges of thought with and between experts are desired, interactive methods can be considered. If this is not so important, then a questionnaire or a series of interviews may suffice.
– The range of available expertise that is considered relevant. This influences the size of the group. Usually, the starting point is groups of eight to twelve persons to have sufficient breadth. Sometimes, however, it is desirable to involve a much larger group of experts, for example because, besides the different aspects, there are cultural differences that also must be considered. Questionnaires or a Delphi-like approach will usually be used in these cases. It is important that the group of experts that is consulted is *representative* for the spectrum of insights and approaches that are considered relevant.

The Delphi Method

The Delphi method was named after the Greek town of Delphi. Greek generals used to go there in ancient times to consult the local oracle. Depending on omens, decisions were made about, for example, the undertaking of military campaigns. It is a classical form of exploring the future that looked to the supernatural for support.

The so-called Delphi method was developed in the mid-1950s in the United States, mostly by the employees of the RAND Corporation who used this method for defence research. American military expertise was used for this method to investigate how Soviet forces would use their strategic nuclear weapons against American industrial centres (and subsequently of course how the Americans could prevent this kind of attack and/or limit the damages as much as possible).

The Delphi method is a method of questioning based on the repeated and systematic investigation of expert opinion about a certain topic. A team of researchers carries out the surveys. The monitor group manages the process and summarizes and interprets the results.[4] The method works according to several steps (at least eight):

- Defining and clarifying the topic on which expert opinions is required. The question needs to be meaningful for the problem-solving process and needs to be formulated so clearly that the experts that are being consulted will interpret it in the same way. This phase also sets the direction for the identification of experts.
- Identifying and selecting experts.
- Drafting and mailing of questions for the first round. In general, the questions in the first round should be open because this leaves room for the experts to put forward their own ideas and viewpoints. So, for instance, it should include questions about the experts' expectations of future contribution of nuclear fusion to the energy supply as well as their underlying reasons for their statements.
- Answering and returning the first round of questionnaires by the participants.
- Analysing and summarizing the answers from the first round by the monitor group.
- Depending on the question or questions asked, this can be a list of the aspects mentioned, or an overview of expert statements (anonymous) by % of those who held the opinions (e.g. 20% thinks that nuclear fusion will make an important contribution to the energy supply within thirty years; 40% thinks within fifty years and 40% thinks it will never happen). An overview of the arguments is also important.
- Drafting and sending questionnaires for the second round. In the second round, the respondents receive a summary of the results from the first round together with a request to react to these results. Often this will include a ranking of aspects or arguments (which of the mentioned aspects or arguments do you think are most important? And next? And next?). Participants may also be asked to adjust answers that were given in the first round, or for additional information (for instance, do you adhere to your statement about the contribution of nuclear fusion? If so, what do you think are the crucial conditions that have to be met to realize your vision?).
- Answering and sending back the questionnaires from the second round by the participants.
- Analysis and aggregation of the answers from the second round.
- Drafting of a questionnaire for the third round. This can run analogically to the previous round, where, depending on the statements that have been made, the focus can shift. For example, when after the second round the conclusion is that there is no consensus about the chances of nuclear fusion in the long term, the third round could focus on crucial conditions.
- Analysis and aggregation of answers from the third round, and either closing by making final conclusions, or a continuation of the process with one or two more rounds. The decision whether to continue or not is dependent on the degree of convergence in opinions that has occurred, whether it is useful – in terms of the solution to the problem – to ask additional questions, assessing whether the participants are still sufficiently motivated to continue, and of the available means and time.

The Delphi approach has the advantage that a large (ranging from ten to more than a hundred participants) and geographically diverse group of selected experts can be involved, and that those experts can express their opinions anonymously. That way, the ideas are

4 See: Bell (1997: 261-263); Porter et al. (1991: 214-219).

not linked to persons and can be judged on their merits independently from the status of the expert concerned. Furthermore, opinions cannot easily be linked to people, which enables that person to change his or her mind during the process without having to publicly announce it. It also prevents dominant people from influencing others in the group and thwarting *groupthink*.

Furthermore, the Delphi approach offers the possibility to include a large spectrum of views and in the final report there is also room for minority viewpoints.

The disadvantages are the length of time it takes, the substantial investment in manpower (monitor group) and the risk that personal preferences of the monitor group will strongly influence everything. Also, in practice, it is often hard to keep the respondents motivated during consecutive rounds. In the end, the quality of the respondents and the nature of the questionnaires are crucial success factors. The internet has substantially shortened the processing time. Questionnaires and answers can be easily exchanged through e-mail. It seems that non-response has become the main problem.

Delphi is also successfully applied in technical administrative research, as in the innovation research of Porter et al. (1991). Another example is the collecting of insights into possible paths of implementation for automated vehicle control in road traffic (Marchau, 2000). An international group of 117 experts was identified and approached. In the first round, sixty-five answers were received, in the second round fifty and in the third and final round forty. In the consecutive rounds, useful statements were made about the opportunities and impediments of automated vehicle control in road traffic. This led to a reduction in the number of feasible types of implementation, an insight that is useful when setting policy priorities. More recently, web-based applications have been introduced and applied successfully (Brill, 2006). Web-based versions of Delphi allow for faster exchange of ideas and opinions, real-time scoring updates, the involvement of large numbers of participants and parallel sessions (Cole, 2013). Nowadays Delphi is widely used in nursing and medical peer consultation and several online Delphi platforms are offering their services.

5.3.3 Scenarios

The term 'scenario' is derived from the movie and theatre world. There it is used to indicate the 'course of events' or the 'story in its context'. The term was introduced in policy literature at the beginning of the 1950s by the mathematician and physicist Herman Kahn who worked for RAND Corporation at the time. His task there, among other things, concerned explorations of the future – which he called *scenarios* – involving the consequences of possible nuclear exchanges with the Soviet Union. Kahn's scenarios came about during the Cold War and mostly had a 'worst case' character. In the political climate of that time, they legitimized a policy that led to an unrestrained development of nuclear weaponry in the United States.

At the end of the 1960s and the beginning of the 1970s, the term scenario was also used in other areas. Known examples can be found in the reports to the Club of Rome, where exhaustion of the world's natural resources stock is sketched, and in the energy scenarios that played a central role in the 'Social Discussion Energy Policy' in the Netherlands at the beginning of the 1980s. In that discussion, scenarios were sketched in which, based on policy choices, an important part of Dutch electricity would be generated through nuclear energy, coal or reusable resources (sun, wind and water). Scenarios are also used in the business sector. The most striking example of this is Shell. Thanks to the scenarios Shell developed, the company was better prepared than the competition for the unexpected changes in the oil market during the oil crisis that was precipitated by OPEC in the 1970s.

During the last decennia, working with scenarios has become very popular both in the private and in the public sector. At the same time, the use of the term has widened considerably. The term 'scenario' is so general that it can be used to indicate every form of exploration of the future, including explorations that are based on extrapolations, regression models or causal models. For example, in international climate research, they speak of diverging climate scenarios that are the consequence of 'high' or 'low' emission scenarios. The latter research relies heavily on (causal) mathematical models based on the extrapolation of past developments. This produces a variety of possible images of the future but does not constitute a lot of surprises. The term is also used in other disciplines, such as safety science. There it involves the possible combinations of disrupting circumstances that cause failures. The consequence is that we cannot speak of 'the' scenario approach. Approaches vary widely, where the terms 'scenario' and 'scenario approach' are used in different ways. This confusing situation justifies a closer look at the approach used when it is referred to as 'the' or 'a' scenario approach.

Types and Functions of Scenarios

There are three dimensions that can distinguish types of scenarios.

Point in Time or Time Path

A scenario can comprise either a description of a possible future situation at a certain *point in time* (in the last century the year 2000 was favourite, now scenarios run until 2030 or 2050), or a sketch of a *time path* of the present situation to a future one. The time path is sketched in terms of events and decisions that lead up to the possible future situation.

Explorative or Normative

Scenarios can have an *exploring* or a *normative* character. Exploring scenarios sketch one or more *possible* images of the future (or developments) without any statement being made about the desirability of it. *Exploring* scenarios are therefore called *explorative*. Projective scenarios are often used and are also a part of explorative scenarios, where developments from the present and the past are extrapolated to the future and where the starting point is an assumed continuity of social development. Examples of explorative scenarios are the projections and long-term scenarios from the CPB.

Normative scenarios use a desired image instead. They offer a sketch of a future that is considered ideal, for example a situation of peace and tolerance, or a situation where the environmental impact is minimized. Normative (also called *prospective*) scenarios are mostly used to design the path to the starting situation from the desired future situation, with the objective to investigate which policy could lead to the desired situation. This is often called 'backcasting' – the opposite of 'forecasting' (Vergragt & Quist, 2011). The term 'trend-break scenario' is also used here to indicate that a future path is sketched that radically breaks with current trends. The Dutch program Sustainable Technological Development (DTO) offers a recent example of this kind of normative approach. Going from the desire to reduce impact on the environment drastically, normative images of the future have been drafted where the environmental burden was reduced by a factor 10 in comparison with current environmental burden. Subsequently research was started to find out how this desired image of the future could be achieved. Desired images are often set in opposition to undesired images or 'doom' scenarios and/or compared with the future situation with an unchanged policy (the so-called reference scenario).

Context, Policy and Strategic Scenarios

Scenarios either can be about the *context* of the problem or about *policies* for problem-solving or a combination of both. *Policy scenarios* describe possible developments of the problem or system itself, where the problem owner or policy-maker can influence the choices that give direction to the development. In policy scenarios, the context of the policy is presumed to be constant. For instance, the different urbanization scenarios for the Dutch Randstad (PBL, 2012) concentrate on the spatial spreading patterns that can be influenced by the government and these scenarios assume that the context stays the same in all cases (the same population growth, the same economic growth). The same is true for the Chinese urbanization scenarios that foresee continued growth of its megacities and the establishment of five super regions.

Contextual scenarios provide images of possible future environments of the policy or system to be considered. They are mainly used to make statements about the robustness of possible policies. These scenarios focus on the environment or context of the problem that cannot be influenced by the policy-maker, but that can significantly influence the results of a policy. In the above-mentioned example of the urbanization scenarios of the Netherlands and China, such contextual factors are, for instance, economic development, immigration and climate change.

Strategic scenarios deal with images of the whole, i.e. they combine policies and contextual developments. Strategic scenarios are used to clarify strategic choices between kinds of developments or policies by providing insight into the expected effects.

Well-known examples of strategic scenarios are the '*Mont Fleur* scenarios' that were developed in South Africa at the beginning of the 1990s and that played an important part in the peaceful transition from apartheid to democracy. These scenarios sketch several diverging transition pathways in South Africa in terms of how difficult it would be to influence political and social developments in the areas affected by the policy. It turned out from exploring the *Mont Fleur* scenarios that most of the possible developments would probably lead to sharpened social conflict situations with serious negative consequences. Only cooperation between the different racial groups and adjustment of the revolutionary African National Congress goals (toning down) could keep the country from an economic downfall. This development with the appealing name 'flight of the flamingoes' was considered as the most desirable scenario (see Figure 5.6). The other scenarios called Ostrich, Lame Duck and Icarus sketched futures with non-representative, incapacitated and populistic governments respectively. Subsequently, it fulfilled the role of an image to strive for and was used as a normative scenario. Thanks to this *Mont Fleur* scenario exercise, outdated ideas such as nationalizing of all businesses were quickly discarded while the pace of the proposed changes (a dwelling and electricity for everyone within five years) was reduced (Jaworski, 1996).

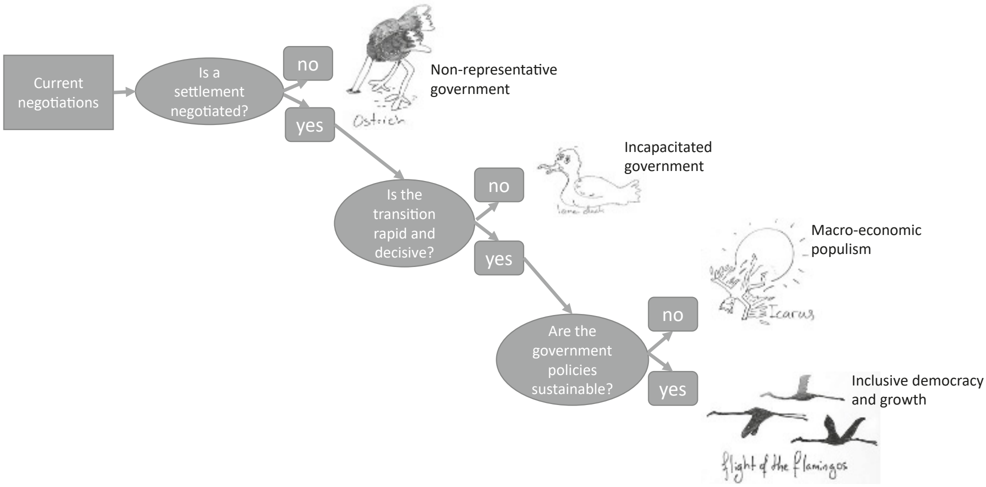


Figure 5.6 The logic of the Mont Fleur Scenarios (Source: Own work)

To summarize, a scenario approach is specified by indicating whether it is about:
– an image of a future point in time or an image of a path of development to the future;
– a possible or desired development or situation;
– an image of the future of a policy and the system, of only the environment of the system that is being looked at, or a combination of policy, environment and resulting system development.

5.4 Developing Scenarios

In this section we will look at building contextual scenarios, a scenario approach that is specifically developed to offer scope to views of the future that differ from existing trends to be able to investigate the robustness of the proposed policy. This approach usually has a qualitative nature, and leads to global, easy recognizable descriptions of images of the future that have the objective to stimulate discussions and reactions. Interactive group approaches are often used to stimulate idea forming about possible or desirable futures (Enserink, 2000a, 2004; Enserink et al., 2000; Onencan et al., 2016). In general, the focus is not so much on exploring the probable, but on exploring the plausible.

Within problem exploration, contextual scenarios are extremely useful to evaluate whether the demarcation of the system and its environment are right and whether all relevant factors have been included and classified in the right way. A scenario exercise clarifies the distinction between means (available to the policy-maker) and external variables (cannot, or only to a limited extent, be influenced by the policy-maker), and how they influence (via causal relations) the criteria. To design and write creative and effective scenarios is a specialism: to write a good, i.e. a credible and groundbreaking scenario is not only a matter of knowledge and skills, but also the result of a creative process and in-depth intellectual discussions. In practice, scenarios are mostly designed by interdisciplinary teams who, during the design process, put forward their ideas and results several times to a broad forum of other creative and critical experts and clients. This is done not only to safeguard quality but also to gain support to increase the effectiveness of the scenarios as a policy instrument.

All explorations of the future, and therefore scenarios too, have the goal to contribute to learning processes of policy forming and/or system design. Scenarios are an instrument of analysis that can be used to challenge social actors to co-think and co-design images of the future to enlarge the social support of the policy.

The sequence of steps is described in short in Table 5.2, and every step is briefly explained.

Table 5.2 Sequence of steps for the design of contextual scenarios

Step 1	Determine the key question	Formulate the question, problem definition or proposed policy.
Step 2	Determine the factors or crucial powers in the environment of the policy field	Indicate which contextual factors determine success or failure of measures regarding a certain policy field.
Step 3	Determine the driving forces or mega-trends behind these factors	Indicate which forces cannot be influenced by own policy, but influence the already distinguished factors.
Step 4	Arrange the factors and forces according to importance and uncertainty	Select the most important and the most uncertain forces.
Step 5	Design the scenario logic	Use the selected forces as axes for designing the scenario skeleton that spans the scenario space (scenario logic).
Step 6	Detail the scenarios	Elaborate on three or more scenarios and pay attention to all forces and factors.
Step 7	Evaluate the key question	How does the key question look in each scenario? How do you evaluate the effects of the alternatives in different scenarios? Is the decision robust? Which vulnerable points exist?
Step 8	Monitor the developments	Are there developments that make adjustment of the policy necessary (in time)?

Step 1: This step may seem trivial, but it is essential because the choice of the problem or decision has an essential influence on how things progress. Here it is important to make a statement about the relevant time frame and about the objectives of the problem owners.

Step 2: Firstly, it is essential to distinguish the system and the environment in this step (see Figure 5.7). The system comprises those factors and mechanisms that can be influenced, directly or indirectly by the problem owners, and whose development is a subject of interest for these owners. Contextual factors are variables that influence the development of the system (and therefore the degree to which the problem owners achieve their goals) but that cannot be influenced by the problem owners themselves.

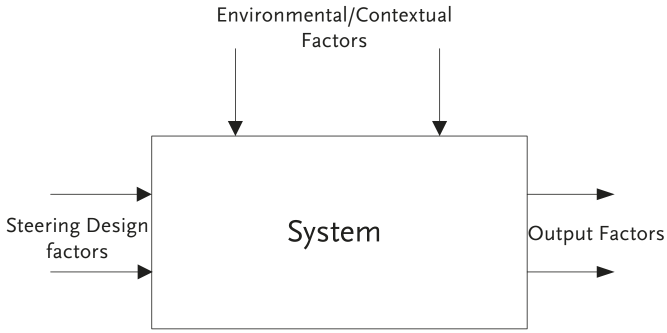


Figure 5.7 Framework for system demarcation

Contextual scenarios aim explicitly at the contextual factors. Actions that can be used by the problem owners themselves are absolutely not a part of it. Identifying important contextual factors needs to be based on insights into the working of the system. For a company like Shell, these are factors that cannot be influenced by the company itself, such as the oil price on the global market, the total demand for oil products, the strategic behaviour of the oil-producing countries, the position and strategies of competing companies, etc. The latter factors all can come from causal maps and/or end-means analyses, but brainstorming is also a good instrument to generate factors.

Step 3: This step is about identifying the so-called driving forces that determine the developments of the factors from the previous step. In the case of Shell, consider the international economic development, the breakthrough of alternative technologies for finding energy, geopolitical stability (Kuwait, Iraq, USA), and so on. Brainstorming, causal maps and/or end-means analyses combined with logic reasoning can help to identify the driving forces.

Step 4: A creative team will quickly be able to identify a wide spectrum of factors and driving forces. These are not all equally relevant when viewed from the problem definition as formulated in Step 1. Only the relevant factors need to be included. These are the factors/driving forces that

– have an *uncertain* development and
– that can have a *significant influence* on the ultimate policy objectives.

In the example about Shell, this means that the demographical development is eliminated because it is reasonably predictable, and it does not have as large an influence as some of the other factors.

Step 5: The driving forces that are left after Step 4 will form the axes for possible future scenarios. Every combination of different assumptions about each of the driving forces produces in principle a potential image of the future. The chosen axes together are called the scenario logic because they make up the skeleton or space within which the possible futures are located. Often three axes will be elaborated because of practical reasons (i.e. clarity, intelligibility). A choice for four, five or more axes is also defendable, however, and not uncommon.

Step 6: This step is the translation of the abstract concept to a concrete image of the world, elaborated in the form of a story, graphically or otherwise. It is advisable to give every scenario an easily recognizable, catchy name. It is also important to limit the elaboration to the main lines because too many details may be distracting. It is also useful to write from the perspective of the future situation, looking back on how it originated from the past: *The national income has risen sharply, but the division of income has become more skewed. A sharp division in society has occurred. Neoliberal values are generally accepted: free competition, globalization, individual responsibility and less government interference. Environmental measures have been perceived as significantly hindering competition and have been withdrawn under pressure of the free market.*

A well-known trap is the conscious or subconscious use of probabilities in the design of scenarios, for instance by opting for an extremely positive, an extremely negative and an 'intermediate' scenario. There is a fair chance that the intermediate scenario is viewed as the most probable and that a strategy is chosen that works best with this 'most probable' scenario. This conflicts, however, with the basic line of thought behind the approach (taking into account the *plausible*, not the *probable*).

Step 7: Once the contextual scenarios have been elaborated, application follows. Scenarios can be used in several ways. Scenarios are most often used while estimating the effectiveness of alternative policy options. For each policy option, the effects in each scenario are estimated, providing insight into the strength of the alternatives. Assessing effectiveness can be done by a multi-criteria analysis or by filling in a scorecard for each of the contextual scenarios. Robust policy measures are those that work positively in various futures. If a measure is not robust, adjustments are needed, or at least by following a '*hedging*' strategy damage will be limited or avoided. Strategy evaluations can also lead to preparing measures in case a threatening future development becomes reality (think of Shell). Furthermore, insights offer leads for monitoring the strategic environment. These monitoring strategies will have to mainly focus on developments in those contextual factors that are harmful for the chosen strategy.

