

---

## Contents

|   |           |
|---|-----------|
| <b>Part I: Understanding Natural Processes and Modelling</b>                        | <b>1</b>  |
| <b>1 The Erosion of Coasts and the <i>Atlas of the Italian Beaches</i></b>          | <b>3</b>  |
| <b>2 Upwelling of the Sea over the Past 11.5 cal kyr B.P.</b>                       | <b>9</b>  |
| 2.1 Coastal Mobility  | 9         |
| 2.2 Instrumental Data (Satellite and Marigraph)                                     | 10        |
| 2.3 Palaeoclimatic Data   | 10        |
| 2.4 Curves from Coral Reefs   | 14        |
| 2.5 Models  | 14        |
| 2.6 The Universal Deluge  | 15        |
| 2.7 Conclusions   | 16        |
| References  | 16        |
| Additional References   | 17        |
| <b>3 Meteorological Factors Influencing Slope Stability</b>                         | <b>19</b> |
| 3.1 Introduction  | 19        |
| 3.2 Methodology and Study Areas   | 20        |
| 3.3 Correlation Between Meteo-Climatic Factors and Slope Stability                  | 22        |
| 3.3.1 Falls and Topples   | 22        |
| 3.3.2 Slides  | 25        |
| 3.3.3 Spreads   | 27        |
| 3.3.4 Flows   | 29        |
| 3.4 Conclusions   | 33        |
| Acknowledgements  | 34        |
| References  | 34        |
| Additional References   | 34        |
| <b>4 Use of Radar Rainfall Estimates for Flood Simulation in Mountainous Basins</b> | <b>37</b> |
| 4.1 Introduction  | 37        |
| 4.2 Correction Procedures for Range-Dependent and Mean-Field Biases                 | 39        |
| 4.2.1 Range-Dependent Bias  | 39        |
| 4.2.2 Mean-Field Bias   | 41        |
| 4.3 Data and Case Studies   | 41        |

|          |   |           |
|----------|---|-----------|
| 4.4      | Comparison of Basin-Average Rainfall Estimates Based on Radar and Rain Gauge Measurements ..... | 44        |
| 4.5      | Sensitivity of Rainfall-Runoff Transformation to Radar Rainfall Errors .....                    | 46        |
| 4.6      | Conclusions .....   | 50        |
|          | Acknowledgements .....  | 51        |
|          | References .....  | 51        |
|          | Additional References .....   | 52        |
| <b>5</b> | <b>FLOODSS: A Flood Operational Decision Support System .....</b>                               | <b>53</b> |
| 5.1      | The Flooding Problem .....  | 53        |
| 5.2      | The Need for a Flood Planning and Management DSS .....  | 54        |
| 5.3      | Aims and Structure of FLOODSS .....   | 55        |
| 5.4      | Conclusions .....   | 63        |
|          | References .....  | 63        |
| <b>6</b> | <b>A Brief Overview of Hydrological Modelling .....</b>   | <b>65</b> |
| 6.1      | Background .....  | 65        |
| 6.1.1    | What is a Hydrological Model? .....   | 65        |
| 6.1.2    | Areas of Application .....  | 66        |
| 6.1.3    | Hydrograph Analysis – Discharge, Stage .....  | 66        |
| 6.1.4    | Discharge Modelling .....   | 67        |
| 6.1.5    | Hydrodynamic Simulation .....   | 68        |
| 6.2      | Scale of Modelling .....  | 69        |
| 6.3      | Characteristics of Typical Applications of Hydrological Models .....                            | 70        |
| 6.3.1    | Design .....  | 70        |
| 6.3.2    | Forecasting .....   | 72        |
| 6.3.3    | Reconstruction of Historic Events .....   | 73        |
| 6.3.4    | Scenario Investigation .....  | 74        |
| 6.4      | Statistical Estimation .....  | 74        |
| 6.4.1    | Hydrological Statistics .....   | 74        |
| 6.4.2    | Extreme Value Distributions .....   | 75        |
| 6.4.3    | Fitting Distributions to Data .....   | 75        |
| 6.4.4    | Hydrographs .....   | 77        |
| 6.4.5    | Joint Probability .....   | 77        |
| 6.4.6    | The QdF Method .....  | 78        |
| 6.4.7    | Risk Assessment .....   | 78        |
| 6.5      | Rainfall-Runoff Modelling .....   | 80        |
| 6.5.1    | Unit-Hydrograph Models .....  | 80        |
| 6.5.2    | Process-Based Models .....  | 83        |
| 6.6      | Flow Routing .....  | 86        |
| 6.7      | Hydrodynamic Modelling .....  | 87        |
| 6.8      | Modelling in Practice .....   | 89        |
| 6.9      | Areas of Difficulty and Future Research .....   | 89        |
|          | Acknowledgements .....  | 92        |
|          | References .....  | 92        |

