

Contents

Acknowledgements — VII

List of Figures — XV

List of Tables — XVII

1	Introduction — 1
1.1	Our Complex World — 1
1.2	Is a Structured Decision Process Really Necessary? Common Objections — 2
1.2.1	It's My Job to Make Good Decisions — 3
1.2.2	I Can't Trust a Computer Program to Make Decisions for Me — 3
1.2.3	It's Possible to Make Decision Models Reach Any Conclusion That You Want — 3
1.2.3.1	Advocacy-Based Approach and Potential Effect of Cognitive Biases — 4
1.2.3.2	Inquiry-Based Approach — 5
1.2.4	Garbage In, Garbage Out — 6
1.2.5	We Have Our Own Standardized Decision-Making Process — 6
1.3	Why This Book? — 7
1.4	MCDM Applications — 8
1.4.1	Energy Planning and Policy — 8
1.4.2	Oil and Gas Exploration and Production (E&P) — 8
1.4.3	Healthcare Decision Making — 9
1.4.4	Environmental Management — 10
1.5	Terminology — 10
1.5.1	Multicriteria Decision Analysis (MCDA) — 11
1.5.2	Decision — 12
1.5.3	Decision Analysis — 12
1.5.4	Good Decision — 12
1.5.5	Uncertainties — 13
1.5.6	Risk — 13
1.5.7	Decision Makers — 13
1.5.8	Stakeholders — 13
1.5.9	Values — 13
1.5.10	Objectives — 14
1.5.11	Goals — 14
1.5.12	Criteria — 14
1.5.13	Objectives Hierarchy — 14
1.5.14	Alternatives — 15

1.5.15	Level or Score —	15
1.5.16	Trade-Offs —	15
1.5.17	Optimization —	16
1.6	Benefits of MCDM —	16
1.6.1	Includes Nonfinancial as well as Financial Objectives —	16
1.6.2	Offers Insights in Values and Trade-Offs —	17
1.6.3	Identifies Creative and Implementable Alternatives —	18
1.6.4	Reveals the Impact of Uncertainties —	18
1.6.5	Identifies the Alternative Most Aligned with Decision Makers’/ Stakeholders’ Values —	20
1.6.6	Provides a Singular Comprehensive Analytical Framework —	20
1.6.7	Communicates the Totality of Consequences —	21
1.6.8	Potential for Significant Cost Savings —	21
	References —	23
2	Introduction of a Case Study —	26
2.1	Integrated Capital Assessments —	26
2.2	History of Town of Greenville —	29
2.3	Developing a Strategic Plan for Greenville —	31
2.4	Community Interests —	31
2.5	Purpose of Proposed MCDM —	32
2.6	Superfund Cleanup —	33
2.6.1	Sediment Project Status —	34
2.6.2	Remedial Costs —	35
2.6.3	Impact of Sediment Remediation Alternatives on Greenville Strategic Plan —	36
2.6.3.1	Alternative 1 – Complete Dredging —	36
2.6.3.2	Alternative 2 – Hotspot Dredging —	38
2.6.3.3	Capping —	39
2.6.3.4	Monitored Natural Attention —	39
2.6.3.5	Confined Disposal Facility (CDF) —	39
2.7	Example Survey —	40
	References —	40
3	Foundations of MCDM —	41
3.1	Reviewing the Fundamentals: A Strategy for Simplifying MCDM —	41
3.2	Fundamental Elements of Decision Problems —	42
3.2.1	Choices —	43
3.2.2	Known Facts —	45
3.2.3	Chance Events —	45
3.2.4	Constraints —	48
3.2.5	Value Measures —	50

3.2.6	Preferences — 50
3.3	Fundamental Concepts — 50
3.4	Systems Engineering and Systems Thinking — 51
3.4.1	Systems Modeling — 51
3.4.2	Systems Thinking — 52
3.5	Fundamental Concepts of Probability Theory — 55
3.5.1	Bayes' Formula and Subjective Probabilities — 61
3.5.2	Describing Experimental Data — 65
3.5.3	Graphical Representations of Experimental Data — 65
3.5.3.1	Frequency Histograms — 65
3.5.3.2	Discrete and Continuous Distributions — 67
3.5.3.3	Cumulative Distribution Functions – Discrete and Continuous Distributions — 69
3.5.4	Measures of Central Tendency — 70
3.5.5	Measures of Dispersion — 72
3.5.6	Distinguishing Properties of Probability Distributions — 73
3.5.7	Probability Distributions Most Useful for MCDM — 75
3.6	Fundamental Concepts of Finance — 77
3.6.1	Time Value of Money — 77
3.6.2	Net Present Value — 77
3.6.2.1	Nominal Versus Real Dollars — 79
3.6.2.2	Real Discount Rate — 80
3.6.2.3	Advantages of Stepwise Structuring of Cash Flow Analysis Within Spreadsheets — 80
3.6.2.4	Calculating NPV — 81
3.7	Fundamental Concepts of Economics — 82
3.7.1	The Basic Economic Problem — 83
3.7.2	Opportunity Cost — 83
3.7.3	Rational Person Assumption — 84
3.7.4	Revealed Preference Analysis — 84
3.7.5	Stated Preference Analysis — 84
3.8	Behavioral Economics — 85
3.8.1	Risk Aversion in Gains — 86
3.8.2	Risk-Seeking in Losses — 87
3.8.3	Choice Preference as a Function of Decision Frame — 88
3.8.4	Cognitive Biases — 90
3.8.5	Emotions and Rationality — 92
3.9	Decision Quality — 93
3.9.1	Appropriate Frame — 94
3.9.2	Creative Doable Alternatives — 95
3.9.3	Meaningful Reliable Information — 95
3.9.4	Clear Values and Trade-Offs — 95