A second way in which scenarios can be used is for exploring how a problem could develop if no action is taken. The development of a problem situation in the future is important; a problem may get worse or even disappear when the context changes; this would have severe implications for the relevance of specific problems and knowledge gaps and consequently impact on policy and research agendas. If a problem persists in various future scenarios, one could see it as a robust problem that needs attention; this finding justifies spending time and money on the issues.

To assess how a problem might evolve in a given scenario, the impact of a scenario on the outcomes of interest has to be identified. Analytically, a given scenario is specified by the scores on the different axes that span the scenario space. Since each axis is related to external forces, the scores of a scenario can be translated to scores on the different external forces. Using these scores and a system diagram, an assessment of how the different outcomes of interest evolve can be made. By comparing the impact of a scenario on the outcomes of interests with the goals, one can assess whether a problem disappears (i.e. the gap between the outcomes and the goals becomes smaller), a problem becomes worse (i.e. the gap between the outcomes and the goals becomes larger) or the problem changes in character (i.e. new gaps between outcomes and goals emerge). Alternatively, if the system contains feedback or a scenario has conflicting impacts on the system (i.e. some external factors make the problem worse while others make the problem smaller), the analyst cannot specify what the impact of the scenario will be on the problem without further research. This implies that there is a knowledge gap about how the problem will be affected by the different scenarios.

Within the problem analysis, the contextual scenarios can provide insight into the uncertainties surrounding the problem and the possible development of the problem in the future. The question that the analyst will ask himself at this moment is: are there any factors or developments in the environment of the problem that influence the nature, severity and demarcation of the problem and if so, in what direction? These insights can lead in practice to a better demarcation of the system. New, contextual, factors can be added to the system diagram while other factors will turn out to be redundant or less relevant. And by making the relations between factors explicit, the distinction between means, external factors and criteria will become clearer. This provides insight into the occurring knowledge gaps – for instance, that we do not know exactly what the nature of the relation between factors is – and into the nature and urgency of the researched problem situation. To be able to identify knowledge gaps in this and previous steps of the analysis and to have a good problem demarcation are things that help in the formulation and prioritizing of the research questions.

Step 8: Policies should be designed and implemented that anticipate possible events; these policies should have the character of no-regret strategies or adaptive policy-making. At the same time, critical contextual factors should be monitored to allow for timely adaptations of the policy. If changes occur in the critical contextual factors, this then can lead to adjustments of the policy or to commencing with previously prepared measures. The latter is what gave Shell a head start on the competition in the early 1970s when the oil crisis occurred.

5.5 Example: Scenario Analysis for Examining Civil Aviation Infrastructure Options in the Netherlands

In the last section, we elaborated on the process of developing context scenarios. In this section, we will further elucidate the development of scenarios using an example. This example is derived from an actual scenario study carried out in 1997 on behalf of the Dutch government. The scenario study was part of a larger policy analytical study into the future of civil aviation in the Netherlands known as the TNLI study. Context scenarios were developed to assess the robustness of different policy options that the Dutch government was considering.

5.5.1 Step 1: Determine Key Question

A basic assumption of the TNLI study was that the Netherlands would accommodate future air transport demand. The focus was therefore on the different policy options available for accommodating future air transport demand. To assess the robustness of these policy options with respect to the future, context scenarios were developed. The main question these scenarios would have to answer was: What are different plausible futures for civil aviation? The scope of the scenarios would be the future of civil aviation in the Netherlands and developments that could affect this. Given the long lifespan of infrastructure, a time horizon of thirty to forty years was chosen.

5.5.2 Step 2: Determine the Contextual Factors

In order to identify the contextual factors, experts and different stakeholders were interviewed. The resulting list of factors was complemented by a literature study. After several iterations, a list of twenty-six relevant contextual factors was identified (see Table 5.3).

Table 5.3 Contextual factors

Airport capacity
Availability of land for building new airports or expanding existing airports
Continued existence of the EU
Economic parity between countries in Europe, Far East and North America
Flexibility of labour markets
French and German High Speed Train (HST) networks are linked to each other
Global macroeconomic environment
HST network in Italy and Spain
HST network linking Paris, Brussels, Cologne, Amsterdam and London
HST speeds of up to 300 km/hour
Impact of ICT technology on the demand for business travel
Impact of oil price on the demand for air travel
Incremental improvements in technology resulting in quieter, cleaner and more fuel-efficient engines
Location of economic growth in Europe
Microwave landing systems and GPS will be in use
Night curfew at most European airports
Number and type of airlines
Potential for breakthrough technologies
Potential for multilateral negotiation of air traffic agreements
Presence of government subsidies
Presence of Mega Jumbos (i.e. A380/747-800)
Presence of Unified European Air Traffic Management System
Profitability of the aviation industry
Size of industry in terms of passenger and cargo volumes
Trade volumes within and between regions
Willingness to pay for direct vs hub flights

5.5.3 Step 3: Cluster the Contextual Factors into Driving Forces

The next step was to cluster the twenty-six factors into driving forces. Table 5.4 shows an overview of driving forces resulting from the clustering of factors identified under Step 2. The driving force 'economic environment' contains factors that describe how the economy in Europe and the rest of the world could develop. The economic environment will shape the size and location of demand for air transport. The oil price was kept separate from the economic environment, for the main uncertainty here is how the oil price would affect the demand for air travel. The driving force 'High Speed Trains' contains factors relating to the rise of a HST network in Europe. The development of HST in Europe can affect the demand for air transport within Europe because people might choose to take the train instead. Telematics focuses on the rise of ICT technology and the extent to which this might affect the demand for business travel. The underlying idea was that the rise of ICT could enable teleconferencing, thereby reducing the need for business travel. Land usage emphasizes the availability of land around the existing airports and how this limits the possibilities for adding infrastructure. The driving force 'airspace' focuses on how air traffic within Europe is organized. During the mid-nineties, attempts were made to integrate the airspace of the different European countries into a single system, managed by a single organization. During the TNLI study it was uncertain how this would play out. Aircraft technology contains factors that describe the different elements of an aircraft in terms of size and propulsion. Related to airspace, during the mid-nineties the European Union tried to privatize and liberalize the aviation industry in Europe. The driving force 'structure of the aviation industry' contains factors related to this effort. The driving force 'behaviour of passengers' focuses on the type of connection that passengers would prefer. Would they prefer a cheaper hub and spoke network, or would they be willing to pay for direct flights? The final driving force contains factors describing the health of the worldwide aviation industry.

Table 5.4 Driving forces

Economic environment
Global macroeconomic environment
Economic parity between countries in Europe, Far East and North America
Location of economic growth in Europe
Trade volumes within and between regions
Flexibility of labour markets
Fuel market
Impact of oil price on the demand for air travel
High Speed Trains
HST network linking Paris, Brussels, Cologne, Amsterdam and London
HST network in Italy and Spain
French and German HST networks are linked to each other
HST speeds of up to 300 km/hour
Telematics
Impact of ICT technology on the demand for business travel
Land usage developments
Availability of land for building new airports or expanding existing airports
Airspace management
Presence of Unified European Air Traffic Management System
Aircraft technology
Presence of Mega Jumbos (i.e. A380/747-800)
Incremental improvements in technology resulting is quieter, cleaner and more fuel-efficient engines
Potential for breakthrough technologies
Structure of the European Airline Industry, and the Netherlands' role in it
Microwave Landing Systems and GPS will be in use
Night curfew at most European airports
Presence of government subsidies
Potential for multilateral negotiation of air traffic agreements
Airport capacity
Number and type of airlines
Continued existence of the EU
The preferences and behaviour of passengers
Willingness to pay for direct vs. hub flights
The health of the global civil aviation industry
Size of industry in terms of passenger and cargo volumes
Profitability of the aviation industry

5.5.4 Step 4: Classify the Driving Forces According to Their Impact and Uncertainty

Table 5.5 shows the classification of the driving forces in terms of their uncertainty and their relative impact on the system of interest. The driving forces HST, 'land usage' and 'airspace' all have little impact on the future of civil aviation in the Netherlands and are of low uncertainty. HST has a low impact because of the planned integration of the Netherlands into the European network. It is expected that HST can only compete on short distances where demand for aviation is already low. Land usage also has a low impact because the different airports in the Netherlands all have excess capacity and are not significantly affected by the limits in available land. Finally, airspace integration in Europe will have some effect but it will not drastically change the way in which the aviation system will function. The uncertainty for all three is insignificant because of the long-term plans that were already in the implementation phase.

The economic environment and oil prices can have a significant impact on the demand for aviation. However, the economic rise and fall has proven to be relatively stable over time. Similarly, oil prices are dependent on the economic situation reducing the extent of uncertainty surrounding the long-term fluctuations in oil prices. By contrast, experts differ in opinion on how telematics will develop and uncertainty is thus high. However, the experts and literature agreed that there would always be a need for business travel even if advanced telematic technology were in use. The impact was therefore judged to be low.

The three remaining driving forces were all considered to be both uncertain and have a high impact on the future of civil aviation in the Netherlands. The structure of the European airline industry and the regulatory regime under which the industry will operate will shape the ownership structure of the Dutch airports and airlines. However, in 1997 it was unclear whether all the member states of the EU would cooperate with the planned privatization and liberalization. Passenger preferences will shape the basic structure of the aviation network in Europe, in turn determining how the airports in the Netherlands would be used. The final driving force, the health of the global civil aviation industry, was judged to be important because it would determine which airlines and which airline manufacturers would be in the market. Given the volatile history of aviation, with airlines and manufacturers going bankrupt, uncertainty was high.

Table 5.5 Classification of Driving Forces

		Uncertainty	
		Low	**High**
Impact	**Low**	High Speed Train Land-use developments Airspace management	Telematics
	High	Economic environment Fuel market	Structure of the European Airline Industry The preferences and behaviour of passengers The health of the global civil aviation industry

5.5.5 Step 5: Design a Scenario Logic

From Table 5.5, we can deduce that the scenario logic will consist of the following driving forces – structure of the European Airline Industry, preferences and behaviour of passengers, and the health of the global civil aviation industry. For clarity, extreme states for each dimension were specified. For the structure of the European Airline Industry, the extreme states are a fully liberalized market and a state-owned and state-operated industry. For the preferences and behaviour of passengers, the extreme states are a strong preference for direct flights on the one extreme and a strong preference for indirect flights through hubs on the other extreme. For the third dimension, the health of the global civil aviation industry, the extreme states are on the one hand a profitable industry and on the other hand an unprofitable industry. Together, all this is illustrated in Figure 5.8.

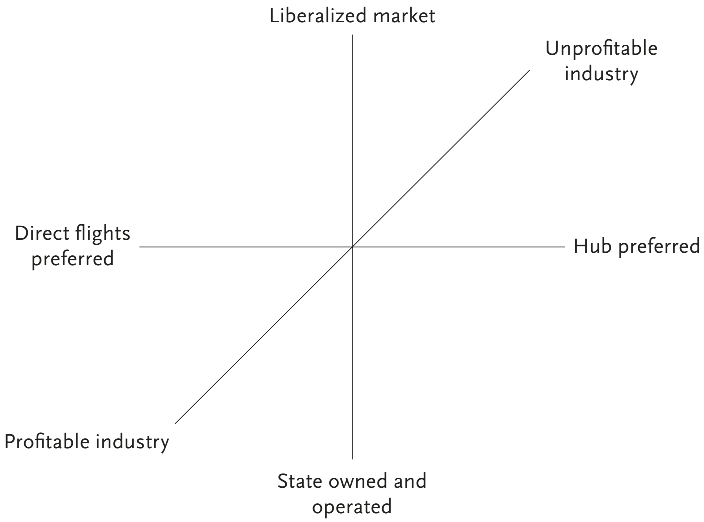


Figure 5.8 Scenario logic

5.5.6 Step 6: Detail the Scenario

For the TNLI study, five scenarios were specified further. Given the aim of using the scenarios for assessing the robustness of policies, the factors for the different driving forces were quantified. Here we will focus on a single scenario, Scenario 5. Table 5.6 shows the specification of this scenario for each of the factors. Taken together, this scenario can be characterized as a scenario in which passengers prefer direct flights, the aviation industry has been privatized and liberalized, and worldwide the industry is in decline.

Table 5.6 Specification of scenario 5

Structure of the European Airline Industry and the Netherlands' role in it	
Microwave Landing Systems and GPS will be in use	No
Night curfew at most European airports	Yes
Presence of government subsidies	No
Potential for multilateral negotiation of air traffic agreements	Multilateral treaties
Airport capacity	Three mega hubs, none in the Netherlands
Number and type of airlines	Three mega airlines, none using the Netherlands as its base of operations
Continued existence of the EU	Yes

Futures

The preferences and behaviour of passengers	
Willingness to pay for direct vs. hub flights	Strong preference for direct flights
The health of the global civil aviation industry	
Size of industry in terms of passenger and cargo volumes	Industry is in decline
Profitability of the aviation industry	Profitability is in decline

Text box 5.1 Specification of scenario: A possible scenario story

23 January 2031

In its annual report, the Schiphol Industrial Area and Aviation Group (SIAAG) reports it generated over 200 new jobs in commercial services and nanoelectronics. SIAAG is largely based on real estate management (Airport City) and the applied nanosciences companies it started twenty years ago. Airport activities contributed 32% to SIAAG's total production volume. The latter percentage has been more or less stable since 2020, when former Amsterdam Airport Schiphol hit an all-time low with a passenger volume of only eighteen million after losing its status as a European hub. In that year, Air Europe, the world's third largest airline, completed the relocation of its European hub activities to Milan, leaving Paris and Amsterdam as regional hubs. Remember that at the turn of the century, Schiphol had an annual passenger number of forty-four million and forecasts saw this rising to sixty million in 2020.

Since 2020, SIAAG has shown a stable growth in passenger numbers of about 5% annually, largely stemming from new direct connections to short and intermediate distance destinations. SIAAG ascribes this growth to new regional airlines opening new direct connections to European and North African cities. The new operators are flying short haul (up to 2,500 km), highly efficient hydro-powered planes and have limited services on board to reduce cost. The feeder operations of the three mega airlines to London, Prague, and Milan, which were the basis for survival during the early 2020s have started to lose market share to these new operators as travel time savings for European and North African destinations can be huge. The new operators are lobbying for the lifting of the night curfew and the opening of the window of flight hours: 'our new hydro-powered aircraft are very silent, so the night curfew is not necessary anymore', said Mrs Ellis Jackson, spokesperson of Cheetah, one of the fastest growers in this market.

SIAAG's cargo activities, which traditionally accounted for about 40% of departures, are currently in a decline and revenues are dwindling. The long-distance haul of high value goods has been reduced, especially now that trade in the important plant and flower sector has become almost 100% virtual; only Dutch flowers are now flown out. Recovery of this market is not expected.

5.5.7 Step 7: Evaluate the Key Question

The aim of the TNLI study was to identify different plausible futures for civil aviation in the Netherlands and reflect on the implications of each of these futures on the infrastructure that would be required to accommodate demand. In case of Scenario 5 discussed in Step 6, the implications are that no new infrastructure is needed. The airports in the Netherlands have sufficient capacity to handle the demand for direct flights and for flights from the Netherlands to one of the three mega hubs. If this future were to come to pass, any new investments in expanding airport capacity in the Netherlands would be rendered superfluous. As opposed to this, in some of the other scenarios that were analysed, there

Futures

was a clear need for additional investments in capacity at Schiphol. Given the uncertainty about future demand for air transport and about the type of network that would be in place, the advice was to develop an adaptive policy for the future of civil aviation in the Netherlands. This adaptive policy would prepare plans for capacity investments, but implementation would depend on how the actual situation developed.

5.6 Beyond Exploring the Future

The methods discussed in this chapter all focus on exploring the future and reflect some of the most frequently employed methods in practice. In recent years however, due to challenges like climate change-induced disasters, the financial crisis of 2007-2008, and the corona pandemic, all kinds of extensions, hybrids and novel methods for exploring uncertainty have emerged. Moreover, there is also increasing attention for dealing with uncertainty in policy-making in addition to exploring uncertainty.

One very active area of development is the combined use of modelling and simulation with scenario methods. Broadly speaking, two styles of approaches exist. On the one hand, there is the ‘storyline and simulate’ approach. Here, qualitative scenarios are developed first for example using the methods described in Section 5.3. Next, the scenario developers work closely with modellers to translate each scenario into a set of input parameters for a simulation model. This enables the use of scenarios with more formal models of the system under study. This ‘storyline and simulate’ approach is for example the way in which climate change scenarios are developed by the IPCC. First scenarios have been created for future socio-economic conditions and for how emissions of greenhouse gasses might develop over the coming century. These shared socio-economic pathways and their so-called reference concentration pathways are then used as input to, for example, global climate models to estimate how the mean average annual temperature will change, or what this would imply for sea-level rise.

On the other hand, there is also a rich literature on ‘exploratory modelling’ and ‘scenario discovery’. Here one starts with a simulation model of the system under study. Next, one identifies the key uncertain parameters associated with this model and tries to estimate plausible ranges for these parameters. You can think of this as a very large n-dimensional space, or uncertainty space, where each point in this space represents one possible parametrization of the simulation model. By running the model thousands of times for carefully selected points in this space, you can explore this uncertainty space. These points are computational experiments that reveal how the system would behave if the sampled parameters would be true values. Scenario discovery is then the analysis of these thousands of experiments. Typically, the outcomes of the experiments are first classified based on which results are of interest and which not. For example, the analysis can focus on those experiments where the problem becomes worse. Next, using machine learning algorithms, you can identify from where in the uncertainty space these experiments under which the problem becomes worse originate. So, within what subspace of the uncertainty space does the problem become worse? This can then be translated into a narrative that can be communicated more broadly (Kwakkel, 2017). Exploratory modelling and scenario discovery are frequently used to inform climate adaptation on infrastructure systems where models of the infrastructure system are readily available.

While ‘storyline and simulate’ and ‘scenario discovery’ both focus on exploring the uncertainty by combining formal models with qualitative techniques, a separate line of work focused on dealing with uncertainty. Given that the future is fundamentally open and uncertain, what should a decision-maker do? The focus here has been on designing policies that can be adapted over time in response to how the future is unfolding. Popular methods for this include adaptive policy-making and dynamic adaptive policy pathways (Haasnoot et al., 2013). The basic premise of both is that a policy is seen as a series of actions where new actions are taken only if certain pre-specified conditions have been met. Developments are carefully monitored, and if key thresholds are passed, the implementation of new actions is triggered (Kwakkel et al., 2016). Dynamic adaptive policy pathways underpin climate adaptation policies in many countries included the Dutch Delta Program, the Thames Estuary, The Vietnam Mekong Delta Plan and coastal adaptation strategies in New Zealand.

5.7 Takeaways

– We cannot know the future, but we can think what it might look like and prepare for it.
– Most formal methods like trend extrapolation, causal relations and analogy are based on the assumption of continuity.
– Expert consultation is widely used for exploring uncertainties and expectations of future developments of which the Delphi method is growing in popularity thanks to web-based applications.
– Explorative scenarios sketch possible images of the future; normative scenarios sketch a desired or undesired future.
– Policy scenarios describe how a system would evolve if specific policies would be implemented and presume the context of these polices to be constant.
– Context scenarios describe the behaviour of the system when changes in the context influence the behaviour of the system; they are used to assess the robustness of policies under changing external conditions.
– Developing scenarios is a method (eight steps) as well as a process of building trust and system understanding by the participants.
– Exploratory modelling and scenario discovery focus on exploring the uncertainty by combining formal models with qualitative techniques.
– A next step in future studies is the development of adaptive policies and exploration of adaptive policy pathways.

References

Bell, W. (1997). *Foundations of Futures Studies: Human Science for a New Era. Volume 1, History, Purposes, and Knowledge*. New Brunswick: Transaction Publishers.