|   |     |
|---|-----|
| A.6 Appendix · Model Application Procedure .....  | 94  |
| A.6.1 Introduction .....  | 94  |
| A.6.2 Model Definition .....  | 94  |
| A.6.3 Model Construction – Topographic Data .....   | 96  |
| A.6.4 Model Construction Hydrometric Data .....   | 98  |
| A.6.5 Model Proving .....   | 100 |
| A.6.6 Baseline Simulations .....  | 102 |
| A.6.7 Assessment of Results .....   | 104 |
| <br><b>7 Slope Instabilities and Restauration in the<br/>Historical Town of Orvieto</b> ..... | 107 |
| 7.1 A Brief History of Orvieto .....  | 107 |
| 7.2 Geomorphological Aspects .....  | 108 |
| 7.3 Failures .....  | 109 |
| 7.4 The Works Necessary to Preserve the City of Orvieto .....                                 | 110 |
| 7.5 Restoration of the Slopes and the Ditches .....   | 111 |
| 7.6 Consolidation of the Rock .....   | 116 |
| 7.7 Restoration of the Walls and Tidying up of the Rocks Edges .....                          | 116 |
| 7.8 Survey and Consolidation of the Cavities .....  | 117 |
| 7.9 Instrumentation and Geodetical Net .....  | 119 |
| <br><b>Part II: Hazard and Risk Assessment</b> .....  | 125 |
| <br><b>8 Heavy Rainfall Hazards</b> .....   | 127 |
| 8.1 Introduction .....  | 127 |
| 8.2 Concept and Methodology of Heavy Rainfall Hazard .....                                    | 127 |
| 8.2.1 The Maximal Annual Daily Rainfall .....   | 128 |
| 8.2.2 Maximal Annual Rains from Rains above a Threshold .....                                 | 128 |
| 8.3 Results: Return Periods and Trends .....  | 129 |
| 8.3.1 The Return Period .....   | 129 |
| 8.3.2 The Trend .....   | 131 |
| 8.4 Do Extreme Data Mean Extreme Processes? .....   | 134 |
| 8.5 Conclusion .....  | 137 |
| Acknowledgements .....  | 137 |
| A.8 Appendix .....  | 138 |
| A.8.1 Second Method for Determining Heavy Rains (Above a Threshold) ....                      | 138 |
| <br><b>9 Snow Avalanches</b> .....  | 141 |
| 9.1 Introduction .....  | 141 |
| 9.2 Avalanche Formation .....   | 143 |
| 9.2.1 Avalanche Topography .....  | 143 |
| 9.2.2 Snow Pack .....   | 145 |
| 9.2.3 Weather Conditions .....  | 146 |
| 9.3 Runout Models .....   | 148 |
| 9.3.1 Statistical $\alpha/\beta$ -Model .....   | 150 |