3.9.5	Logical Correct Reasoning —	95
3.9.6	Commitment to Action —	95
	References —	96
4	The MCDM Process —	98
4.1	Is the Complete MCDM Process Required for Every Decision? —	99
4.2	How Much Effort Should Be Invested in the Decision Analysis Process? —	101
4.3	Outline of the MCDM Process —	101
4.4	Inviting Stakeholders to Share in Decision Making —	103
4.4.1	Potential Levels of Stakeholder Involvement —	103
4.4.2	Recommended Levels of Stakeholder Involvement —	104
4.5	Structure Phase —	105
4.5.1	Concept of the Decision Hierarchy —	106
4.5.2	The Participants in the Decision Process and Their Roles —	107
4.5.2.1	Decision Executive —	107
4.5.2.2	Decision Analysis Facilitators —	108
4.5.2.3	Decision Review Board —	109
4.5.2.4	Project Team Members —	109
4.5.2.5	Stakeholders —	109
4.5.2.6	Subject-Matter Experts —	110
4.5.3	Preframing Meeting Activities and Exercises —	110
4.5.4	Framing Meeting Exercises —	112
4.5.4.1	Background Information Review —	113
4.5.4.2	Stakeholder Analysis and Engagement —	115
4.5.4.3	Document Policies —	117
4.5.4.4	Develop Objectives Hierarchy —	117
4.5.4.4.1	Top-Down Objectives Hierarchy Approach —	117
4.5.4.4.2	Bottom-Up Objectives Hierarchy Approach —	118
4.5.4.4.3	Blended Objectives Hierarchy Approach —	119
4.5.4.5	Example Objectives Hierarchy —	119
4.5.4.6	Identifying Value Measures (Criteria) —	121
4.5.4.6.1	Double Counting —	121
4.5.4.6.2	Conceptual Independence —	121
4.5.4.6.3	Stated in Natural Units —	122
4.5.4.6.4	Categorical Criteria —	122
4.5.4.6.5	Identifying a Starting List of Criteria —	122
4.5.4.7	Designing Alternatives —	123
4.6	Exercises —	125
	References —	125

5	The Evaluation Process – Building the MCDM Model — 127
5.1	Quantifying Preferences and Uncertainties — 127
5.2	Conjoint Surveys — 128
5.2.1	Administering the Conjoint Survey — 129
5.2.2	Example Conjoint Survey — 130
5.2.3	Design of Experiments — 132
5.2.4	Evaluating Conjoint Surveys Using Linear Regression — 134
5.2.5	Calculating Criteria Weights — 135
5.2.6	Interpreting Linear Regression Results — 135
5.3	Fitting PDFs to Actual Data — 144
5.3.1	Using @Risk's Distribution Fitting Feature — 144
5.3.2	Selecting Which Fitted Distributions to Use — 149
5.4	Defining Input Distributions Based on Expert Judgment — 155
5.4.1	Class Estimating Exercise — 156
5.4.2	Documenting Expert Elicitation Results — 161
5.4.3	Shaping PDFs Based on Subject-Matter Expert Elicitation — 162
5.5	Estimating the Probability of Discrete Events — 163
5.5.1	The Probability Wheel — 164
5.5.2	Standardized Probability Phrases and Tabular Visual Aids — 165
5.5.3	References to Processes Where Probabilities Are Well Known — 166
5.6	Structuring the MCDM Model — 167
5.6.1	The Additive Value Function — 167
5.6.2	Probabilistic Normalization — 168
5.6.3	Examples MCDM Model Structure – Conceptual and Actual — 168
5.7	MCDM Template — 172
5.8	Cash Flow Model Template — 173
5.9	Exercise — 180
	References — 180
6	The Agreement Phase — 182
6.1	Addressing the Issue of Distributed Authority — 183
6.2	Case Study of Stakeholder Involvement — 184
6.2.1	Consult Level — 184
6.2.2	Involve Level — 185
6.2.3	Collaborate Level — 185
6.2.4	Empower Level of Stakeholder — 186
6.3	Developing Output Results — 186
6.4	Communicating Insights — 189
6.4.1	Output Cumulative Distribution Functions and Probability Distributions — 190
6.4.2	Sensitivity Tornado Diagrams — 192
6.4.3	MCDM Score Stacked Bar Graph — 192

XIV Contents

6.4.4 Comparing Alternative Risks Using Box and Whisker Plots — **194**
6.4.5 Comparison of Value Measures Across Alternatives — **195**
6.4.6 Output Descriptive Statistics — **195**
6.5 Commit to Implement — **196**
6.6 Summary Statement — **196**

Appendix A Example Stakeholder Survey — 199

Appendix B Case Study: Example Stakeholder Analysis — 203

Appendix C Case Study Objectives Hierarchy — 205

Appendix D Case Study Strategy Table — 207

**Appendix E Case Study: Completed Conjoint Surveys and Objectives
hierarchy — 211**

Index — 221