Brill, J., Bishop, M. & Walker, A. (2006). An Investigation into the Competencies Required of an Effective Project Manager: A Web-based Delphi Study. *Educational Technology Research & Development, 54*(2), 115-140. https://doi.org/10.1007/s11423-006-8251-y

Cole, Z.D., Donohoe, H.M. & Stellefson, M.L. (2013) Internet-Based Delphi Research: Case Based Discussion. *Environmental Management* 51, 511–523. https://doi-org.tudelft.idm.oclc.org/10.1007/s00267-012-0005-5

Futures

Enserink, B. (1993). *Influencing Military Technological Innovation: Socio-Technical Networks and the Development of the Supersonic Bomber*. Delft: Eburon.
Enserink, B. (2000). Building Scenarios for the University. *International Transactions in Operational Research, 7*(6), 569-584. https://doi.org/10.1111/j.1475-3995.2000.tb00217.x
Enserink, B. (2004). Thinking the Unthinkable – the End of the Dutch River Dike System? Exploring a New Safety Concept for the River Management. *Journal of Risk Research, 7*(7-8), 745-758. https://doi.org/10.1080/13669870210166185
Enserink, B., van Bemmelen, I. & Kuiper, O. (2000). *RivierenLand Ex-ante evaluatie van het Transitieproces – een scenariostudie*. Rapport aan de Dienst Weg- en Waterbouwkunde, Directoraat-Generaal Rijkswaterstaat, Ministerie van Verkeer en Waterstaat.
Funtowicz, S. O., & Ravetz, J. R. (1990). *Uncertainty and quality in science for policy* (Vol. 15). Springer Science & Business Media.Garcia-Mata, C. & Schaffner, F. I. (1934). Solar and Economic Relationships: A Preliminary Report. *Quarterly Journal of Economics, 49*, 47. https://doi.org/10.2307/1883875
Glenn, J. C., Gordon, T. J., & Florescu, E. (2008). *2008 State of the Future*. World Federation of United Nations Association., https://www.millennium-project.org/publications-2-3
Guess, G. M. & Farnham, P. G. (2000). *Cases in Public Policy Analysis*. Washington: Georgetown University Press.
Haasnoot, M., Kwakkel, J. H., Walker, W. E. & Maat, J. (2013). Dynamic Adaptive Policy Pathways: A Method for Crafting Robust Decisions for a Deeply Uncertain World. Global Environmental Change, *23*(2), 485-498. https://doi.org/10.1016/j.gloenvcha.2012.12.006
Jaworski, J. (1996). *Synchronicity. The Inner Path of Leadership*. San Francisco: Berrett-Koehler Publishers.
Knight, F.H. (1921) *Risk, Uncertainty* and Profit. Boston and New York, Houghton Mifflin Company
Kwakkel, J., Walker, W., Marchau, V. (2010) Classifying and communicating uncertainties in model-based policy analysis. International Journal of Technology Policy and Management 10(4):299 – 315. https://doi.org/10.1504/IJTPM.2010.036918
Kwakkel, J. H. (2017). The Exploratory Modeling Workbench: An Open Source Toolkit for Exploratory Modeling, Scenario Discovery, and (Multi-objective) Robust Decision Making. Environmental Modelling & Software, *96*, 239-250. https://doi.org/10.1016/j.envsoft.2017.06.054
Kwakkel, J. H., Haasnoot, M. & Walker, W. E. (2016). Comparing Robust Decision-Making and Dynamic Adaptive Policy Pathways for Model-based Decision Support under Deep Uncertainty. Environmental Modelling & Software, *86*, 168-183. https://doi.org/10.1016/j.envsoft.2016.09.017
Lenz, R. C. Jr. (1962). Technological Forecasting. ASD-TDR-62-414, Aeronautical Systems Division, Air Force Systems Command (DDC Number AD 408 085).
Lipinski, A. & Loveridge, D. (1982). Multiple Perspective: Concept, Application and User Guidelines. *Systems Practice, 2*(3), 307-331. https://doi.org/10.1007/BF01059977
Marchau, V. (2000). *Technology Assessment Automated Vehicle Guidance. Future Prospects for Automated Driving Implementation* (dissertatie). Delft: Delftse Universitaire Pers.

Marchau, V. A., Walker, W. E., Bloemen, P. J. & Popper, S. W. (2019). *Decision Making under Deep Uncertainty: From Theory to Practice* (p. 405). Springer Nature, DMDU OPEN

Marchetti, C. (1980). Society as a Learning System: Discovery, Invention, and Innovation Cycles Revisited. *Technological Forecasting and Social Change, 18*, 267-282. https://doi.org/10.1016/0040-1625(80)90090-6

Meadows, D., Richardson, J. & Bruckmann, G. (1982). *Groping in the Dark; the First Decade of Global Modeling*. 6th IIASA symposium on global modeling, expanded proceedings. Chichester: Wiley.

Meijer, M. H. & Korving, H. (2001). Beslissen over het Riool onder Onzekerheid. *H2O, 34*(20), 19-21.

Onencan, A., Enserink, B., van de Walle, B. & Chelang, J. (2016). Coupling Nile Basin 2050 Scenarios with the IPCC 2100 Projections for Climate-induced Risk Reduction. *Procedia Engineering, 159*, 357-365. http://doi.org/10.1016/j.proeng.2016.08.212

Planbureau voor de Leefomgeving (2012). Nieuwe steden in de Randstad. Verstedelijking en suburbaniteit. PBL Den Haag isbn 978-94-91506-14-7.

Porter, A.L., Roper, A.T., Mason, T.W., Rossini, F.A., Banks, J. (1991) Forecasting and Management of Technology. ETM Wiley Series in Engineering & Technology Management. John Wiley & Sons INc New York, Chichester, Brisbane, Toronto, Singapore

Rosenhead, J. (1989). Robustness Analysis; Keeping Your Options Open. In J. Rosenhead (Ed.), *Rational Analysis for a Problematic World*. Chichester, West Sussex: John Wiley and Sons Ltd.

Schnaars, S. P. (1989). *Megamistakes: Forecasting and the Myth of Rapid Technological Change*. New York: The Free Press.

The Futures Group International (1994). Scenarios. In J. C. Glenn (Ed.), *1999. Futures Research Methodology Version 1.0*. American Council for the United Nations University. https://www.millennium-project.org

van Asselt, M.B.A., Rotmans, J. (2002) Uncertainty in Integrated Assessment Modelling. *Climatic Change* 54, 75–105 (2002). https://doi-org.tudelft.idm.oclc.org/10.1023/A:1015783803445

van Daalen, C., Thissen, W. & Verbraeck, A. (1999). Methods for the Modeling and Analysis of Alternatives. In A. P. Sage & W. B. Rouse (Eds.), *Handbook of Systems Engineering and Management* (Chapter 26). pp. 1037-1076. New York: Wiley. ISBN 978-0471154051.

van der Sluijs, J.P. (1997) Anchoring Amid Uncertainty: On the Management of Uncertainties in Risk Assessment of Antropogenic Climate Change. Universiteit Utrecht, PhD Thesis

Vergragt, P. J. & Quist, J. (2011) Backcasting for Sustainability: Introduction to the Special Issue. *Technological Forecasting and Social Change, 78*(5), 747-755. www.sciencedirect.com/science/article/pii/S004016251100062X.

Walker, W.E., Harremoës, P., Rotmans, J., van der Sluijs, J.P., van Asselt, M.B.A., Janssen P. & Krayer von Krauss, M.P. (2003) Defining Uncertainty: A Conceptual Basis for Uncertainty Management in Model-Based Decision Support, Integrated Assessment, https://doi.org/10.1076/iaij.4.1.5.16466.

Walker, W.E., Marchau, V.A.W.J., Kwakkel, J.H. (2013). Uncertainty in the Framework of Policy Analysis. In: Thissen, W., Walker, W. (eds) Public Policy Analysis. International Series in Operations Research & Management Science, vol 179. Springer, Boston, MA. https://doi-org.tudelft.idm.oclc.org/10.1007/978-1-4614-4602-6_9.

Wise, G. (1976). The Accuracy of Technological Forecasts: 1890-1940. *Futures, 8*(5), 411-419. https://doi.org/10.1016/0016-3287(76)90005-7.

6 From Synthesis to Plan of Action

In the previous chapters, we analysed various aspects of the policy problem. Now we are facing an important challenge: synthesizing the outcomes of the individual analyses to yield a rich and insightful problem description. Also, based on our synthesis, we need to diagnose or characterize the problem and think up follow-on activities; we should offer the problem owner(s) a new perspective and suggest some next steps towards a solution of their problem.

Remember you started from the initial problem perception of the problem owner (Figure 6.1). This perception could be biased or otherwise flawed and therefore as an analyst you are supposed to investigate and analyse the problem yourself. In the previous chapters, you learnt to analyse different dimensions of a policy problem: the system, the actors and the uncertainties. This chapter discusses how to synthesize these partial analyses, which is supposed to lead to a rich problem understanding and subsequent rich problem description. Most likely, the rich problem description provides new insights to the problem owner: presenting factors, actors, relations, dependencies, or concerns and issues that had been overlooked before. It provides a solid foundation for the 'Plan' stage (Figure 6.1), which should lead to ideas for solving the problem as is shown in the right-hand part of the figure. In this planning stage you have to transit to making a sensible plan; you have to characterize or frame the problem, identify knowledge gaps and propose follow-on activities. As a final product, you come up with a (re-)framed problem description and a plan of action for follow-on activities. The latter products are discussed in greater detail in the next chapters; in this chapter we will discuss how to get to a rich problem description and then focus on the activities in the 'Plan' stage.

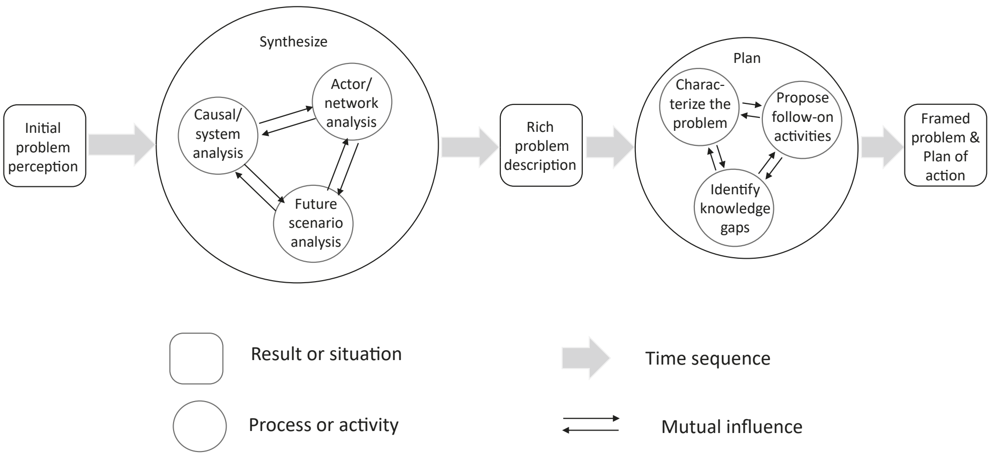


Figure 6.1 Steps in problem analysis

Synthesis

Before discussing how this can be done, we emphasize that synthesizing the partial analyses is more than summarizing their outcomes. Instead, the aim is to generate new insights by combining those outcomes. In doing so, you will arrive at conclusions that transcend the outcomes of each partial analysis separately – the whole is more than the sum of its parts. For this, you will need to adopt the role of the 'reflective practitioner' (Schön, 1995), which means you should question your own experiences and insights, thus improving those insights and increasing your value for your problem owner. What this entails in practice is the subject of the current chapter.

Synthesizing the partial analyses is typically accomplished by taking the following steps:

1. revise the initial system diagram drawing on the actor analysis and the scenario analysis, and ensure that all your diagrams and analyses are consistent with each other;
2. revise the initial problem description to yield the rich problem description.

As depicted in Figure 6.1, once the rich problem description has been developed, the time has come to plan and think about follow-on activities. The follow-on activities should enable the problem owner and other actors to move the problem in the direction of a (partial) solution. It might even be just a first step in the process towards problem-solving. Three activities are required as a preparation for writing the plan of action: characterizing the problem, identification of knowledge gaps and deciding on suitable follow-on activities.

Characterizing the problem is what we do by taking a kind of 'helicopter view'; we try to discern patterns and mechanisms that may characterize the problem. We should ask questions like: what is happening here?; what are the main characteristics of the problem?; what perspective should we take?; what problem frame would be helpful to move towards a solution for the problem? For instance: is the problem leaning towards a dispute on values; is it a content or (missing or disputed) knowledge problem or more institutional or (political) process oriented?

Knowledge gaps are relevant when they hinder progress. Knowledge gaps can be manifold ranging from uncertainties about the extent to which specific factors influence the functioning of the system, to lack of knowledge about the values and concerns of specific stakeholders, to disputes about the legitimacy of the decision-making process itself.

Proposing suitable follow-on activities comes next, as the characterization of the problem and the eventual knowledge gaps determine in what direction solutions should be sought. However, what follow-on activities should be considered suitable is also determined by the role that the policy analyst intends to take in these follow-on activities. Depending on their background, some analysts will be more inclined to quantitative modelling activities while others might be great process moderators and prefer to mediate in value conflicts. Anyway proposing follow-on activities in fact is the underlying objective of any problem exploration as the initial analysis is intended to surface the relevant issues and to focus the research efforts on the real causes of the problem. Clearly, the character of the problem, the proposed (research) activities and the specialisms of the team proposed to execute the follow-on activities should all match. Only if the problem exploration showed that the problem actually did not exist, no follow-on activities should be suggested.

As discussed, the rich problem description therefore is the starting point for the 'Plan' stage, which is accomplished by:
1. characterizing and framing the problem;
2. identifying knowledge gaps that might require further study;
3. a reflection on the role you need to take as a policy analyst to support the problem owner in subsequent steps;
4. proposing follow-on activities that will help the problem owner to bring the problem closer to a solution.

These steps are discussed one by one in the following sections. Beware though that in practice planning is an iterative process. As depicted in Figure 6.1, the three activities – characterizing the problem, identifying knowledge gaps and proposing follow-on activities – are not necessarily occurring in this sequence; but definitively they are mutually influencing each other. Planning therefore is an iterative process and may not be as structured as depicted here.

6.1 System Diagram Revision

The synthesis draws on all three partial analyses presented in Chapters 3, 4 and 5. The system diagram is the main conceptual model for this synthesis. The system diagram, as presented in Chapter 3, depicts the system of interest.

A system diagram for an initial problem perception (as perceived by the problem owner) consists of the following four components
1. a causal diagram of factors representing the system itself;
2. the means of the problem owner;
3. the external factors;
4. the criteria (outcomes of interest).

Remember that in problem explorations, the initial system diagram represents the problem as framed by the problem owner or client. This initial diagram was developed in a number of iterative steps in which different conceptual modelling techniques were employed: a means-ends diagram to make the first demarcation choices; an objectives tree for the identification of criteria; and a causal map for the identification and structuring of system factors, external factors, means and their relations. By doing so, we created a conceptual model of the problem, thinking through the problem as framed by the problem owner; through causal reasoning we constructed a 'mental map' (Rein & Schön, 1993) of the problem from the perspective of the problem owner. This initial system diagram was the point of departure for further problem exploration by means of two additional partial analyses: an actor analysis (Chapter 4) and a scenario analysis (Chapter 5). After these additional analyses, it is time to revisit and most probably revise the initial system diagram and adapt it to our newly gained insights. As visualized in Table 6.1, this means you have to determine if and how the initial system diagram should be modified. Below we exemplify how the actor analysis and scenario analysis may prompt the need to revise the initial system diagram.

Table 6.1 Elements of system diagrams that visualize two phases in problem description

System Diagram I **Initial Problem Perception**	**System Diagram II** **Rich Problem Perception**
System boundary	Adjusted system boundary encompasses the diverging problem perceptions of other actors and reflects new insights about what factors can be controlled with the available means
Causal diagram of factors representing the system itself	New (system) factors may have become apparent or factors are found to be insufficiently relevant and can be left out
Means of the problem owner	New means (input factors) are added to signal that they may be available when other actors become active allies of the problem owner, thus forming a coalition of like-minded actors
Relevant external factors	Other relevant external factors may have become apparent; the system boundary has shifted or factors have been shown to be irrelevant
Criteria (outcomes of interest)	New criteria (output factors) may be added to accommodate for the wishes of critical actors

First, actor analysis provided additional insights into the problem and its social, institutional and/or political environment. It produced an inventory of actors and their perceptions, objectives and resources, and identified the critical actors present in the problem situation. You determined the resource dependencies, pinpointed critical actors, and identified potential support and opposition in the actor network. Therefore, you now know what additional means might be available to the problem owner and what concerns should be taken into account for creating an acceptable solution. These insights may require you to revise the problem formulation as new dilemmas may have become part of it. Consequently, the system diagram may need to be changed in one or more of the following ways:

– New criteria (output factors) may be added to accommodate for the wishes of critical actors.
– New means (input factors) may be available as other actors become active allies of the problem owner, thus forming a coalition of like-minded actors.
– New factors (system factors) may have become apparent.
– New external factors may have become apparent.
– The system boundary might need to be changed as the problem changed due to the diverging perceptions and objectives (criteria) of other actors.

Second, the scenario analysis may have revealed important factors that are outside the span of control of the problem owner or the supportive critical actors. Still, these external factors can influence the outcome and effectiveness of policies and should therefore be incorporated in the system diagram. In addition, new information on possible external developments may also lead to a problem shift or even a new problem definition. In the Netherlands, for instance, scenarios on climate change may reveal that we should expect periods of severe drought instead of superfluous rainfall. Such insights trigger the need for new water management policies aimed at storing water instead of focusing on water drainage. These insights from a scenario analysis may lead to alternative problem formulations and the need to adapt the system diagram in one or more of the following ways:

– New external factors that impact factors in the system may need to be added.
– New factors (system factors) may have become apparent.

– The system boundary may need to be moved because some of the internal factors are found to be outside the influence of the problem owner or the other way around: external factors turn out to be under the control of the problem owner or its allies.

Beware: in this book we focused on scenario analysis as a tool or method to explore future uncertainties, but there exists a wealth of methods for exploring the future and for dealing with uncertainty. For some problems it might suffice to do a simple trend extrapolation or you might need to focus on specific model uncertainties (see Chapter 5). Though taking uncertainties into account in your analysis is a prerequisite for a decent problem analysis, exploring the future also supports the design of potential policies and strategies. Apart from triggering changes to the system diagram, the scenario analysis may also provide insights into the importance of various other external factors and may be used to assess the robustness of proposed policies. The latter may also prompt the need for *adaptive policies* and the design of monitoring regimes that monitor the developments in key external forces that may spur the need for changes in policy. This may also prompt the need for further research, for instance by additional (dynamic) exploratory modelling or scenario studies, by designing *adaptive policies* and/or by the design of monitoring regimes that monitor the developments in key external forces (Haasnoot et al., 2013; Kwakkel et al., 2015). This further research may eventually lead to changes in policy.

6.1.1 Consistency Check

Revising the system diagram as described here is in fact an iterative process. In practice, many analysts will be checking and updating their models time and again during the partial analyses; after each analytical activity, new insights lead to adaptations of the previous models. Therefore, the activities above should take place at various points in time, not only after having finalized the partial analyses. Throughout the problem exploration process and the various iterations, the analyst should continuously check for consistency in and between the models and listings they produce. For instance, if specific criteria are found to be relevant in the objectives tree, they may not lack in the system diagram and the other way around. When checking for consistency, the analyst needs to make important conceptual decisions about the relevance of factors and the system's demarcation. The scope and framing of the problem is determined by these choices. Important choices should therefore be made explicit and justified to allow the potential commissioner of proposed follow-on activities to realize the consequences of these choices. They might influence the content and scope of the problem and the expected outcome of proposed follow-on activities.

6.2 Rich Problem Description

The analysis started with an initial problem description based on the insights and perspectives of the problem owner. As argued before, this initial problem description may have been biased or flawed due to the one-sided perspective that was (deliberately) chosen. To provide a more thorough understanding of the problem, additional analyses were carried out to enrich the initial problem description with, for instance, the perspectives of other actors. Now that we have synthesized these additional analyses and drawn up a consistent, multi-actor system diagram, it is time to produce a rich problem description that does justice to the complexity of the (multi-actor) problem situation in a better way than the initial problem description did.

A rich problem description should make explicit the difference between the problem owner's initial concerns as a starting point for the research and the richer picture of the current (or future) situation, which is the result of our analytical efforts and the desired situation. Therefore, a rich problem description should assume a multi-actor perspective, i.e. the problem description should take into account the different concerns, objectives and means of other important actors and position the problem owner in this field of actors as this position and the problem owner's dependency on other actors' means influences the range of possible actions and solutions. In addition, a rich problem description should take into account foreseeable future developments that could alter the problem situation for the better or the worse and sketch the level of uncertainty.

Situations do exist where there is no problem owner (yet), for instance situations where one knows something is going to happen or change in the (near) future, but no one is or feels responsible (yet). For instance, technical developments like autonomous driving, artificial intelligence, blockchain technology, or deep-sea and arctic mining are potentially disruptive technologies that have the potential to change the world as we know it today. The purpose of a rich problem description then is to indicate what parties should play a role in facilitating, regulating, slowing down or preventing such developments.

Typical for a rich problem description is that the analyst also distances themselves from the initial perspective of the problem owner. Supported by the insights gained in the additional analyses, the analyst tries to see the larger picture: what are the main causes of the enriched problem; what are potential tensions between the critical actors; what are the uncertainties threatening the status quo.