|           |  |            |
|-----------|--|------------|
| 9.3.2     | Voellmy Block Model .....  | 153        |
| 9.3.3     | PCM Block Model .....  | 153        |
| 9.3.4     | NIS Visco-Elastic Plastic Deformable Body Model .....  | 154        |
| 9.4       | Legislation and Avalanche Hazard .....   | 157        |
| 9.5       | Avalanche Hazard Zoning; Hazard Zoning Principles .....  | 158        |
| 9.5.1     | Mapping Standard .....   | 158        |
| 9.5.2     | Types of Maps .....  | 159        |
| 9.5.3     | Zoning Procedure .....   | 160        |
| 9.6       | GIS as a Tool for Hazard Zoning .....  | 161        |
| 9.7       | Sustainable Development? .....   | 162        |
|           | References .....   | 162        |
|           | Additional References .....  | 163        |
| <b>10</b> | <b>Land Use Planning in Hazard Mitigation: Intervening in Social and Systemic Vulnerabilities – An Application to Seismic Risk Prevention</b> .. | <b>165</b> |
| 10.1      | Introduction .....   | 165        |
| 10.2      | Land Use Planning: A Tool of Risk Prevention Strategies .....  | 166        |
| 10.3      | Measuring and Assessing Risk: The Hazard Analysis .....  | 171        |
| 10.4      | Measuring and Assessing Risk: The Vulnerability Factor .....   | 173        |
| 10.5      | The Case of Alaska .....   | 179        |
| 10.6      | Conclusions .....  | 181        |
|           | Acknowledgements .....   | 182        |
|           | References .....   | 182        |
| <b>11</b> | <b>Landslide Susceptibility Mapping: A Methodological Approach</b> .....   | <b>183</b> |
|           | Landslide Phenomena .....  | 184        |
|           | Landslide Prediction .....   | 185        |
|           | Landslide Hazard and Risk .....  | 186        |
|           | References .....   | 186        |
| <b>12</b> | <b>Application of an Integrated Method for Landslide Hazard Assessment in the Area of Corvara in Badia (Dolomites, Italy)</b> .....              | <b>187</b> |
| 12.1      | Introduction .....   | 187        |
| 12.2      | Geomorphological Analysis .....  | 188        |
| 12.3      | Slope Instability Analysis .....   | 190        |
| 12.4      | Landslide Susceptibility Mapping .....   | 193        |
| 12.5      | Landslide Hazard Assessment .....  | 195        |
| 12.6      | Conclusions .....  | 196        |
|           | Acknowledgements .....   | 197        |
|           | References .....   | 197        |
| <b>13</b> | <b>Tsunami Hazard in Southern Italy</b> .....  | <b>199</b> |
| 13.1      | Introduction .....   | 199        |
| 13.2      | Tsunami Generation Mechanism .....   | 200        |
| 13.3      | Tsunami Impact on the Coasts .....   | 202        |
| 13.4      | Tsunamis in Southern Italy .....   | 203        |