6.3 Characterizing and Framing the Problem

The rich problem description is the outcome or product of the analyses that have been executed. The next challenge though is to offer a perspective for problem-solving or at least for moving the problem into the direction of a solution by suggesting a next step. For thinking up such a strategy, for offering a perspective for problem-solving, the practical experience and tacit knowledge of the analyst are an important basis. Practitioners will advise you to take a so-called 'helicopter view' of the issue at hand. When looking at the problem from some 'distance', you might be able to discern what are the main issues; what patterns can be seen; is the problem leaning more towards the technical or organizational domain; is there consensus or conflict; is the lack of knowledge determining the outcome; an institutional mismatch or the lack of cooperation? In this way, priority issues and/or a specific perspective can be chosen; what issues should be resolved first to move towards a solution; and how can they be characterized? Recognizing such general patterns and prioritizing the issues that need to be tackled first will help to frame or reframe the problem at hand. Beware that the way of characterizing or framing the problem largely determines what follow-on activities will be proposed as will be discussed in the remainder of this chapter and is illustrated in Table 6.2.

Typical frames are for instance the existence of large differences in values between the critical actors because of which they do not agree on what the problem is about and whether or not or in what way the problem needs to be solved. Another well-known frame is that the solution of one problem generates new or even bigger problems as the negative consequences may be affecting yet another actor. Table 6.2 provides you with some examples of frequently used problem frames that may serve as a reference to frame other problems.

Table 6.2 Examples of problem characterizations

Problem Characterization
Large differences in values and/or problem perception and (need for) solution
Large differences in problem perception among stakeholders about one promising solution
Trade-off to be made in choosing one out of various (technical) solutions
Uncertainty about incentives for (potential) cooperation from stakeholders needed in realization of a promising solution
Institutional design and/or hierarchy in stakeholder arena hampers problem-solving
Large uncertainty about the future hampers problem-solving
Chicken-and-egg problem hampers reaching policy goal

As indicated, the characterizations or problem frames in Table 6.2 may apply to a wide range of policy problems. Each frame corresponds to a different storyline that may be used to report about the problem and about the proposed follow-on activities. In Chapter 8, we will elaborate on using these problem frames to generate such storylines.

Problem framing is an iterative process; going back and forth between the rich problem description and the insights on the functioning and flaws of the system under study and the resources and knowledge available to the analysts. Consequently, the perspective towards solving the problem is sketched. Obviously this is not a straightforward activity; therefore, in Section 6.5, we will discuss how you might classify or characterize the problem at hand by using the hexagon model of Mayer et al. (2004). The hexagon model sketches the potential positions and the role of the analyst in problem-solving. This will help to further explore how you might use the framed problem to arrive at useful follow-on activities. But first we will discuss the need for making explicit the knowledge gaps and discuss their role in the planning stage.

6.4 Knowledge Gaps

During the extensive problem analysis so far, the analyst most probably discovered new issues and uncertainties that may be the starting point for further research into the complex issue at hand. Moreover, the scenario analysis would have revealed which knowledge gaps and strategic options are robust or not robust at all in most of the possible future scenarios. In other words, which issues remain pressing under varying circumstances and thus deserve attention. Knowledge gaps typically emerge from:

– new factors;
– unknown impacting factors and relations between factors;
– uncertainties about impacting factors and the relation between factors;
– uncertainties about system behaviour;
– new actors;
– new issues and issues voiced by concerned actors and stakeholders;
– uncertainties about actors' perceptions or positions;
– uncertainties about the occurrence and impact of external factors;
– unknown effects and impacts of new solution alternatives/strategies.

Consequently, knowledge gaps can vary in nature: they may be technical or systemic in character but can be of a social, political or economic nature or a combination of these.

Clearly the analyst has to decide which issues should be tackled and what research is needed. Most often, moving a problem closer to its solution implies some research will be needed. Even in severe conflicts of interest, where only mediation might work, often there are underlying or related issues, which might be solved by scientific research.

Addressing knowledge gaps like the ones listed above most likely will be part of any proposal for further activities. It is important to realize to bring forward only those gaps that hinder progress. The to-be-acquired knowledge should contribute to problem-solving to support the client/problem owner to move his/her problem closer to a solution. In other words, the proposed research should be relevant and contribute to problem-solving. The latter issues and the action of writing a research plan to handle these content- or knowledge-related issues are discussed in more detail in Chapter 7.

6.5 The Role of the Analyst

In the rich problem description we have been framing the problem – we determined the type of problem that we are dealing with; is the problem more content oriented or process oriented or a mix of the two and what aspect gets priority? This characterization or framing of the problem will help us understand what follow-on activities are suitable for the problem owner to move towards a solution of the problem. Also, it will help us as a policy analyst to determine what role we need to take in subsequent steps. To determine the role we might take as a policy analyst, we propose to use the hexagon model of policy analytical activities and styles by Mayer et al. (2004; see Figure 6.2). Below, we discuss how we may use the hexagon model to understand the policy analyst's role in subsequent steps.

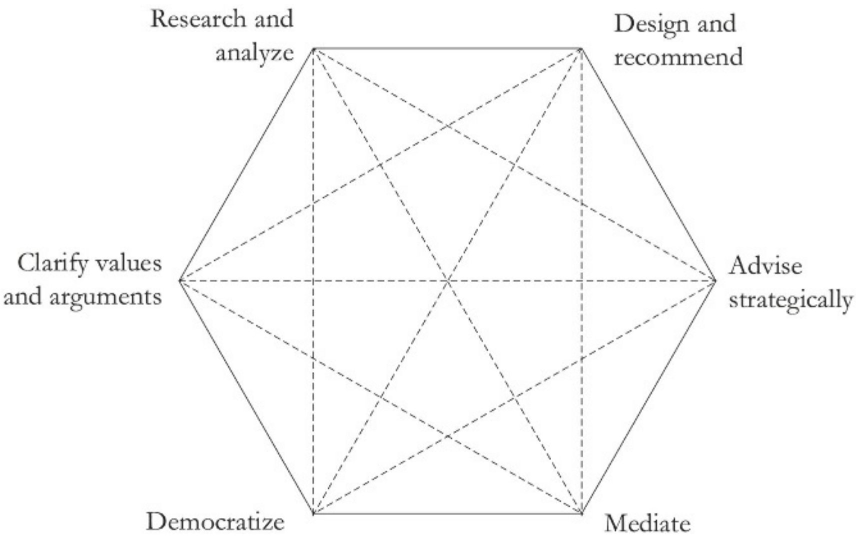


Figure 6.2 The hexagon model of policy analytical activities (Source: Mayer et al., 2004: 173)

Synthesis

6.5.1 Six Types of Policy Analytical Activities

The hexagon model defines six types of policy analytical follow-on activities, such as 'Research and analyse' or 'Mediate' (see Figure 6.2; we refer to the article by Mayer et al. (2004) for a complete survey of activities). To be able to further the solving of the policy problem, we need to select one or more such types of suitable follow-on activities. Departing from our rich problem description, we characterized the problem and listed the knowledge gaps that may prevent progress making towards a solution. Now we need to consider how the different types of activities mentioned in the hexagon model may contribute to tackling the problem. Finally, we will have to select the types of activities that seem most appropriate.

We provide two examples: first, consider a policy problem in which the problem owner seems to be overlooking certain clever solutions and has not paid sufficient attention to ideas and concerns of other stakeholders. This typically calls for activities of the type 'design and recommend' from the hexagon model: 'design and recommend' activities aim to find solutions and compare their effectiveness, costs, feasibility, etc. This problem may, therefore, be characterized as one in need of a better defined solution space.

Second, consider a policy problem in which certain groups of citizens threaten to haul the decision-makers into court because they feel they had no say in the decision process. This type of problem typically requires activities from the 'democratize' section of the hexagon model to make the problem-solving process more inclusive. Therefore, this problem may be characterized as one that suffers from underrepresented actors.

In Section 6.3, we discussed how we might characterize problems and in Table 6.2, we presented a list of problem characterizations we often come across in practice. Each problem characterization or problem frame corresponds to one or more activities from the hexagon model by Mayer et al. (2004) as shown in Table 6.3. The hexagon model and the analytical activities depicted at its six corners will be discussed in more detail in the next section when we focus on the role of the analyst.

Table 6.3 Examples of problem characterizations and follow-on activities

Problem Characterization	Corresponding Hexagon Follow-On Activities
Large differences in values and/or problem perception and (need for) solution	Clarify Values and Arguments; Mediate
Large differences in problem perception among stakeholders about one promising solution	Clarify Values and Arguments; Design and Recommend
Trade-off to be made in choosing one out of various (technical) solutions	Design and Recommend; Research and Analyse
Uncertainty about incentives for (potential) cooperation from stakeholders needed in realization of a promising solution	Advise Strategically; Mediate
Institutional design and/or hierarchy in stakeholder arena hampers problem-solving	Research and Analyse; Mediate
Large uncertainty about the future hampers problem-solving	Clarify Values and Arguments; Design and Recommend
Chicken-and-egg problem hampers reaching policy goal	Advise Strategically; Research and Analyse

The examples in Table 6.3 show how the hexagon model by Mayer et al. may be used once there is a rich problem description and the problem has been characterized. The chosen characterization leads us to selecting one or more suitable *types of follow-on activities* from the hexagon that are likely to contribute to solving the problem that the problem owner faces. Another way to determine subsequent steps is to consider the *policy analyst's role* in addressing the problem. For this, the hexagon model may be used as well.

As shown in Table 6.4, every type of activity in the hexagon model comes with a different role of the policy analyst in the follow-on process. For instance, the 'Research and analyse' type of activities require the analyst to act as an independent scientist who keeps a professional distance from clients. In contrast, analysts engaged in 'Advise strategically' type of activities need to be engaged client advisors with much less need of scientific independence. For a complete description of policy analytical roles associated with the various types of activities in the hexagon model, we refer to the original article by Mayer et al. (2004).

Similar to selecting the type of activities, determining the role of the policy analyst may also help to choose follow-on activities. For instance, if you decide that the problem at hand needs a client counsellor or mediator to further it, this indicates that the problem is essentially different from the one that requires an independent scientific researcher.

Table 6.4 Roles of the policy analyst

Activity	Policy Analyst Role
Research and Analyse	Independent scientist; Objective researcher
Design and Recommend	Independent expert; Engineer; Impartial advisor
Clarify Values and Arguments	Logician or ethicist; Narrator
Advise Strategically	Involved client advisor; Client counsellor
Democratize	Democratic (issue) advocate; Process designer
Mediate	Facilitator; Process manager; Action researcher

Source: Mayer et al. (2004)

6.5.2 Blends of Activities and Roles

In practice, we find that the majority of policy problems cannot be addressed by a single type of activity or a single role of the analyst. Instead, they are usually addressed by a blend of activities and roles from the hexagon model.

For instance, we may select a blend of activities from the top half of the hexagon. The top half of the hexagon (Figure 6.2) consists of activities that are predominantly aimed at knowledge discovery. These activities are suitable for policy problems that require factual questions to be answered, where evidence can be gathered and/or where additional analysis can be usefully applied to reduce uncertainties and help decision-makers. Activities from the top half of the hexagon require an analytic style in which the 'content' aspects (numbers, quantification and modelling) are key and the 'process' (stakeholder involvement and management) is supportive.

In contrast, activities for treating political or contentious issues, where there is no agreement on objectives and values, may be found in the bottom half of the hexagon. Here, the 'process' aspects of the activities are key and the 'content' is supportive. These types of problems require process-oriented types of follow-on activities, where the commitment of actors and stakeholder management are more important for problem-solving than the production of factual knowledge (see also the difference between 'Traditional Science' and 'Interactive Analysis' as distinguished by De Bruijn & Porter, 2004). Consequently, if activities from the top half of the hexagon, such as modelling and computer simulation, are required in such problems, they need to be carefully embedded in the activity's process to keep all actors 'on board'. If not, they may lead to unsuccessful outcomes that are not accepted by all participants in the activity.

Selecting a blend of follow-on activities from either the top half or the bottom half of the hexagon also bears consequences for the role that you as a policy analyst need to assume. Activities from the top half call for a more rigorous, scientific approach to produce irrefutable, factual outcomes. In contrast, activities from the bottom half require you to be more sensitive to issues at the personal and group level to maintain a supportive atmosphere that promotes social learning among the participants.

Summarizing, in most cases a blend of activities from the hexagon model is required to work towards a solution. Often activities from either the top half or the bottom half of the hexagon are selected. The choice for either half bears consequences for the role of the analyst as explained above. It should be noted, though, that many policy problems require both content-oriented and process-oriented follow-on activities. For instance, assume that our analysis showed that modelling the behaviour of vehicle owners would be worthwhile for assessing the effectiveness of road levies and other policy measures. We know, however, that these policies are heavily contested and parties are fighting over the character of the problem: some find it a matter of calculating the optimal tax levels (content-oriented activity), whereas others require a debate about the fundamental justification of these measures (process-oriented activity). Therefore, in this case it might be wise to propose a blend of activities from both the top half and the bottom half of the hexagon. For instance, to involve parties in a participative modelling process. This may yield the outcomes of the modelling exercise to be accepted by all.

6.6 Proposing Follow-On Activities

As mentioned in the introduction to this chapter, our synthesis should ultimately lead to a framed problem and a plan of action for the problem owner to allow the problem owner to take the next steps towards a solution of their problem.

If you selected generic activities as mentioned in the hexagon model, you will need to specify them before adding them to a plan of action. For instance, if you propose to 'set up a mediation effort', you will need to specify at least which parties will be involved and what conflict will be the topic of the mediation process. Often, detailed specifications are needed for your client to accept your proposal. Also, you should specify what expertise, what scientific disciplines will be needed and how you or your associates may support the problem owner in the proposed activities. Your proposal should, therefore, convince the problem owner that you have the skills and knowledge required to successfully support the problem owner in the proposed subsequent steps.

We emphasize that there exist many types of plans of action. What type is suitable for your situation depends mainly on how you framed the problem. For instance, if the problem is framed as 'large differences in values and/or problem perception and (need for) solution' and, therefore, calls for follow-on activities of the type 'Clarify Values and Arguments' or 'Mediate' (see Table 6.3), the plan of action should contain a process description aimed at overcoming these differences in values and problem perceptions. The plan should convince the problem owner that your approach is most suitable to proceed towards a solution of the problem.

Different problem frames therefore do require different types of plans of action. In the following chapter, we elaborate on one specific type: the research proposal. As indicated in Chapter 1, within the context of this book, particular attention is given to conducting research as a follow-on activity; therefore, in Chapter 7, you will learn how to plan activities aimed at generating new knowledge to fill in eventual knowledge gaps that you identified in the policy problem. Even though a research proposal is the typical step-up towards activities in the 'research and analyse' corner of the hexagon, a research proposal has a much wider use and is also useful for most of the other research activities located in the top half of the hexagon.

6.7 Takeaways

- Synthesis implies including in the initial system diagram all relevant factors surfacing in the actor analysis and the scenario analysis and checking for consistency.
- The synthesis results in a revision of the initial problem description to yield the rich problem description.
- Planning is an iterative process that includes characterizing the problem, determining knowledge gaps and proposing follow-on activities.
- Mayer's hexagon model is a good tool for deciding on suitable follow-on activities and the role of the analyst in these activities.

References

De Bruijn, H. & Porter, A. L. (2004). *The Education of a Technology Policy Analyst – to Process Management*. Technology Analysis & Strategic Management, 16(2), 261-274. https://doi.org/10.1080/0953732041000168291 9.

Haasnoot, M., Kwakkel, J. H., Walker, W. E. & Ter Maat, J. (2013). Dynamic Adaptive Policy Pathways: A Method for Crafting Robust Decisions for a Deeply Uncertain World. *Global Environmental Change, 23*(2), 485-498. https://doi.org/10.1016/j.gloenvcha.2012.12.006.

Kwakkel, J. H., Haasnoot, M. & Walker, W. E. (2015). Developing Dynamic Adaptive Policy Pathways: A Computer-Assisted Approach for Developing Adaptive Strategies for a Deeply Uncertain World. *Climatic Change, 132*(3), 373-386. https://doi.org/10.1007/s10584-014-1210-4.

Mayer, I. S., Van Daalen, C. E. & Bots, P. W. G. (2004). Perspectives on Policy Analysis: a Framework for Understanding and Design. *International Journal of Technology, Policy and Management, 4*(2), 169-191. https://doi.org/10.1504/IJTPM.2004.004819

Rein, M. & Schön, D. (1993). Reframing Policy Discourse. In F. Fischer & J. Forester (Eds.), *The Argumentative Turn in Policy Analysis and Planning*. Durham: Duke University Press.

Schön, D. (1995). *The Reflective Practitioner: How Professionals Think in Action*. Farnham: Ashgate.

Synthesis

7 The Research Plan

In the previous chapter, we revisited the initial system diagram and the initial problem definition and synthesized the outcomes of the individual analyses to yield a rich problem description. This enabled us to assess the character of the problem situation, and to explore our options as analysts to do meaningful additional research, taking knowledge gaps as a point of departure. In this chapter, we go into more detail on what constitutes a knowledge gap, we explain what types of relevant and researchable questions can be formulated, we provide considerations in choosing appropriate research methods to answer your research questions and we explain how to write a research plan.

7.1 Introduction

Problem analysis has revealed what is important for actors. This 'relevant part of the real world' is what we call the *system of interest*. The models used to demarcate this system, especially the multi-actor system diagram, represent assumptions that you, the policy analyst, have made about this system: assumptions about the present and future state of the system, about chains of cause and effect, about actions and events that may change the system state through these causal chains, and – last but not least – about how the various actors perceive the system of interest and their own position, about their interests and goals, and about the strategies they may adopt to achieve those goals.

If you have been thorough in your analysis, these assumptions will be based on 'best available knowledge': empirical evidence on the current system state, scientifically sound theories that explain the causal relations, and best practice models for projecting the outcomes of actions and external events beyond the control of the actors involved. But as pointed out in Section 6.4, you may discover 'blind spots' in your analysis (new actors, issues, solutions or events that introduce new factors and relations), and some of your assumptions may be uncertain 'best guesses' because science offers no empirical evidence or sound theories on particular aspects of the system of interest that you have demarcated. For example, data on the specific geographic area, social group or industrial activity may be lacking, or theories and models may be too general to provide reliable projections on the appropriate spatial and/or temporal scale.

Such 'knowledge gaps' might be filled by performing additional research. However, research is costly, and takes time, so you will always need to prioritize knowledge gaps: what is really 'need to know', and what is merely 'nice to know'. You will have to convince your client that the additional research you would like to do is worthwhile. Hence this chapter: *The Research Plan*. A research plan identifies the most pressing uncertain but researchable assumptions for your client, and then makes a convincing case on how the validity of these assumptions can be established through scientific research.

The research plan should show that you know what you are looking for, and that you know how the results will contribute to the broader problem-solving process. A research plan therefore should answer the following questions:

- Why? Research relevance. The research plan specifies the knowledge gaps that are addressed, and shows how the research results will contribute to problem-solving.
- What? Research scope. The research plan defines the research questions that will be answered in order in order to acquire the knowledge which can fill the knowledge gaps.
- How? Research process. The research plan specifies the research methods that will be employed in order to answer the research questions, and justifies why these methods are appropriate for answering the research questions.
- When and who? Research planning. The research plan addresses the operational planning of the activities needed to conduct the research process, in terms of time, deliverables and people to be involved, in order to show that the research is feasible.

In the following sections we will first further develop the notion of 'knowledge gap', and then show how you can operationalize it by formulating research questions, choosing appropriate methods and planning your research to meet time and resource constraints.

7.2 Why? – Knowledge Gaps

The first question to be answered is, 'why'? Why is research needed? What knowledge is currently lacking, and how will this knowledge support problem-solving? This justification process is the first part of a research plan, and it builds directly on the main findings of your problem analysis: you discovered a number of knowledge gaps that need to be addressed. These knowledge gaps form the crucial justification for performing the research described in the research plan. A knowledge gap identifies which knowledge is not yet practised ('expertise', 'know-how') or provided in the scientific literature ('evidence', 'theory'), but relevant for the policy process *and* amenable to scientific enquiry. The latter condition excludes philosophical questions ('What is the purpose of life?', 'Does God exist?') and ideological theses ('Individual freedom is the basis for prosperity.') as knowledge gaps. Even though such assumptions can be rigorously debated, they cannot be ascertained by what we consider to be a scientific method.

You can identify knowledge gaps by critically questioning the system models and actor models that you have used to define and demarcate the problem, by performing a thorough literature review, and/or by discussing the issue with stakeholders. The type and urgency of the knowledge gaps you discover can vary widely, depending on the phase in the policy life cycle (Van Daalen et al., 2002). When you consider the four subprocesses in the policy process as depicted in Figure 1.1, you will see that these subprocesses will give rise to different questions:

1. *Agenda setting*: When a policy issue is discovered and put on the agenda by some stakeholder group, this raises questions like 'who are affected?', 'how many?', 'in what ways?', 'how strongly?' and 'how soon?' The factual knowledge provided by research will inform the political debate on' the urgency of the problem (cf. the decision tree in Figure 2.1).
2. *Decision-making*: When analysts, often in consultation or collaboration with stakeholders, investigate a policy issue, and explore measures that could mitigate or resolve it, this raises questions about causal mechanisms in the system of interest. For example, 'how much does A contribute to B?', 'what if C continues to increase?', 'how likely is that to happen?', 'how effective will measure D be?' and 'what will be the costs and other externalities?' By filling this type of knowledge gap, research facilitates design

and *ex ante* appraisal of alternative policies along the lines of systems analysis as described in Chapter 3.

3. *Policy implementation*: When the political debate converges to the point that a particular policy is embraced, this policy must be translated into some institutional arrangement that legitimizes its implementation (cf. Section 4.4.3). This raises questions about formal procedures and accountability, for example 'who should be eligible for financial aid?', 'under which conditions?', 'who will decide on applications?' and 'how will disputes be resolved?', and also questions about efficiency, like 'how should we allocate budgets?' and 'how high will the transaction costs be?' These questions may be answered through applied research in fields like organizational science, law and economics.
4. *Policy impact*: Assessing the impact of current policies raises not only questions like 'how effective was measure A?' and 'what part of our target group have we reached?', but also questions like 'is the present policy still effective?' and 'which adjustments should be made?' Research can fill this type of knowledge gap by providing performance indicators and instruments for monitoring, forecasting and periodic assessment of performance indicators. When the problem appears to be solved, or other issues become more urgent, stakeholder groups will raise questions like 'do costs still outweigh benefits?', 'what if we stop?' and 'how well have goals been achieved?' *Ex post* evaluation research will allow lessons to be drawn from successful policies as well as failures.

Evidently, the knowledge gap will also relate to the substance of the policy issue, e.g. flood protection, irrigation, transport, crime prevention or social inequality. Substantive knowledge is typically situated in a scientific discipline, so it makes sense to consider which disciplines might contribute relevant knowledge. Despite its image of 'ivory tower', academic research is sensitive to societal needs (Fecher & Hebing, 2021), so you may also identify relevant knowledge gaps by making a quick scan of recent publications in specific fields of natural science and technology (e.g. hydrology, energy, logistics), behavioural sciences (e.g. economics, sociology, history, criminology) and multidisciplinary fields of academic research (e.g. political science, public administration, behavioural decision analysis). If you have more time, you can identify knowledge gaps by using rigorous identification and prioritization methods such as scoping reviews (Colquhoun et al., 2014), possibly combined with stakeholder consultation (Gold et al., 2013).

The next step is then to elaborate the most relevant knowledge gaps so that you can make a convincing argument to your client that it is not only desirable but also feasible to obtain this knowledge.

7.3 What? – Research Questions

The second question to be answered is 'what?' What will be researched? This can be the system of interest as a whole, but more typically you will want to study a specific phenomenon within this system. This phenomenon then is the *object* of your research. To crisply define a knowledge gap, the main research question for your research plan should make clear what this object of research is. To demonstrate that your main question is amenable to scientific enquiry, you elaborate it in a series or hierarchy of sub-questions. These sub-questions should reflect how the research can be decomposed into research activities that, when performed successfully, will lead to an answer to the main question.

To achieve this, it is helpful to differentiate between categories of research questions. The primary category comprises *empirical questions*, i.e. research questions that can be answered through observation of some real-world phenomena. Within this broad category, we discern *descriptive* questions, *explanatory* questions and *relational* questions.

Descriptive research questions serve to affirm assumptions about the past and present state of the system of interest, for example: 'what is the total annual consumption of electricity of all EU countries?', 'has animal welfare improved significantly over the last decade?' and 'how good is the water quality of the River Rhine?' These questions will help assess the extent to which the present situation differs from what your client finds desirable (cf. Section 3.3). The general form of a descriptive question is 'what is the value of X?' where X is a variable that represents a specific factor in the system of interest. Note that X can also represent a criterion, e.g. the value of lost load (Schröder & Kuckshinrichs, 2015), the highest number of large animals per hectare that is still considered acceptable or the minimum level of dissolved oxygen required by some aquatic species.

Explanatory research questions serve to affirm assumptions about causal relations between factors that you have identified in your system diagram (cf. Section 3.5). Although the term 'explanatory' suggests that this type of question should be formulated as 'why does X change?' or 'what causes X to change?', you are free to use different forms, for example: 'how will prices on the electricity spot market change when renewable power generation capacity triples?', 'is biological farming good for animal welfare?' and 'what part of the nitrogen and phosphate concentrations in the Rhine can be attributed to agricultural practices?' Note that each of these examples reflects that an explanatory question addresses a causal relation between a dependent variable and one or more independent variables, hence the general form: 'how strongly is the value of Y affected by the value of X?', or even more precisely: 'assuming that $Y = f(X)$, what is the function f?' Here, Y is the dependent variable, function f defines the causal relation $X \rightarrow Y$, while the independent variable X can be a vector $(X_1, \ldots, X_N)$ that represents several factors in the system of interest. Note that this abstraction does not exclude qualitative research questions, as X and Y can be nominal variables, and f can be a logical proposition.

Relational research questions are similar to explanatory questions in that they question whether factors in the system of interest relate to each other. The distinction is that they do not assume that this relation is causal (Pearl, 2000). This type of question is relevant when you try to find good proxies for factors of interest that cannot be measured directly (Frost, 1979, cf. Section 3.3.2). Some examples are '(how) does regional electricity consumption relate to population density?', 'do animals with elevated cortisol levels exhibit more stressful behaviour?' and 'what water conditions relate to trout population size?' Investigating such questions can help you cope efficiently with lacking data (demographic data are often publicly available with high spatial resolution), provide an objective quantitative scale for a qualitative factor that is difficult to observe (cortisol levels as indicator for stress) or single indicators for complex conditions (presence of fish as indicator for water quality).

All empirical research questions have in common that the factors that are to be observed must be clearly defined (otherwise they cannot be observed/measured). This condition is generally true for physical quantities: variables such as electrical energy, the power generation capacity of a wind turbine, cortisol levels and heart rates of cattle or the concentration of nutrients in water can be measured on standardized unit scales like ppm and g/l.

When well-established standards are lacking, this lack of clarity is part of the knowledge gap, but cannot be resolved by posing empirical questions. When this is the case, you should add sub-questions like ‘what is animal welfare?’ or ‘what standard for river water quality is appropriate for this research?’ Such questions belong to the category of *definitional* research questions, and answering them typically requires review and synthesis of definitions used in the literature (cf. Hewson, 2003, on animal welfare), or a well-argued selection of one particular standard from a larger set (cf. Tango & Batiuk, 2013, on water quality).

Note that the subcategories of research questions do not relate to a specific purpose, whereas your research will be prompted by specific knowledge needs of actors in a policy process. When you look again at our examples of questions that may be raised in a policy process (Section 7.2), they typically are empirical. *Agenda setting* will give rise to descriptive questions that must lead to new factual knowledge about the system of interest. *Decision-making* will typically give rise to explanatory questions, either evaluative (to identify the causes of the problem) or design oriented (to assess *ex ante* whether particular measures will be effective). *Policy implementation* will raise design-oriented questions to define efficient procedures and monitoring tools, while questions related to *policy impact* will be a mix of descriptive questions and evaluative (*ex post*) explanatory questions like ‘how effective was the implementation of policy P to meet goal G?’

The last category we mention here comprises *methodological research questions*. Similar to definitional research questions, methodological research questions become relevant when science offers no well-established standards or best practices for measuring variables and/or the strength of the relations between these variables. This lack of methodological knowledge may be due not only to the novelty of a research field, but also to a diversity of perspectives, as different scientific disciplines will favour different methodologies. Methodological questions generally have the form ‘how can X be (efficiently) measured?’ or ‘which method is most appropriate to do A?’ In fact, you can see them as ‘normal’ research questions that concern a special ‘system of interest’: your research methodology. We will elaborate on methods in the next section, but should point out here that you may also need to add methodological research questions when science offers a wide range of standard methods for the same purpose (e.g. methods for statistical testing of hypotheses, methods for preference elicitation or methods for time series analysis).

As you elaborate the main research question into more specific empirical, definitional and methodological questions, you should also consider what is the most logical order for these questions. A common practice is to present your sub-questions in an order that reflects the phases in the research. For example, when your main research question is ‘how will investments in large-scale variable renewable energy sources (vRES) affect electricity markets?’, you can start with definitional sub-questions that focus on the clarification of the key concepts, e.g. ‘what are vRES?’, ‘what makes vRES different from conventional fossil-fuelled power plants?’ and ‘how do electricity markets function?’ Note that questions that address the scope of your research, such as ‘what are the geographic boundaries?’ and ‘what is the time frame?’, should already have been answered by your definition of the knowledge gap.

Then you formulate empirical sub-questions to operationalize the relevant variables, and the relation between independent variables (investments in vRES) and dependent variables (market prices and producer surplus), e.g. 'what are the average cost price and market price of electricity, given the demand, the installed capacity of conventional power plants and vRES assets, and seasonal conditions (wind speed, insulation)?'

Empirical questions that call for experimental research typically raise methodological questions that relate to the implementation phase of your research, for example 'what confounding variables should be controlled for?', 'how many replications are required?' and 'what is an appropriate baseline scenario?' Although it is good practice to raise methodological questions down to this 'nuts and bolts' level, these details should not distract from the more fundamental questions that will be addressed. Bear in mind that you can also raise methodological questions later in your research plan, when you present the research methods that you plan to use.

The main takeaway of this small example is that the context of a knowledge gap co-determines how to address it: the concepts you use and the questions you pose should connect to the knowledge that is already available, and the methods you choose should comply with the established best practices in the scientific research community.

7.4 How? – Research Methods

The third question to be answered is 'how?' How will the research questions be answered? This asks for research methods. A research method prescribes how a particular type of research question can be answered in a way that is rigorous, transparent and reproducible. In practice, each sub-question may require its own specific research method or a combination of methods.

Every research method comprises (1) a conceptual framework that provides a precise and unambiguous terminology for detailing both the subject of enquiry and how it will be studied, and (2) a step-by-step operating procedure with logically sound decision rules that define – using the terminology provided by the conceptual framework – what the researcher should do under various conditions. A research method is scientifically sound when it precisely and consistently defines the meaning of concepts, and each step of its procedure complies with acknowledged academic standards.

The term 'research methodology' generally refers to the study of research methods, but you can safely use it to refer to the specific arrangement of methods that you plan to use in your research. What research methods are suitable for answering a particular research question not only depends on the type of question but also relates to its context, i.e. the other sub-questions you have formulated for the main research question and the methods you select to answer them. Your methodology must be internally consistent, i.e. conceptual frameworks and procedures should not contradict each other. This is why we speak of a research *design* (De Vaus, 2001). You can think of your methodology as if it is a piece of engineering, an artificial system (Churchman, 1971; Simon, 1996) that you design to produce an answer to your main research question. In this engineering metaphor, your research methodology is like a big machine that you design to produce an answer to your main research question, and the research methods you use to address specific sub-questions then are like the moving parts of this machine.

In the following subsections we introduce – quite briefly – a selection of methods relating to the types of research question we distinguished in Section 7.3. Our aim here is to show the methodological variety, to illustrate what makes a method scientifically sound, to provide pointers to where you may look for appropriate methods, and to encourage you to be creative but also rigorous when adapting existing methods, or devising your own. Outlining the premises and procedure for each method is beyond the scope of this chapter, so we do this only selectively.

7.4.1 Methods for Definitional Enquiry

Methods in this category aim to clarify the meaning of concepts so that they can be used to formulate assumptions. Note that this relates strongly to the methods for systems analysis, actor analysis and scenario analysis discussed in Chapters 3, 4 and 5. Although the strict conventions for graphical notation of concepts and relations may suggest otherwise, these methods depend most heavily on natural language. The main challenge is to choose the right words that capture the meaning of a concept, be it a factor, the interests of an actor or the societal dynamics that drive external forces.

Not surprisingly, the basic method for achieving this is to scan the literature to find how other people – not only researchers, but also your client and other stakeholders – name and define factors of interest. When doing so, you may discover existing conceptual frameworks that provide appealing categories of concepts. Such frameworks can be a big help, but they may also introduce an *a priori* bias to your research. Bear in mind that other researchers have developed their frameworks with a particular function in mind (cf. Binder et al., 2013), and that this function could be incompatible with what you intend to do.

If you want to conceptualize your research with a minimum of *a priori* concepts, you may want to consider using 'open coding' as it is practised as part of the grounded theory approach (Glaser & Strauss, 1999). This method provides a rigorous procedure for highlighting concepts and key phrases in texts (or other sources), grouping them in tentative categories and reflecting on their meaning.

If your aim is to clarify concepts that represent complex ideas, such as 'smart grids', 'natural behaviour of animals' or 'a natural river', you can use basic linguistic methods like giving examples or using analogies or metaphors, but you can also look into more elaborate methods such as exemplar methodology (Bronk, 2012) and narrative methods like storytelling (Moezzi et al., 2017).

As terms become meaningful only in relation to other terms, the general criterion for validity of a conceptual model is that it is semantically coherent and consistent. For informal representations in natural language, the criterion will be consensus: people must agree that the definitions make sense, and find that they use terms in the same meaning. This also applies to formal representations of concepts, such as semantic networks and ontologies, but these can be validated further by means of formal logic (Beers & Bots, 2009; Hinkel et al., 2014).

7.4.2 Methods for Descriptive Enquiry

Methods in this category aim to produce valid assumptions about properties of the object of research. Descriptive methods are geared to measure the value of variables through empirical observation. A variable is a property of some unit of observation. This can be the object of research as a whole (e.g. a spot market for electricity such as the Amsterdam Power Exchange), but more often the unit of observation is a specific entity type within the system (e.g. a single producer or consumer). Measuring a variable entails that the type and range of values it can have are clearly defined, and this entails that the variable has a scale. This scale can be nominal, ordinal, interval or ratio. Table 7.1 provides some illustrative examples. Note that the properties of the unit of observation can also be the number entities or occurrences of discrete events within this unit of observation, such as the number of households connected to a grid, the number of cattle in a region or the number of trout that pass a fish ladder. Also note that the value of a variable can be a set of entities, such as the list of Member States of the European Union.

Table 7.1 Examples of variables as properties of a unit of observation

Unit of Observation	Property	Domain Scale and Range	Unit
High voltage cable	Area	Ratio, 500–2500	mm^2
	Actual load	Ratio, 0–1000	MW
	Current carrying capacity	Ratio, 0–1500	A
	Transmission type	Nominal (AC or DC)	-
Cow	Body mass	Ratio, 30–1500	kg
	Milk yield	Ratio, 0–60	l/day
	Breed	Nominal, ~1000 breeds, e.g. Aberdeen Angus, Blonde d'Aquitaine, Yurino, Żubroń	-
River	Discharge	Ratio, 0–200,000	m^3/s
	Tributaries	Set of nominal	-
Point location	Latitude and longitude	Ratio, 0–360	deg
	Wind speed	Ratio, 0–35	m/s
	Passing trout	Integer	-
Country	Unit transmission tariff	Ratio, 0–30	€/MWh
	Stock of cattle	Integer, 0–350 million	-
	Cultural heritage	Nominal (narratives)	-
	Environmental performance index	Ratio, 0–100	-
European Union	Member States	Set of nominal	-
	Energy policy	Nominal	-

The observed values of variables are data. Data obtained on a set of entities or events can be aggregated using descriptive statistics such as count, frequency (occurrence of nominal scale values), sum, mean, minimum and maximum value, variance and standard deviation. Such aggregation methods serve to measure variables representing properties of the encompassing unit of observation, for example the mean time between power outages, the average price of electricity on the spot market, the hours per day that cows spend ruminating or the daily variability in dissolved oxygen in water. Note that the restrictions on what logical and arithmetical operations are permitted on the scale of a variable also limit how data on this variable can be aggregated.

The general criterion for the validity of observation methods is that they comply with the acknowledged standards of a scientific community, such as the International System of Units. Note that this entails that a variable must be clearly defined before it can be measured, and that this may raise additional definitional as well as methodological sub-questions. The methods used in studies of cultural heritage (Piñeiro-Naval & Serra, 2019), the environmental performance of countries (Hsu & Zomer, 2016) and the EU energy policy (Eckert & Kovalevska, 2021) provide instructive examples of scientifically sound methods for operationalizing complex qualitative variables.

Factual assumptions are typically affirmed by repeated observation, e.g. by aggregating observations over a (large) sample, by using different survey questions to measure the same variable or by means of triangulation in a case study (e.g. Ammenwerth et al., 2003). These aggregation methods must also comply with acknowledged standards. For example, the meaning of standard deviation as a measure for variability is (as the name suggests) standard across scientific domains, but the definition of other variability measures such as volatility may vary across domains.

7.4.3 Methods for Relational Enquiry

Methods in this category aim to establish whether there exists a relation between a set of variables. A relation between variables X and Y entails that a variation in the values of X in some way corresponds to a variation in the values of Y. Note that this does not require that X and Y are quantitative variables. The relation between qualitative variables such as rules and regulations that structure an electricity market (X) and strategic opportunities for energy suppliers (Y) can be investigated just as well as the relation between quantitative indicators such as consumer surplus and investments in new power generation units, but the research methods will be different.

When X and Y both have a nominal scale, relations can only be formulated as logical propositions like 'in context X_1 we can expect to observe Y_1, whereas in context X_2 we expect to observe Y_2'. Ordinal scales allow propositions like 'in contexts showing high values of X we expect to observe low values of Y'. Quantitative scales allow propositions like 'X is proportional to Y'. When variables X and Y are both quantitative (and preferably have a ratio scale), the extent to which variables X and Y are related can be measured using standard indicators for covariation, typically covariance and correlation.

When you have no *a priori* assumptions about relations between variables, you can induce them from observations. When you have quantitative data on a set of variables X_1, ..., X_N, you can construct a correlation matrix to see for which variable pairs (X_i, X_j) the absolute value of their correlation coefficient is relatively high. If some or all variables have nominal or ordinal scales, you can use classification methods such as logistic regression to look for patterns that indicate covariation of variables.

Methods for affirming assumptions about relations between variables are called hypothesis testing methods. The tentative proposition that a relation between variables X and Y exists is the hypothesis, and the test consists of assessing how likely it is that the observation data obtained for X and Y could have been obtained if the relation between X and Y would *not* exist. This test can be performed in many different ways (chi-square, Student-t, ANOVA, etc.), and we refer to standard text books for guidance for selecting an appropriate method.

7.4.4 Methods for Explanatory Enquiry

Explanatory research questions differ from relational research questions in that they seek to establish a *causal* relation between dependent and independent variables. A causal relation $X \rightarrow Y$ implies that a change in the independent variable X necessarily results in a change in the dependent variable Y. For a relation to be causal, two more conditions must be satisfied in addition to covariation as defined in the previous subsection: temporal precedence and control for 'confounding' variables. Temporal precedence entails that the change in Y always occurs before or simultaneously with the change in X. Control for confounding variables means that the change in Y cannot be explained by changes in variables other than X. In other words, when $Y = f(X)$ and Y also co-varies with Z, then Z must be part of X.

Because methods for answering explanatory research questions must verify that these additional conditions are met, they are more elaborate. Experiments and surveys must be designed such that potentially confounding variables are identified and controlled for, and that observations of the system of interest permit control over time. Moreover, methods should include mechanisms to verify that, when results suggest that a relation $X \rightarrow Y$ is causal, this relation is not *spurious*, where spurious means that the observed covariation between X and Y is actually the result of an underlying shared cause Z, i.e. $X = g(Z)$ and $Y = h(Z)$, rather than $Y = f(X)$.

Note once again that causal relations and methods for establishing them need not be quantitative. For example, the case study method can be applied to construct qualitative causal models. Such models will then have the form of historical narratives that give a plausible explanation of a chronological chain of events by arguing how the actions of actors follow logically from their motives as opportunities present themselves. Also note that the scientific rigour of qualitative methods for explanatory enquiry can be tested, for example by asking all interviewees whether they concur with the reconstruction and interpretation of events, by actively soliciting counterfactual evidence by contrasting alternative narratives (as alternative hypotheses) or a combination of these.