|           |   |            |
|-----------|---|------------|
| 13.4.1    | Tsunami Catalogues .....  | 203        |
| 13.4.2    | A Statistical Approach to Tsunami Hazard .....  | 204        |
| 13.4.3    | Deterministic Approach to Tsunami Hazard: Scenarios .....   | 205        |
| 13.5      | The 1627 Tsunami in Gargano .....   | 205        |
| 13.6      | The 1693 Tsunami in Eastern Sicily .....  | 207        |
| 13.7      | The 1908 Tsunami in the Messina Straits .....   | 208        |
| 13.8      | Conclusions .....   | 210        |
|           | Acknowledgements .....  | 210        |
|           | References .....  | 210        |
| <b>14</b> | <b>Integrated Investigations on Landslides –<br/>The Example of the Super Sauze Earthflow .....</b>     | <b>213</b> |
| 14.1      | Introduction .....  | 213        |
| 14.2      | Geological Conditions Favourable to Landsliding .....   | 213        |
| 14.2.1    | Geological and Geomorphological Features of the<br>Barcelonnette Basin .....                            | 213        |
| 14.2.2    | The Barcelonnette Basin Landscape .....   | 215        |
| 14.2.3    | Landslides .....  | 215        |
| 14.2.4    | The Super Sauze Landslide .....   | 215        |
| 14.2.5    | Triggering and Evolution .....  | 217        |
| 14.3      | Integrated Methods and Technics .....   | 217        |
| 14.3.1    | Terrestrial Topometry .....   | 217        |
| 14.3.2    | GPS Measurements .....  | 217        |
| 14.3.3    | Digital Photogrammetric Analysis .....  | 220        |
| 14.3.4    | Geophysical Investigations .....  | 220        |
| 14.3.5    | Geotechnical Investigation .....  | 224        |
| 14.3.6    | Hydrological and Hydrogeological Investigation .....  | 230        |
| 14.4      | Modelling and Hazard Assessment .....   | 232        |
| 14.5      | Conclusion .....  | 235        |
|           | Acknowledgements .....  | 236        |
|           | Additional References .....   | 237        |
| <b>15</b> | <b>Disaster, Communication and Public Information .....</b>   | <b>239</b> |
| 15.1      | Introduction .....  | 239        |
| 15.2      | Basic Definition .....  | 239        |
| 15.2.1    | The ‘Crisis’ as a Social Element .....  | 239        |
| 15.3      | The Social System During Emergencies .....  | 240        |
| 15.3.1    | Before the Event .....  | 241        |
| 15.3.2    | The Initial Phases of the Emergency .....   | 242        |
| 15.3.3    | The Central Phase of the Emergency:<br>The Local Community and the Other Actors During the Crisis ..... | 242        |
| 15.3.4    | The Recovering Phase .....  | 244        |
| 15.4      | The Problem of Communication between Scientists<br>and the Populations .....                            | 244        |
| 15.5      | Ensuring a Role for Information in Disaster Management Plans .....                                      | 244        |
|           | References .....  | 246        |

|   |     |
|---|-----|
| <b>Part III: Implementing Sustainable Development</b>   | 247 |
| <b>16 Natural Disasters and Sustainable Development:<br/>From Theory to Practice in Italy?</b>                                  | 249 |
| 16.1 Introduction   | 249 |
| 16.2 Problem Identification and State of the Art  | 250 |
| 16.2.1 Natural Disasters, Costs and Victims in Italy  | 250 |
| 16.2.2 What Scenario is for the Future?   | 252 |
| 16.2.3 The Legislative Situation  | 255 |
| 16.2.4 Fund Flow  | 258 |
| 16.3 Sustainability Objectives  | 258 |
| 16.3.1 Related Conditions   | 258 |
| 16.3.2 Objectives   | 260 |
| 16.4 Action   | 260 |
| 16.5 Aspects Relating to Employment   | 266 |
| 16.6 Implementation and Control   | 267 |
| 16.6.1 Development of Regulations and Legislative Tools for<br>Managing Territorial Safety                                      | 267 |
| 16.6.2 Quality Control of Proposals and Projects and<br>Coherence of Financial Flows  | 268 |
| 16.7 Conclusion   | 269 |
| References  | 269 |
| Acknowledgements  | 269 |
| Additional References   | 270 |
| <b>17 A Risk Analysis and Sustainability Approach to Natural Disaster<br/>Assessment and Mitigation Philosophy in the World</b> | 271 |
| 17.1 Introduction   | 271 |
| 17.2 Societal Impacts of Violent Natural Disasters  | 274 |
| 17.3 Economic Impacts of Violent Natural Disasters  | 278 |
| 17.4 Why are Natural Disasters Important?   | 280 |
| 17.5 Philosophy and Keys for Mitigation Strategies  | 283 |
| 17.6 Structural and Non-Structural Mitigation Measures:<br>A Rational Approach  | 288 |
| 17.7 Towards a Technical-Administrative Procedure for<br>Population Disaster Risk Assessment                                    | 290 |
| 17.8 Conclusions and Suggestions  | 292 |
| Acknowledgements  | 294 |
| References  | 294 |
| Additional References   | 295 |
| <b>18 Activities of UNESCO for Natural Disaster Reduction</b>   | 297 |
| 18.1 Introduction   | 297 |
| 18.2 Earthquake Hazards   | 298 |
| 18.3 Volcanic Hazards   | 298 |
| 18.4 Tsunamis   | 298 |
| 18.5 Hydrometeorological and Other Hazards  | 299 |