Just as definitional relations form the core of conceptual frameworks, causal relations form the core of theories. The classic example of a theory is Newtonian physics, which defines a set of assumptions relating concepts like force, acceleration, mass, distance, time and speed as mathematical relations, based on the assumption that force F causes acceleration a of a mass m according to $a = F/m$. Likewise, economic theory assumes that people, given the information they have, will opt for choices that maximize their utility. Do not make the common mistake to present or refer to a conceptual framework as if it is a theory. A framework can be used for description of (patterns in) system behaviour, but not for explanation or prediction of this behaviour.

The focus on causality in research, especially in support of policy-making, is understandable: without theories, i.e. consistent sets of assumptions about causal relations between factors, it would be impossible to determine what can be done to obtain a desired consequence or to avoid an undesirable outcome. But exactly because policy-making relies on causal assumptions, explanatory research meant to inform decision-making on a controversial issue such as climate change mitigation will be scrutinized and challenged, as exemplified by Goulet Coulombe and Göbel (2021).

7.4.5 Using Models in Research

The examples we selected in the previous subsections show that all methods involve representing some parts or aspects of the system of interest by means of a model of some form: qualitative or quantitative, informal verbal narratives or formal mathematical equations, tabular data, diagrams, computer code, games or some combination of these. Definitional models represent the meaning of terms, and hence resemble dictionaries or encyclopaedias, or definitional equations such as, for example, the one that defines the economic concept of weighted average cost of capital:

$$\text{WACC} = \frac{E}{V} \cdot \text{Re} + \frac{D}{V} \cdot \text{Rd} \cdot (1 - \text{Tc}),$$

where E is the market value of the firm's equity, D is the market value of the firm's debt, V = E + D, Re is the cost of equity, Rd is the cost of debt and Tc is the corporate tax rate.

Descriptive models describe the state of some part or aspect of a system. They may be qualitative ('the water is clear') or quantitative ('the water temperature is about 10 degrees Celsius', or 'Tw = 283 K'), and this can be generalized to time series and more complex data sets. Descriptive statistics such as sum, mean, mode and standard deviation that aggregate data sets also are descriptive models because they pertain to a single variable.

Relations between variables can be represented in many ways, e.g. graphically as causal relation diagrams (a qualitative conceptual model) or as scatter plots with a regression line (a quantitative empirical model), but also in tabular form as in Table 2.1 (a qualitative conceptual model) or as a correlation matrix (a quantitative empirical model). Note that the equation for WACC defines a relation between variables in a similar way as the price-demand function $P = d(Q) = q_0 - a \cdot Q - b \cdot Q^2$, whereas the former is a definitional model and the latter represents a descriptive relation where the parameter values q_0, a and b can be obtained by performing quadratic regression on a data set with paired empirical observations of price P and demand Q. Then also note that this equation represents an observed pattern (demand goes down when price goes up and vice versa), whereas $a = F/m$ represents a causal relation (exerting a force on a mass will cause it to accelerate).

Knowledge of the relations between the variables in a system permits the construction of models that can simulate the dynamic behaviour of this system. Such simulation models can be used as a substitute for the real object of research in cases where doing empirical research on the real object is too costly or too risky. Evidently, the validity of research results obtained with simulation models depends on how well these models represent the real object of research.

Simulation models typically comprise numerous equations, but the spectacular increase in computing power in the past decades has enabled modelling at large scale and in high detail. Constructing simulation models that are logically sound and empirically valid raises methodological questions, and this has led to a variety of modelling methodologies that provide alternative conceptual frameworks and working procedures. Some examples are the applied general equilibrium modelling approach (Ginsburgh & Keyzer, 2002), the system dynamics approach (Forrester, 1961) and the agent-based modelling approach (Epstein & Axtell, 1996). If you look into these methodologies, you will find that, despite fundamental differences in conceptual framework, they rely on the same criteria for scientific validity: sound logic of the model structure, and consensus within the academic community on the interpretation of variables, on the theories (and their limitations) that underlie the causal assumptions, and on the measures for goodness of fit between model behaviour and empirical data.

Note that simulation models need not be quantitative nor computer based. Thought experiments and scenario studies that reason about potential outcomes of policies or impacts of events, and serious games designed to observe how players can interpret regulations strategically also are simulation models for answering 'what if ...?' questions.

A model can be the final result of your research when it represents the system of interest in a way that answers the main research question (e.g. a set of stories that exemplify different stakeholder views on a policy issue), but more often it will be an intermediate result that you then use to answer specific sub-questions of the main research question. A typical sequence could be that you develop a quantitative simulation model that operationalizes your system diagram (cf. Section 3.5), use this simulation model to assess the impacts of different alternatives under a range of scenarios, elicit stakeholder preferences, arrange impacts and preferences in a multi-criteria, multi-scenario decision model which you then use to rank alternatives according to a robustness metric, such as least regret (cf. Kim & Chung, 2014 for a more elaborate research design).

When designing your research, it helps to think of models as functional components of your methodology. Qualitative and quantitative models can reinforce each other when developed jointly (Hérivaux et al., 2021). Note that the function of a model does not follow one-to-one from its type or form. Decision models can be used as components of a simulation model, e.g. to represent bidding strategies and market clearing (Pozo et al., 2013), but a simulation model can also be used as component of a decision model, e.g. when using robust optimization of policies under deep uncertainty (Bartholomew & Kwakkel, 2020). A simulation model can be part of a serious game, but a serious game can also be used as a simulation model, which in turn can be used to perform a variety of functions in policy research (Bots & Van Daalen 2007).

7.4.6 Data Management in Research

Empirical research will require data as the basis for analysis. These data requirements typically follow from the research questions and the methods and models you have chosen for answering them. These data can be collected as part of the research or they can be obtained from existing sources and databases. In most cases, data needs are considerable, and data collection may well be the most time-consuming step in the research. Therefore, the research plan should make clear that data are available (by mentioning specific sources, such as archives, reports and databases) or can be obtained (by specifying data collection methods such as interviews, surveys, longitudinal studies or real-time remote sensing).

In some cases you may also be required to specify how data will be managed, stored and made available during the study, how data will be shared upon completion of the research project and how you will mitigate the risk of data loss, data breach or other threats. Some data may be confidential, for example because they allow the identification of living individuals, because they are commercially sensitive (e.g. cost prices or patentable research results) or because they relate to national security. For such data, your research plan should also specify how you will obtain permission to use it (e.g. a process of informed consent) and how you will ensure that only authorized people have access to the data.

7.4.7 Involving People in Research

Research will always require people. The obvious minimum is a single researcher (you) performing desk research, but more likely you will involve other people, and in different capacities: fellow researcher, external advisor, reviewer, domain expert, practitioner, participant in an experiment, respondent to a survey, interviewee, etc. Like models, people also are functional components in your research design, so you must consider what qualities these people should have to be 'fit for purpose'. Experts should not only be knowledgeable, but also be acceptable, i.e. be perceived by your client and other stakeholders as authoritative and impartial (or at least non-controversial) in their views. When you select participants, you will want them to represent a particular stakeholder or social group, possibly in both senses of the word: to have similar perceptions, preferences and behaviours, and also to speak on behalf of their constituency. When you select your subjects for an experiment or for a survey, you will also think of incentives that may increase response rates. In all cases, you should be aware of your responsibilities as a researcher, consider how your research design will affect the people you involve and how you will communicate with them. This communication protocol may be an important part of your research plan (Barreteau et al., 2010).

7.5 When? Who? – Research Planning

Different types of knowledge needs may call for different research approaches, and some will be much more elaborate and time-consuming than others. When you write a research plan, you must consider the availability of time and other resources: research facilities, brainpower, and of course money. The purpose of making an operational research planning is twofold: (1) to assess the feasibility of your research plan and (2) to convince your client that the research will deliver valuable results.

A research planning is quite similar to a recipe for a cake: it specifies the type of cake (research deliverables), the required ingredients (existing data and models, subjects) and utensils (experts, lab facilities, monitoring systems, software tools), the intermediate products (observation data, models, results from experiments), and all the necessary activities in a logical order and with their estimates of how much time they will take.

By research deliverables we mean research results that are consolidated in a specific form. The content of deliverables follows from your research questions, but not their form. Typical research deliverables are reports, but your client may want to have policy briefs, i.e. compact documents that present research and recommendations in plain language, and draw clear links to policy issues and options. Infographics and short video clips that can be posted on social media can serve to reach a much broader audience. Other deliverables such as observation protocols, data sets and models can enhance transparency and reproducibility, while conference presentations and articles in academic journals can affirm the scientific status of the research.

The methods that you have selected and/or developed should suffice to identify the research activities that need to be planned. You can scan related literature to obtain time estimates for these activities, but do make use of practical experience by consulting with experts and peers. Standard project planning techniques like the critical path method (CPM) can help you organize activities in time, assess risks and build in slack (Riol & Thuillier, 2015). Position deliverables smartly in time to prevent peaks in workload. Keep in mind that sharing intermediate results can help to keep the confidence of your client and the commitment of other participants.

Knowledge, and in particular know-how, resides in people, so your plan should not only specify what will be done and when, but also by whom. This relates not only to researchers, but also to subjects, participants, advisors, external reviewers and supporting staff. Iterate through your planning to verify that your research team has all the required competences. Try to obtain intrinsic commitment from experts, advisors and reviewers based on genuine interest in the research. Such commitment combined with good reputation and past performance (also as a team) can lend more credibility to your plan.

Summarize your planning in a form that is communicative. A well-constructed Gantt chart provides an overview of research activities and their planning in time, and can highlight important events (deliverables) as milestones. Finally, estimate what funding you need for the proposed research. Most likely, human resources will constitute the largest cost item on your budget, but you should also consider what facilities you may need. Even if you require no special lab facilities or computational resources, the cost of more mundane things like meeting places, catering and travel expenses may still be considerable.

7.6 Conclusion

Evidently, all the effort you have put into your research plan will be in vain unless your client decides to commission the proposed research. That is why it is crucial to make a convincing case for the research you propose. Bear in mind that your client is probably not interested in scientific research, or even in policy analysis. Your research plan will be interesting only when it is made crystal clear to your client that the knowledge that will be developed will be *useful*. First and foremost, your client must be convinced that this knowledge will in some way allow for better decision-making. It is up to you to demonstrate what issue is at stake, what decisions need to be made and what your client and/or other actors should know to make well-informed choices. If you succeed, then you must also convince your client that your research will effectively provide relevant knowledge. With this final section, we intend to provide some additional guidance for developing a research plan.

A good research plan starts with an introduction of no more than one page that (1) outlines the policy problem, highlighting specific societal needs and recent developments that have brought this problem onto the political agenda; (2) characterizes the policy arena by naming and positioning the most relevant actors in this arena; (3) diagnoses the current state of the policy process in terms of competing interests and interdependencies between key players; and (4) ends by framing a decision as a dilemmatic choice that your client will soon have to make.

Assuming that your problem diagnosis convinces your client of the relevance and urgency of this decision, you then focus on what knowledge your client will need to make a wise decision. If possible, refer to what is presently considered as best practice in similar situations, and then motivate why this 'best available knowledge' does not suffice for the decision at hand. Be succinct. If you identify multiple knowledge gaps, it can help to present them in order of increasing relevance, and end with the most crucial gap. This should lead seamlessly to the main research question of your research plan. Then presenting your sub-questions in logical order should suffice to clarify the objective and scope of your research.

For the following pages of your research plan, your primary concern is its credibility. To demonstrate that your research will provide valid answers to the formulated questions, the methods you propose must be scientifically sound, and your selection must be well argued. Make sure that you do not embarrass yourself by presenting frameworks as theories, or software tools as methods. Where possible, refer to research projects that show successful application of similar approaches and methods. Do not hesitate to make pragmatic choices to cope with time pressure or other resource constraints, but make your trade-offs explicit. While presenting your methodology, focus on why it is 'fit for purpose' and do not elaborate in detail; it is better to show your methodological proficiency by providing operational details when you present the planning of research activities. Then double-check that the methods section and planning section of your research plan are consistent. This goes two ways: the research activities should follow the methodology, but also be feasible within time and budget constraints, or your plan loses credibility.

In the final part of your research plan, you focus on results. Here, your aim is to show that the research outcomes will indeed fill the knowledge gap that you identified in the introduction. This does not mean that you have to predict the answers to your research questions, but you should be able to explain how the answers that you will produce will affirm assumptions that are presently uncertain, but crucial for making wise decisions. After this review of expected conclusions, also add a paragraph in which you summarize the most important research deliverables (e.g. reports, policy briefs) and specify how and when you will make them available, and to whom.

By anticipating how the research results will be used, you can not only improve your arguments why your client should commission the research, but also strengthen some weak points in your research plan. As a quick check, you can reflect on the ambition level that you have for the actual utilization of the deliverables using the seven-point scale defined by Knott and Wildavsky (1980). The lowest utilization level is *reception* (your client accepts your deliverables and pays the bill), followed by *cognition* (your client reads your reports and understands the conclusions) and then *reference* (the knowledge actually changes your client's views and this shows in how your client communicates with other actors). Bear in mind that sound methods and valid results alone do not suffice even to reach these lower levels of utilization. You will also have to give serious thought to effective ways of presenting your research and its outcomes.

The more ambitious utilization levels are *effort* (your client tries to act on your recommendations or convince other actors to do so), *adoption* (the knowledge actually influences the outcomes of the policy-making process), *implementation* (the knowledge is embedded in standards and procedures for operational processes) and finally *impact* (this implementation leads to changes that are favourable for your client). To attain these higher levels, you will have to think more deeply about how you can improve your research plan so that the results will indeed be 'actionable' for your client.

Revisiting your choice of research questions and methods, and also the people you plan to involve (as co-researchers, experts or reviewers, but also as participants or subjects) from this 'actionability' perspective, will help you make your research plan better and more convincing. It is good practice to add a paragraph to your research plan where you outline through what follow-up actions your client can make best use of the results. While making such recommendations, consider not only the limitations of the research, but also how this research will be perceived by other actors in the policy arena. For all your efforts to meet scientific standards, your definitions of concepts and your choice of theories and methods can always be challenged by stakeholders if your conclusions do not align with their views. Such opponents may try to discredit your research, portraying you as a technocrat, a back-seat driver or a hired gun (Mayer et al., 2004, p. 185). Anticipating their criticism may help you make strategic recommendations as to how your client can counter or forestall it.

Finally, you will want to verify that your research plan meets common standards for this type of document. Always provide an abstract that summarizes the knowledge need, the main research question, and the method, and make sure that your sources are well referenced. You may also be required to provide some form of risk assessment in which you identify potential hazards and ethical implications of your research, and specify how these concerns are addressed.

7.7 Takeaways

- A research plan should make clear that the proposed research will produce knowledge that your client needs to advance the policy decision-making process.
- The main research question and its elaboration in sub-questions must detail your client's most urgent knowledge need; the associated research methodology must then demonstrate that each question can be answered through scientific enquiry. This entails that the proposed research should uphold in peer review.
- A research method comprises a conceptual framework and an operating procedure that produces an answer to a research question. A method is scientifically sound when it precisely and consistently defines the meaning of concepts, and each step of its procedure complies with acknowledged academic standards.
- Models can perform multiple functions as components of your research methodology: they can define the meaning of concepts, and how these can be observed empirically; they can describe the state of a system in terms of (aggregated) empirical observations; and they can define relations between variables, either as a hypothesis (to be tested empirically) or as a substitute for the real system (to study its behaviour under various conditions).
- A research plan must be a persuasive text. From the start, it must captivate the attention of your client, and then inspire confidence that the research is useful, that its design is scientifically sound and practically feasible, and that results will be delivered on time and merit the expense.

References

Ammenwerth, E., Iller, C. & Mansmann, U. (2003). Can Evaluation Studies Benefit from Triangulation? A Case Study. *International Journal of Medical Informatics, 70*(2-3), 237-248. https://doi.org/10.1016/S1386-5056(03)00059-5.

Barreteau, O., Bots, P. W. G. & Daniell, K. A. (2010). A Framework for Clarifying "Participation" in Participatory Research to Prevent Its Rejection for the Wrong Reasons. *Ecology and Society, 15*(2), 1-22.

Bartholomew, E. & Kwakkel, J. H. (2020). On Considering Robustness in the Search Phase of Robust Decision Making: A Comparison of Many-Objective Robust Decision Making, Multi-Scenario Many-Objective Robust Decision Making, and Many Objective Robust Optimization. *Environmental Modelling & Software*, 127, 104699. https://doi.org/10.1016/j.envsoft.2020.104699.

Beers, P. J. & Bots, P. W. G. (2009). Eliciting Conceptual Models to Support Interdisciplinary Research. *Journal of Information Science, 35*(3), 259-278. https://doi.org/10.1177/0165551508099087.

Binder, C. R., Hinkel, J., Bots, P. W. G. & Pahl-Wostl, C. (2013). Comparison of Frameworks for Analyzing Social-Ecological Systems. *Ecology and Society, 18*(4), 26. https://doi.org/10.5751/ES-05551-180426.

Bots, P. & Van Daalen, E. (2007). Functional Design of Games to Support Natural Resource Management Policy Development. *Simulation & Gaming, 38*(4), 512-532. https://doi.org/10.1177/1046878107300674.
Bronk, K. C. (2012). The Exemplar Methodology: An Approach to Studying the Leading Edge of Development. *Psychology of Well-Being: Theory, Research and Practice*, *2*(5). https://doi.org/10.1186/2211-1522-2-5.
Churchman, C. W. (1971). *The Design of Inquiring Systems: Basic Concepts of Systems and Organization.* New York: Basic Books, Inc.
Colquhoun, H. L., Levac, D., O'Brien, K. K., Straus, S., Tricco, A. C., Perrier, L., Kastner, M. & Moher, D. (2014). Scoping Reviews: Time for Clarity in Definition, Methods, and Reporting. *Journal of Clinical Epidemiology*, *67*(12), 1291-1294. https://doi.org/10.1016/j.jclinepi.2014.03.013.
De Vaus, D. (2001). *Research Design in Social Research*. London: Sage.
Eckert, E. & Kovalevska, O. (2021). Sustainability in the European Union: Analyzing the Discourse of the European Green Deal. *Journal of Risk and Financial Management*, *14*(2), 80. https://doi.org/10.3390/jrfm14020080.
Epstein, J. M. & Axtell, R. L. (1996). *Growing Artificial Societies: Social Science From the Bottom Up*. Washington: Brookings Institution Press.
Fecher, B. & Hebing, M. (2021) How Do Researchers Approach Societal Impact? *PLoS ONE, 16*(7), e0254006. https://doi.org/10.1371/journal.pone.0254006.
Forrester, J. W. (1961). *Industrial Dynamics*. Cambridge, MA: MIT Press.
Frost, P. A. (1979). Proxy Variables and Specification Bias. *The Review of Economics and Statistics*, *61*(2), 323-325. https://doi.org/10.2307/1924606.
Ginsburgh, V. & Keyzer, M. (2002). *The Structure of Applied General Equilibrium Models*. Cambridge, MA: MIT Press.
Glaser, B. G. & Strauss, A. L. (1999) *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Routledge. https://doi.org/10.4324/9780203793206.
Gold, R., Whitlock, E. P., Patnode, C. D., McGinnis, P. S., Buckley, D. I. & Morris, C. (2013). Prioritizing Research Needs Based on a Systematic Evidence Review: A Pilot Process for Engaging Stakeholders. *Health Expectations*, *16*, 338-350. https://doi.org/10.1111/j.1369-7625.2011.00716.x.
Goulet Coulombe, P. & Göbel, M. (2021). On Spurious Causality, CO_2, and Global Temperature. *Econometrics*, 9, 33. https://doi.org/10.3390/econometrics9030033.
Hérivaux, C., Vinatier, F., Sabir, M., Guillot, F. & J. D. Rinaudo (2021). Combining Narrative Scenarios, Local Knowledge and Land-Use Change Modelling for Integrating Soil Erosion in a Global Perspective. *Land Use Policy, 105*, 105406. https://doi.org/10.1016/j.landusepol.2021.105406.
Hewson, C. J. (2003). What Is Animal Welfare? Common Definitions and Their Practical Consequences. *The Canadian Veterinary Journal, 44*(6), 496-499.
Hinkel, J., Bots, P. W. G. & Schlüter, M. (2014). Enhancing the Ostrom Social-Ecological System Framework Through Formalization. *Ecology and Society, 19*(3), 51. https://doi.org/10.5751/ES-06475-190351.
Hsu, A. & Zomer, A. (2016). *Environmental Performance Index*. Wiley StatsRef: Statistics Reference Online, 1-5. https://doi.org/10.1002/9781118445112.stat03789.pub2.
Kim, Y. & Chung, E. S. (2014) An Index-Based Robust Decision Making Framework for Watershed Management in a Changing Climate. *Science of the Total Environment*, *473-474*, 88-102. https://doi.org/10.1016/j.scitotenv.2013.12.002.

Knott, J. & Wildavsky, A. (1980). If Dissemination Is the Solution, What Is the Problem? *Knowledge: Creation, Diffusion, Utilization*, 4, 537-578. https://doi.org/10.1177/107554708000100404.

Mayer, I. S., Van Daalen, C. E. & Bots, P. W. G. (2004). Perspectives on Policy Analysis: a Framework for Understanding and Design. *International Journal of Technology, Policy and Management, 4*(2), 169-191. https://doi.org/10.1504/IJTPM.2004.004819

Moezzi, M., Janda, K. B. & Rotmann, S. (2017) Using Stories, Narratives, and Storytelling in Energy and Climate Change Research. *Energy Research & Social Science*, *31*, 1-10. https://doi.org/10.1016/j.erss.2017.06.034.

Pearl, J. (2000). *Causality: Models, Reasoning, and Inference*. New York: Cambridge University Press.

Piñeiro-Naval, V. & Serra, P. (2019). How Do Destinations Frame Cultural Heritage? Content Analysis of Portugal's Municipal Websites. *Sustainability, 11*(4), 947. https://doi.org/10.3390/su11040947.

Pozo, D., Sauma, E. E. & Contreras, J. (2013). A Three-Level Static MILP Model for Generation and Transmission Expansion Planning. *IEEE Transactions on Power Systems, 28*(1), 202-210. https://doi.org/10.1109/TPWRS.2012.2204073.

Riol, H. & Thuillier, D. (2015). Project Management for Academic Research Projects: Balancing Structure and Flexibility. *International Journal of Project Organisation and Management, 7*(3), 251-269. https://doi.org/10.1504/IJPOM.2015.070792.

Schröder, T. & Kuckshinrichs, W. (2015). Value of Lost Load: An Efficient Economic Indicator for Power Supply Security? A Literature Review. *Frontiers in Energy Research, 3*. https://doi.org/10.3389/fenrg.2015.00055.

Simon, H. A. (1996). *The Sciences of the Artificial* (3rd ed.). Cambridge, MA: MIT Press.

Tango, P. J. & Batiuk, R. A. (2013). Deriving Chesapeake Bay Water Quality Standards. *Journal of the American Water Resources Association, 49*(5), 1007-1024. https://doi.org/10.1111/jawr.12108.

Van Daalen, C. E., Dresen, L. & Janssen, M. A. (2002). The Roles of Computer Models in the Environmental Policy Life Cycle. *Environmental Science & Policy*, 5(3), 221-231. https://doi.org/10.1016/S1462-9011(02)00040-0.

8 Preparing an Issue Paper

Issue papers are written for a client and intend to support the client in addressing or even solving the problem. With that aim in mind, the authors of the issue paper present the problem as they have framed it plus a rationale for follow-on activities. Typically, the issue paper includes a 'plan of action' (Figure 1.2) such as a proposal for further research, for a workshop with stakeholders, for a mediation initiative, etc.

The value of an issue paper lies not in the presentation of new knowledge but in the synthesis of the gathered insights. First, authors collect information about the problem – facts, assumptions and perceptions – from a multidisciplinary, multi-stakeholder perspective with attention for uncertainty and future developments, for qualitative analyses. Sources of information are the client, other stakeholders, and (scientific) literature and other media. Then, the collected information is analysed with methods and techniques presented in the previous chapters. In this chapter, we will discuss how issue papers may be written and formatted.

Text box 8.1 Positioning of client and analyst before commissioning an issue paper

Client Hi, I am so glad that we can talk. I need to hear your ideas about the following. My organization is trying to deal with a rather difficult problem situation, problem P. We really feel an urgency to do something, and possibly solve the problem. This won't be easy since it is kind of a wicked situation and there are quite a few external parties involved, some public, some private. And we are quite uncertain about what the future might bring.

Analyst I understand. Now how might I be of assistance in the matter?

Client Well, my organization wants to decide what our next step ought to be and I need to draw a plan for that. I have some budget to make this plan, but I am not sure that I have enough insight into the problem situation, let alone how to address it.

Analyst Well, it sounds like you need somebody to analyse the situation for you or with you. I can do that and also write a proposal as to how your organization might want to proceed.

Client Yeah, I think this is what I need. A good analysis might help convince my organization to act even though there is quite some uncertainty still.

Analyst I guess you have called me because I have expertise on problems like problem P. How about if I analyse your particular situation, step by step, and develop a proposal for further action based on my diagnosis? My final product will be a so-called issue paper. You can use that in the communication with your and other organizations.

Client Let me tell you a bit more about problem P so that you can indicate how you might proceed and how much time this will take. And then tell me what you need to be able to deliver such an issue paper.

The building blocks for issue papers have been discussed in the previous chapters of this book: a well-structured, original problem statement; a system diagram that is drawn from a multi-stakeholder perspective and its interpretation; an analysis of the stakeholder arena; and insight in important, uncertain future developments in either the system or its context (Chapters 3, 4 and 5). These building blocks, the results of the partial analyses, are used to characterize the problem situation, meaning that the problem is framed or characterized in such a way that it can provide a rationale for follow-up actions that the client might take (Chapter 6). Proposals for follow-on activities are to be included with the issue paper and written according to the guidelines in Chapter 7.

In this chapter, we first address the role of issue papers in the practice of policy analysis. Next, we present a list of eight key elements of issue papers and describe the purpose of the individual chapters. The framed problem is a key element of an issue paper and the problem frame is highlighted with a storyline (Section 8.3). Issue papers must be informative, convincing, consistent and clear, and written fort the client. In Section 8.4, we outline how the different chapters of an issue paper may be prepared. Students of policy analysis may use the list with questions at the end of this chapter to self-assess their work and improve it.

8.1 Role of an Issue Paper in Policy Analysis

Policy analysts typically write 'issue papers' to inform a problem owner, or commissioner of a study, of their findings (Checkland, 1985; Dunn, 1994). Quade (1989) describes an issue paper as 'an approach to formulating a problem'. Many issue papers have been written to provide 'a vehicle for quick dissemination intended to stimulate discussion in a policy community' (RAND Corporation, n.d.). We prefer to take the concept 'issue paper' one step further than communicating results of a problem exploration. An issue paper is not merely a report on what has been done; it includes a proposal for further action also (Thissen & Walker, 2013).

> Issue papers provide a systematic exploration of the problem, at a depth sufficient to give the reader a good idea of its dimensions and the possible scope of the solution, so that it might be possible for the management to conclude either to do nothing further or to commission a definitive study looking toward some sort of action recommendation. (Quade, 1989: 72)

With that goal in mind, analysts detail their vision of the problem: they present key results of a problem analysis from a multi-stakeholder perspective and make suggestions to the client or stakeholders to decide on the next step towards solving their problem. Follow-on activities will depend on the problem situation, the phase in the policy cycle, knowledge gaps and the role perception of the analyst (see Chapter 6).

Issue papers are tools that help to sketch a problem and its context, and to distinguish the main issues from the side issues. Issue papers force analysts to indicate next actions in addressing a problem situation and to formulate what Fujimura (1987) calls 'do-able problems': solvable problems and/or researchable questions. The real challenge for the author/policy analyst lies in this shift in focus from analysis to a proposal for action. The policy analyst should communicate this shift properly to the client and the format of an issue paper should support this communication.

For the reader, and perhaps potential client, the issue paper is a document that gives insight as to how the analyst is going to organize the follow-up project, what activities will be undertaken and how it would contribute to solving the problem. Also, the paper reveals the approach and analytical capacity of the analysts and functions as a showcase of their capabilities. The quality of the issue paper is expected to play a role in the client's decision to award or deny the contract to conduct the proposed study or project.

In this chapter, for practical purposes, we assume that the client and problem owner are one and the same. Nevertheless, it is important to realize that this is not always the case. Sometimes a client may want to play a role in solving a problem while other parties have more problem-solving power but do not (yet) assume problem-ownership for strategic reasons. Then again, a client may want to anticipate a foreseeable future problem situation even though problem-ownership cannot yet be ascribed to a specific party. Perhaps the impact of the situation is not yet known or the responsibilities of potential stakeholders in the new situation have not been regulated. In these situations, the issue paper can be used to critically reflect on the issue of problem-ownership and advise the client how to act accordingly.

8.2 The Key Elements of an Issue Paper

An issue paper has value for the client if its problem analysis adds something new to existing analysis reports and studies. The analyst creates this value through structuring existing information and so creating new insights as to how the problem may be addressed or solved. This implies that the policy analyst, the author of the issue paper, applies a critical and reflective attitude towards information, good analytical skills and good writing skills. These qualities are best learned by doing. The learning process can be enhanced by critical reflection with clients and peers.

According to our own experience and that of others, an issue paper is considered a good issue paper only when the readers, the problem owner and critical actors

– recognize the relevance and value of the provided problem analysis;
– value and accept the choices made in selecting and combining empirical and information and theory for a diagnosis of the problem situation;
– accept the validity of the recommendation for a specified follow-on activity that aims to contribute significantly to solving the problem;
– are convinced that the proposal for this follow-on activity can contribute to the intended effect.

The key elements of an issue paper, its specific contents and argumentation, must support and reflect these qualities. We identify eight elements and describe these briefly in this section starting with the outline of the paper. Section 8.3 discusses the importance of choosing a storyline when presenting the framed problem. The process of writing an entire issue paper is discussed in Section 8.4.

8.2.1 Effective Outline for the Issue Paper

Issue papers are brief. Its contents can be arranged in a general outline as indicated in Table 8.1. Note that this is just one possible outline. Authors on policy analysis like Quade (1989: 73-78), Checkland (1985: 169) and Dunn (1994: 426) provide more detailed and more elaborate outlines.

The format of the issue paper is consistent with Figure 1.2 and Chapter 6: Part 1 of the issue paper, the introduction, presents the initial problem. This part is one to two pages long. Part 2 is based on the results of the partial analyses. It presents the 'framed problem', meaning the adjusted and refined original problem and how it can be characterized based on the analyses. This part may be four to eight pages long. The text of Part 2 may be divided into shorter sections if this part of the paper is too long to be read as one fluent text. The content of Part 3 justifies the proposal in Part 4 and presents a line of reasoning that is consistent with Part 2.

Table 8.1 Standard format for an issue paper

Title Page
A foreword – The author accounts for important choices in the research and ownership of its results.
1. **Introduction** – Four to five paragraphs that present the context or motivation for writing the paper, the initial problem situation as presented to the author, the complexity of solving this problem, and the dilemma that client and/or stakeholders deal with (see 8.4.1).
2. **Framed problem** – a fluent text or synthesis of the main conclusions drawn from the different partial analyses of the system, the stakeholder arena and the future. The storyline of this text is consistent with and builds up to the characterization or diagnosis of the problem.
3. **Conclusion and Recommendations** – the characterization of the problem; knowledge gap to be addressed in support of dealing with the dilemma; and recommendations for further action
4. **A proposal for follow-on activity** – a project plan. This very often entails a proposal for a research project that addresses a knowledge gap that constraints further action or decision-making.
Bibliography – A list of sources of information that have been referred to in the text of the issue paper.
Appendices – A compilation of all conceptual and analytical models that were made for and used in this paper. The models are presented with a short mention of the purpose of the analysis, a short explanation as to what the model shows and what was learned from that, and a list of references used in making the model.

8.2.2 Demarcation of Initial Problem Situation

A client who commissions an issue paper has a problem situation to be addressed. Typically, this is an ill-defined problem that needs sharpening and demarcation (or scoping or delineation) before analyses can start (Chapter 2.5). The first analyses show whether the initial problem definition must be considered 'misguided and erroneous' (Brewer & DeLeon, 1983: 155).

A well-demarcated, initial problem definition gives information about the following: the context of the system in which the problem is situated; identification of the problem owner; identification of critical actors and their apparent stakes with regard to the existing situation and efforts to solve the problem; information on spatial and temporal boundaries (what locality, what deadlines); and the dilemma that the problem owner (and perhaps other stakeholders) must deal with when intervening in the problem situation. The demarcation of the initial problem is the result of a first iteration of the analyses of system boundaries, system diagram, stakeholder arena, client's objectives and means that are available to intervene in the problem situation.

8.2.3 Mutually Consistent, Partial Analyses of Multi-Actor System

Issue papers are based on insights gained from the analytical process as outlined in Chapters 3, 4 and 5 of this book. If indeed the partial analyses are mutually consistent, then the analyst can characterize the problem situation (Chapter 6), draw conclusions and carry these forth in following steps such as drawing recommendations for further action.

The different partial analyses are made by the analysts, preferably in collaboration with the client and in interaction with actors in the problem environment. Consistency of the partial analyses is best achieved by working iteratively. In this book, we present the different tools and methods for analysis in subsequent but separate chapters. However, practitioners of policy analysis may start with a simultaneous download of the available information in one or more diagrams or tables (system diagram, power-interest diagram, etc.) and proceed with enriching one analysis with that learned or discovered in another analysis. Each iteration serves to make or maintain the internal consistency of the set of different in-depth analyses.

8.2.4 Storyline for the 'Framed Problem'

The storyline of Part 2 of the issue paper, the framed problem, provides the logic for structuring the multifaceted information and builds the argument leading up to the conclusion and recommendations. Section 8.3 presents storylines for seven possible problem frames and some further examples can be found in the Annex to this Chapter.

8.2.5 Recommendations and Related Proposal for a Follow-On Activity

At the end of the issue paper, the analyst recommends follow-on activities that enhance the client's capability to solve the problem. Sometimes, the analyst will recommend that the client do nothing and wait until uncertainty about the situation has diminished. In most situations, however, the analyst will sketch a perspective for action and identify a promising action or follow-on activity. A list of such actions is presented in Chapter 6.

The issue paper may include a proposal for the recommended action if this action warrants professional support. Proposals are to be written according to standards of the field of research or discipline in question. In the case that the analyst recommends that knowledge be generated, the proposal will be a plan for qualitative or quantitative research, and is to be written according to scientific standards (see Chapter 7). Quantitative research may include data collection and analysis with various methods, or a simulation study that implies the building of a model or game; qualitative research may make use of case study research, comparative analysis and essay writing to address philosophical questions.

8.2.6 Accountability Statement

For reasons of transparency and professional integrity, the issue paper ought to give information about the position of the author and, if applicable, name the code of conduct or ethical principles that the work complies with. The source of funding for the work and the relationship with particular stakeholders can be addressed here also. Depending on the extent of the problem and the funding of the paper, this statement can be made in a preface or presented separately, immediately after the preface.

8.2.7 A List of Resources or Bibliography

For reasons of scientific integrity, the issue paper must include a list of references and other resources that were used in the analyses or that support the communication of results. Often, these sources can be presented in the APA citation style, which is accepted in education, psychology and the sciences, but the client may have own requirements for referencing.

For reasons of legitimacy, it is important to explicate how the authors have achieved a multiple stakeholder perspective on the problem. The variety of resources used can be shown with the bibliography, both in terms of publication types (scientific journals, books, policy papers, annual reports, minutes of public meetings, legislation, documented interviews, websites, podcasts, etc.) and in terms of authorship (scientists, government, non-governmental organizations, companies, columnists, individual stakeholders, etc.)

8.2.8 A Convincing Style of Communication

The challenge in writing a good issue paper is to convey to the client, in a concise yet convincing manner, what insights have been gained from the problem analysis. This is easier said than done. The format presented in Table 8.1 has a clear beginning and end, and allows the client and other readers to follow the train of thought from the initial problem situation towards recommendations and a plan of action. The argumentative style of writing is well suited to inform and convince the client with clear statements, supportive arguments and examples drawn from literature and the analyses.

Also, an issue paper is more likely to persuade the reader if it focuses on the rationale for the proposed action. To achieve this, analysts ought to focus on the main insights that the analyses have yielded, present these and support them with arguments. Clarity about what is and what is not important is more persuasive than a detailed report of an analysis. A reference to the appendix where the analysis is shown in full will suffice. An extremely detailed paper tends to end up in a drawer and miss its goal of supporting the client in addressing a wicked problem.

Visualization and tabulation of information may aid in making the issue paper to be both informative and concise. For instance, a map or drawing illustrates the geographical demarcation of a problem situation better than text can. Diagrams and large tables may not be included in the main text. Instead, clearly present the insights that were based on such tables and diagrams and refer to the appendix for more detail.

8.3 Different Problem Diagnoses, Different Storylines

A description of the 'framed problem' forms the core of the issue paper. To write this section in an informative and convincing manner, the author fist synthesizes the insights from the rich problem description, decides how the problem situation may be understood or framed (Chapter 6) and then decides on a storyline. The storyline enables the author to present the main findings in a logical and concise manner and enables the reader to understand how the conclusions and recommendations follow from the analyses that preceded the writing of the issue paper.

A storyline shows where the tension is located in the problem situation: within the system, within the actor arena, in future developments, in the 'solution space' for measures, in the values and/or perceptions that actors hold, in the institutional design or formal chart, or in a 'chicken or egg' dependency of developments. The Annex, at the end of this chapter, presents seven such storylines, covering a presentation of the problem situation, conclusions and recommendations to the client. These storylines can be used for the problem characterizations that are listed in Table 6.2. See Text box 8.2 for an example.

Text box 8.2 Storyline for problems that are characterized by large differences in perception among stakeholders with regard to the most promising solution
1. *Framed problem* Briefly describe the promising solution and use performance criteria to sketch its impact. Argue why the client cannot implement this solution unless other parties act also (or refrain from action). Name these critical actors.
Continue by sketching the problem perception of the critical actors (objectives in relation to task and responsibilities, cause of problem, preference for solutions, future) and their position in the stakeholder arena (hierarchy, opponents/friends). Focus on what might change this perception (information, incentives for action, actions of other actors, time). Present these 'mini problem analyses' in a logical order, e.g. present client first and then the largest ally or opponent. Multiple options!
2. *Conclusions and recommendations* Present the diagnosis and a recommendation as to how the client may proceed. Think of creating incentives in relation to exploiting or changing interdependencies, dynamics and strategic positions in the stakeholder arena. Give the rationale for immediate action and how this can be achieved (Chapter 6). Then present the *proposal for a follow-on activity* (Chapters 6 and 7).

8.4 A Systematic Approach to Preparing Issue Papers

The problem description in issue papers should be 'as complete as time and available data permit' (Dunn, 1994: 425; cf. Checkland, 1985: 168). How can this be achieved? A systematic approach in preparing the issue paper may help prevent that important aspects are overlooked or inconsistent.

The different parts of the issue paper will be elaborated in the next subsections. We present a systematic approach to preparing issue papers, meaning that both the analysis and writing processes are structured as subsequent steps. The first steps, the preparation of the problem analysis, are explained in Chapters 3-5 and include data collection and information structuring with various methods and techniques. Next, the insights from the analyses are combined as explained in Chapter 6 and conclusions are drawn in terms of the characterization or framing of the problem and follow-on activities that the client may want to employ. Then a proposal can be written for the follow-on activity according to the guidelines in Chapter 7. Now all the elements for writing the issue paper are available and the paper can be written according to the outline given in Table 8.1.

Writing an issue paper is presented as a step-by-step process, but you will experience that it is not a linear but rather a cyclical or iterative process. Indeed, during the process of analysing and writing, new insights will necessitate the analyst-author to revisit or reiterate analyses and rewrite texts according to the new information. Careful preparation of the writing process may help to cut down the number of necessary iterations. First assemble the results and conclusions that you could draw from the literature search, interviews and the partial analyses and characterize or frame the problem (Figure 6.1). This creates the basis for selecting an appropriate storyline and enables you to start the (iterative!) writing process. We recommend that you start with writing the introduction.

8.4.1 Introduction: The Initial Description Problem

The introduction introduces the subject of the issue paper to the reader. Remember that the issue paper is written for the client who commissioned the work of researching and writing this paper. Therefore, the introduction presents problem in a way that matches the needs and the current knowledge of the client. Where possible, quantify the extent of causes or effects of the problem. Failing to do so may cause some readers to lose interest in the remainder of the paper (too little information on the urgency of the problem) or disregard its outcomes (too little information to be able to verify problem perspectives are aligned). Make proper use of references and problem owner information to ensure that the problems and dilemmas described form an adequate representation of the problem owner's perception.

A good introduction is short and concise and helps the reader get a quick understanding of what the issue paper is about. For most issue papers, this means that an introduction should be no more than two pages in length, or five to eight paragraphs that cover the following elements:

a) *Motivation*: A short description of the problem's context.
b) *Problem*: A short description of the problem as a gap between the desirable situation and the actual or expected situation from the client's perspective. This initial description should also clarify the geographical scope and the time horizon involved.
c) *Problem-ownership*: Address problem-ownership. Mention the problem owner and the problem owner's role in addressing the problem. Or explain that the situation is such that multiple parties are concerned about the problem but it is not yet obvious as to who should assume responsibility in the matter. Name these parties and the roles they could possibly take in addressing the problem.
d) *Indication of solution space*: A problem is interesting for policy analysis only if there is some hope of improving the situation. Explain where can interventions be sought and give an impression of the extent of the solution space: are there alternative solutions to choose from? What is known about the possible benefits and drawbacks of different solutions?
e) *Complexity*: Describe what makes the problem complex enough to warrant further analysis. Provide indications of the most important complexities, be it technical, societal, managerial and political complexities. Name some readily visible interdependencies and conflicting interests between different actors involved.
f) *Dilemma*: Based on the above elements, what is the dilemma the problem owner faces? What is the choice or decision a problem owner needs to make for which they are currently ill-equipped? This dilemma provides the starting point for the in-depth problem analysis.

Table 8.2 Elements of initial problem and writing scheme for introduction

Element	Analytical Techniques that Yield this Information
1. Motivation or problem context	– Means-ends analysis (upper layer, Figure 3.3)
2. Problem, the gap between current and desired situation (or future situation)	– Chapter 2, Figure 2.2
3. Spatial and temporal aspects of the system boundary, given the problem situation	– Scoping of means-ends analysis (Figure 3.3)
4. Main stakeholders involved in relation to problem-ownership	– Power-Interest grid, Figure 4.1 (first iteration)
5. Important factors that influence system performance or relationships among stakeholders	– System diagram, Figure 3.9 (first iteration) – Power-Interest grid, Figure 4.1 (first iteration) – Overview of the main laws or formalized agreements that hamper or support system performance or problem-solving
6. Dilemma that actors must deal with	– Means-ends analysis, Figure 3.4

8.4.2 Description of the 'Framed Problem'

This section of the issue paper is a fluent text and presents the framed problem. It provides the reader with a good understanding of the problem situation as seen from multiple perspectives, leads logically to the conclusions about the essence of the problem and sets the stage for your choice of the role that the client may take to further the problem-solving process. The nature of the problem indicates how you can best structure the information that you have accumulated and convince the reader of the need to act. We recommend that you write this section only after you have synthesized the results of the partial analysis and characterized or framed the problem. The Annex presents different storylines for structuring the 'framed problem' description.

Since you use the argumentative style of writing, it is important that you indicate the sources of information on which you base your statements or argument and refer to these sources. You will use a mix of sources: literature, interviews with client or stakeholders and the conceptual models that you developed yourself (e.g. causal map, means-ends diagram, problem formulations table, formal chart). References to the literature are presented in the bibliography but the models are placed in an appendix and should be referred to as such. Only in exceptional cases do you include figures, maps, diagrams or tables in the main text of the paper. A rule of thumb is that the figure or table ought to support the reader with an illustration of a critical argument. The aim for a text is to be independently readable, meaning that you present enough information to the reader to understand the argument that you present. The reference to the appendix allows a reader to investigate the source of your argument but, at the same time, your sharp text makes this unnecessary.

8.4.3 Conclusions and Recommendations

The last part of issue papers presents the conclusion or diagnosis of the policy analysts and links it to recommendations in support of dealing with the dilemma that was presented in the introduction. Again, ideas for recommendations may be found in Chapter 6 and Table 6.3. Typically, this section lists important knowledge gaps that are relevant for dealing with the dilemma and/or in preparation of the follow-on activity. See Chapter 6.4 for a list of relevant knowledge gaps.

This section is the linking pin between the problem analysis, which is the activity that the client commissioned the analyst to do, and a proposal for follow-on action by the client. Consult Chapter 7 with respect to the knowledge gaps that may be relevant for the follow-on activity that you recommend. Knowledge gaps can be further specified in the proposal that is included with the issue paper. If this activity involves research, knowledge gaps will be presented as research questions in the research plan.

8.4.4 Proposal for Follow-On Action or Research Plan

The contents of a proposal for different follow-on activities have been discussed in Chapter 7, with an emphasis on writing a plan for conducting research. It is important to remember that a reader must be able to understand the proposal independent from the remainder of the issue paper. That said, it is also important to reduce overlap between the conclusions of the issue paper and the introduction of the proposal.

In the introduction to your proposal, you present a justification for the follow-on activity in line with the reasoning that is presented in the issue paper, and consistent with the conclusions and knowledge gaps that are mentioned. You can use the labels of the hexagon model to characterize the follow-on activities, for instance if the activity concerns research, mediation, design, etc. Also, you mention the objective of the proposal: what is the expected result and how will the proposed approach contribute to this?

Next, you present the proposal. Preferably, the approach concurs with the social and political environment in which the follow-on activity takes place. Therefore, the proposal addresses the general organization or adaptation of the activity to the context in which it is to be implemented. Therefore, be specific about, for instance, how data are gathered, about the involvement and role of different actors, or about plans to communicate the activity. Last but not least, the proposal ought to convince the reader of its feasibility and present a time schedule for the main (research) activities to be conducted and an overview of the necessary resources and how they will be obtained.

References

Brewer, G. D. & DeLeon, P. (1983). *The Foundations of Policy Analysis*. Homewood: Dorsey Press.

Checkland, P. (1985). From optimizing to learning: A Development of Systems Thinking for the 1990s. *Journal of the Operational Research Society*, 36(9), 757-767. https://doi.org/10.1057/jors.1985.141.

Dunn, W. N. (1994). *Public Policy Analysis: An Introduction*. Englewood Cliffs: Prentice Hall.

Fujimura, J. H. (1987). Constructing 'Do-able' Problems in Cancer Research: Articulating Alignment. *Social Studies of Science*, 17(2), 257-293. https://doi.org/10.1177/030631287017002003.

Quade, E. S. (1989). *Analysis for Public Decisions*. Amsterdam: North-Holland.

RAND Corporation. (n.d.). *Issue Papers*. www.rand.org/pubs/issue_papers.html.

Thissen, W. A. H. & Walker, W. E. (Eds.) (2013). *Public Policy Analysis, Chapter 4.6*. https//doi.org/10.1007/978-1-4614-4602-6.

Annex

Storylines for framed problems that fit the frame, diagnosis or characterization of the problem itself

A storyline for the problem description is based on the results of the policy analyst's work: literature search, interviews and analyses of system, system context, stakeholder arena and (in)formal agreements that govern stakeholders' actions and interactions, and futures. The interpretation of the results of this work enables the analyst to frame or characterize the problem. In this section, we propose storylines for seven possible problem frames.

The storylines are presented as bullet lists. Making bullet lists is helpful in structuring information as it invites to order and reorder, add and delete ideas for paragraphs.

Examples of problem frames (or problem diagnoses)
A. Large differences in values and/or problem perception and (need for) solution hampers problem-solving
B. Large differences in problem perception among stakeholders about one promising solution hampers problem-solving
C. Insight needed in trade-offs related to choosing one out of various (technical) solutions to further problem-solving
D. Uncertainty about incentives for cooperation among stakeholders hampers realization of a promising solution
E. Institutional design and/or hierarchy in stakeholder arena hampers problem-solving
F. Large uncertainty about the future hampers problem-solving
G. Chicken-and-egg problem hampers reaching policy goal

A Storyline for Problem Framed as 'Large Differences in Values, Problem Perception and (Need for) Solution Hampers Problem-Solving'

Problem description that explains dilemma; storyline highlights lack of shared problem frame

- A brief description of the situation/dilemma, in terms of stakeholder perceptions (how much do they differ?), system performance (who suffers from status quo?), trends and cascade of effects in system behaviour.
- Name the main factors and actors that cause the stalemate situation. Indicate client's position: why must stalemate situation change?
- 'Mini problem descriptions' from the perspectives of 3-5 critical actors. Descriptions highlight the values that motivate the actor and if these are (not) shared, explains other barriers to cooperate and what it takes to remove these. Present mini problems in a logical order, e.g. present client first and then the largest ally or opponent. Multiple options!

Conclusions and recommendations

- Statement of the diagnosis or problem frame. Explicate the main differences that the client ought to pay attention to and indicate possible follow-on activities (Chapter 6).
- Recommendation as to how the client may proceed/act. And a rationale for immediate action and how this can be achieved.
- Objective of *a recommended follow-on activity* (Chapters 6 and 7). What will be achieved if proposal for this follow-on activity is executed?

B Storyline for Problem Framed as 'Large Differences in Problem Perception among Stakeholders about One Promising Solution Hampers Problem-Solving'

Problem description that explains dilemma; storyline highlights various problem perceptions

- Brief description of the one promising solution, using performance criteria to sketch its impact.
- Explanation why (main) problem owner cannot implement this solution unless other parties act also (or refrain from specified actions). Name these critical actors.
- 'Mini problem analyses' of these critical actors in a logical order, e.g. present client first and then the largest ally or opponent. Multiple options!
  - Problem perception(s) include stakeholder objectives in relation to task and responsibilities, perception of cause of problem, preference for solutions and their position in the actor arena (hierarchy, opponents/friends). Include perception of future changes and consequences.
  - Indicate what might change problem perception (information, incentives for action, actions of other actors, time).

Conclusions and recommendations

- Statement of the diagnosis or problem frame. If possible, name ways to influence interdependencies, dynamics and strategic positions in the stakeholder arena.
- Recommendation as to how the client may proceed/act. And a rationale for immediate action and how this can be achieved (Chapter 6).
- Objective of *a recommended follow-on activity* (Chapters 6 and 7). What will be achieved if proposal for this follow-on activity is executed?

C Storyline for Problem Framed as 'Insight Needed in Trade-offs Related to Choosing One Out of Various (Technical) Solutions to Further Problem-Solving'

Problem description that explains dilemma; storyline highlights differences between solutions

- Brief description of the problem/dilemma and the main performance criteria to be improved.
- Brief overview of the most promising solutions (with arguments pro and con).
- Mini descriptions of these solutions in a logical order, e.g. present the most satisficing solution first. Multiple options!

- Descriptions include measures to be employed and their effectiveness; possible externalities; expected impact of solutions in different futures. If relevant, name mitigating actions.
- Descriptions give an insight into the strategic position of stakeholders per solution as well as the possibility of coalition formation in support of one of the solutions.

Conclusions and recommendations

- Statement of the diagnosis or problem frame. If possible, indication of extra measures that the client may take either to mitigate the effect of the trade-off (compensation measures) or to otherwise take away barriers to taking the decision about what trade-off is most acceptable.
- Recommendation as to how the client may proceed. Is it possible to make the trade-off or must it be postponed on order to align stakeholders and increase willingness to accept a trade-off? Rationale for immediate action and how this can be achieved (Chapter 6).
- Objective of *a recommended follow-on activity* (Chapters 6 and 7). What will be achieved if proposal for this follow-on activity is executed?

D Storyline for Problem Framed as 'Uncertainty about Incentives for Cooperation among Stakeholders Hampers Realization of a Promising Solution'

Problem description that explains dilemma; storyline per 'barrier' for cooperation

- Brief description of the promising solution(s) and explanation why (main) problem owner cannot implement either solution unless other parties act also (or refrain from specified actions). Name the 2-4 most important barriers to cooperation (e.g. formal chart regarding tasks/responsibilities, (in)formal agreements, funding, time, political will).
- Mini analyses of these institutional barriers in a logical order, e.g. present the barrier with largest impact first. Multiple options!
  - Analysis of barriers or obstacles starts with labelling of the change or intervention that cannot take place unless the barrier is removed. The nature of the barrier (technical, social or both) and its function in the system, stakeholder arena or institutional design are explained. Who benefits if the barrier continues to exist? Questions about future action of the barrier (impact, continuation) are answered.
  - For each barrier, indicate what actor(s) can take away the barrier and what incentive may prompt them to do so (law enforcement, subsidy, penalty, exchange of costs/benefits, compensation, information). Name supporters of and opponents to barrier.

Conclusions and recommendations

- Coalition of stakeholders to be motivated to cooperate given the right incentives are in place.
- Statement of the diagnosis or problem frame. Explain what the uncertainty about the effectiveness of incentives means for the process of problem-solving.

- Recommendation as to how the client may proceed. Is it possible and desirable that client motivates critical actors to remove institutional barriers or address knowledge gaps? How?
- Rationale for immediate action and how this can be achieved (Chapter 6).
- Objective of *a recommended follow-on activity* (Chapters 6 and 7). What will be achieved if proposal for this follow-on activity is executed?

E Storyline for Problem Framed as 'Institutional Design and/or Hierarchy in Stakeholder Arena Hampers Problem-Solving'

Problem description that explains dilemma; storyline per 'barrier' for problem-solving
- Brief description of the problem situation with emphasis on how either the institutional design and/or stakeholder hierarchy stands in the way of solving the problem.
- Labels of the main 2-4 barriers to problem-solving and explanation if these stem from legislation, market functioning, ownership or formalized stakeholder relationships.
- Mini analyses of these barriers in a logical order, e.g. first present the barrier that can be lifted in a short time frame. Multiple options!
  - Analysis of institutional or hierarchical barriers starts with explanation of the mechanism that hampers problem-solving. Next, measures (in institutional design or stakeholder arena) are discussed to remedy situation, such as knowledge, time, money, formation of or dissolving stakeholder coalition, extending support, political will. Who benefits if such measures do (not) succeed? How fast can measures be effective and how robust given uncertainties about the future?
  - For each barrier, indicate what actor(s) can take such measures and name supporters and opponents.

Conclusions and recommendations
- Statement of the diagnosis or problem frame. Explain what aspect of institutional or hierarchical barrier needs to be lifted first.
- Recommendation as to how the client may proceed (Chapter 6) and a rationale for immediate action and how this can be achieved.
- Objective of *a recommended follow-on activity* (Chapters 6 and 7). What will be achieved if proposal for this follow-on activity is executed?

F Storyline for Problem Framed as 'Large Uncertainty about the Future Hampers Problem-Solving'

Problem description that explains dilemma; storyline per 'contextual scenario'
- Brief description of the problem situation with emphasis on uncertain developments in system context and how this may affect stakeholder values and/or system performance.
- Three or four most important uncertain, external factors and a discussion of the drivers of these uncertainties (ecological, technical, economical, social or political).
- Short presentation of four contextual scenarios as explained in Chapter 5. For each scenario, discuss system performance and the extent to which actor(s) may suffer or

benefit from the described circumstances. Discuss how external factors can cause a shift in system performance or stakeholder satisfaction. Discuss the main assumptions and signpost: what must client and stakeholders monitor to judge in what scenario the system performs.

Conclusions and recommendations

- Statement of the diagnosis or problem frame. Explain what uncertain aspects of the future hamper problem-solving most. Discuss what is needed so that stakeholders can proceed despite uncertainty.
- Recommendation as to how the client may proceed (Chapter 6) and a rationale for immediate action and how this can be achieved.
- Objective of *a recommended follow-on activity* (Chapters 6 and 7). What will be achieved if proposal for this follow-on activity is executed?

G Storyline for Problem Framed as 'Chicken-and-Egg Problem Hampers Reaching Policy Goal'

Problem description that explains dilemma; storyline per 'phase' of development in demand/supply

- Short description of the services or infrastructures for which demand and supply must be developed. Then gap analysis (for current and future situation) that elucidates the overall policy goal, interest and role of the problem owner.
- Naming of 2-4 different phases in development of demand and supply. Description of the interrelatedness of the phases and feedback loops between demand and supply development.
- Mini analyses of these developmental phases in a logical order: phase 1 first. Explanation of measures needed in each phase, who is responsible for their realization and incentives to (not) act. Identification of the main interdependencies between the different phases in the near and far future. Insight into how external factors may accelerate, hamper or neutralize progress. Indication of issues that are critical for, more or less simultaneous, development of demand and supply.

Conclusions and recommendations

- Present the diagnosis that this is a 'chicken-and-egg' problem and motivate this.
- Discuss the risks that actors take when developing demand and/or supply. List the issues that stakeholders need to address to prevent that progress stalls and highlight client's position.
- Recommendation as to how the client may proceed (Chapter 6), either by developing a strategic position in the actor arena or by taking technical or institutional measures. What knowledge gaps, if any, stand in the way of the client's agency?
- Objective of *follow-on activity* (Chapters 6 and 7). What will be achieved if proposal for this follow-on activity is executed?

About the Authors

Bert Enserink is associate professor of policy analysis at Delft University of Technology. He is a specialist in action research, participatory methods, social learning and scenario analysis. Main fields of application are water management and energy transition. He has extensive international experience and teaches courses in policy analysis and intercultural communication.
https://orcid.org/0000-0001-9182-3712

Pieter Bots is associate professor of policy analysis at Delft University of Technology. He is an expert designer of methods and tools for systems analysis and decision support. His present research focuses on multi-stakeholder modelling and simulation of energy grids and markets. He teaches courses in modelling, policy and decision analysis, and designing in socio-technical systems.
https://orcid.org/0000-0003-4569-1549

Els van Daalen is associate professor of policy analysis at Delft University of Technology. She is involved in both teaching and research in the area of methods for systems modelling and analysis. Specific methods of interest are System Dynamics and serious gaming. She has developed and taught courses on problem structuring and systems modelling at all university levels.
https://orcid.org/0000-0001-7635-572X

Leon Hermans works as associate professor in water and environmental policy analysis at TU Delft and IHE Delft. His work focuses on the use of actor concepts and models and on improving the linkages between decision-making, implementation and evaluation, to foster policy learning about complex water challenges now and in the future.
https://orcid.org/0000-0002-5294-9045

Joop Koppenjan is emeritus professor of Public Administration at the Erasmus University Rotterdam. He worked at TU Delft's TPM Faculty from 1996 till 2010. He is specialized in doing comparative case study research between policy areas or countries. His research interests include topics like public policy, network governance, public private partnerships and public service delivery. Areas of application are infrastructure-based sectors such as transport, water, and energy, and social sectors such as social support, care, and safety.
https://orcid.org/0000-0002-0099-5760

Rens Kortmann is assistant professor in policy gaming at Delft University of Technology. He teaches problem analysis and policy game design. His research focuses on designing and evaluating persuasive games about complex socio-technical problems. His main application areas are sustainable development and health care.
https://orcid.org/0000-0002-7088-4222

Jan Kwakkel is a full professor in model-based support for decision making under deep uncertainty at Delft University of Technology. His research focuses on developing and testing innovative model-based techniques for the design of dynamic adaptive policy pathways. He has applied his research in a range of domains including climate adaptation, flood risk management, transport and logistics, resource economics, and national safety and security.
https://orcid.org/0000-0001-9447-2954

Tineke Ruijgh van der Ploeg is senior lecturer of policy analysis at Delft University of Technology. She enjoys supervising students who write issue-papers as a preparation for setting up their Bachelor thesis research projects. Also, she is engaged in project-based education of designing socio-technical systems in one of TPM's MSc programmes.

Jill Slinger is associate professor of policy analysis at Delft University of Technology. She teaches courses on systems modelling at graduate and PhD level and is spearheading the university's teaching on Building with Nature. As Visiting Professor at Rhodes University, South Africa, Slinger is also involved in addressing water and coastal implementation challenges in the developing world.
https://orcid.org/0000-0001-5257-8857

Wil Thissen is emeritus professor of policy analysis at Delft University of Technology. He has led the development of Policy Analysis at TU Delft since 1992 until his formal retirement. He currently enjoys keeping up with the field as a reviewer/editorial board member for several academic journals, in particular in water- and environmental management, and volunteers as a counsellor to actors in developing countries.

Policy Analysis of Multi-Actor Systems is an introduction into the art and craft of problem exploration and problem structuring. It positions policy analysis as a scientific discipline focused on systems analysis in a multi-actor context to support better informed decision-making.
The approach presented in this book is considered to be the cornerstone of the curricula of the Faculty of Technology, Policy and Management of Delft University of Technology and underlies the research on (the governance of) socio-technical systems. Systems thinking applied in a multi-actor environment and its inherent multi-disciplinary character is what makes this work stand out from traditional hard- and soft systems approaches.
The core of the book is dedicated to systems analysis, actor- or stakeholder-analysis and discusses methods for dealing with uncertainty. These analytical activities combined lead to a rich problem description and to plans for further research. Due to the stepwise approach this book serves as a basis for any problem analysis both for our bachelor and master students, our alumni worldwide and any interested practitioners.

TU Delft | Faculty of Technology, Policy and Management | Department of Multi-Actor Systems

The authors of the book *Policy Analysis of Multi-Actor Systems* have all been involved in teaching courses on policy analysis both for bachelor and master students at the Faculty of Technology, Policy and Management of Delft University of Technology. This 2nd edition builds on more than 25 years of research and teaching experience; consequently most examples in the book are based on own research experience. While some of the authors have retired, others are at different stages of their career as a policy analyst. The composition of the team guarantees an ongoing discussion and updating of this foundational course book.