|  |            |
|--|------------|
| 18.6 Educational Buildings and Cultural Monuments .....  | 299        |
| 18.7 Education and Information .....   | 300        |
| 18.8 Post-Disaster Investigations .....  | 300        |
| 18.9 Conclusion .....  | 301        |
| <b>19 Reducing the Effect of Natural Hazards on Urban Areas .....</b>  | <b>303</b> |
| 19.1 Introduction .....  | 303        |
| 19.1.1 Background .....  | 303        |
| 19.1.2 Natural Hazards .....   | 303        |
| 19.1.3 Effects of Natural Hazards .....  | 307        |
| 19.2 Understanding the Risk .....  | 311        |
| 19.2.1 Monitoring and Data .....   | 311        |
| 19.2.2 Exposure of Infrastructure .....  | 314        |
| 19.2.3 Social Elements .....   | 322        |
| 19.3 Reducing the Risk .....   | 326        |
| 19.3.1 Administrator's Role .....  | 326        |
| 19.3.2 Increasing Awareness .....  | 328        |
| 19.3.3 Action for Mitigation .....   | 329        |
| <b>20 The Exposure of Anthropogenic Systems to Natural Hazards .....</b>   | <b>339</b> |
| 20.1 Introduction .....  | 339        |
| 20.2 The Direct and Indirect Cost of an Earthquake .....   | 339        |
| 20.3 Detailed Stocktaking .....  | 344        |
| 20.3.1 Procedures and Methodologies .....  | 344        |
| 20.3.2 Earthquake Stocktaking .....  | 347        |
| 20.3.3 Training .....  | 351        |
| 20.3.4 Execution of the Stocktaking .....  | 353        |
| 20.4 Recommendations and Requirements .....  | 353        |
| 20.4.1 Managerial and Organisational Requirements .....  | 353        |
| 20.4.2 Maps and Data .....   | 353        |
| 20.4.3 Local Experts .....   | 353        |
| 20.4.4 Equipment .....   | 354        |
| 20.4.5 Tentative Time Schedule .....   | 354        |
| 20.5 Hydrological and Meteorological Hazards .....   | 354        |
| 20.5.1 Material and Information Required to Assess the Risk of<br>Floods and Inundations .....                                       | 357        |
| 20.6 Accumulation Problems .....   | 359        |
| 20.7 Conclusions .....   | 361        |
| References .....   | 361        |
| <b>21 Small-Scale Flooding and Muddy Floods as a Geomorphologic<br/>Hazard in Central Belgium: Some Financial Consequences .....</b> | <b>363</b> |
| 21.1 Introduction .....  | 363        |
| 21.2 Study Area .....  | 363        |
| 21.3 Small-Scale Flooding and Muddy Floods as a Geomorphologic and<br>Anthropogenic Hazard .....                                     | 364        |
| 21.3.1 A Conceptual Model .....  | 364        |

|   |            |
|---|------------|
| 21.3.2 The Nature of Small-Scale Flooding and Muddy Floods .....        | 366        |
| 21.4 The Financial Costs of Small-Scale Flooding and Muddy Floods ..... | 368        |
| 21.5 Retention Ponds and Sediment Yield Assessment .....                | 369        |
| 21.6 Financial Costs of Retention Ponds .....                           | 370        |
| 21.7 Conclusions .....  | 371        |
| References .....  | 371        |
| <b>22 GIS and Natural Hazards .....</b>                                 | <b>373</b> |
| 22.1 Introduction .....   | 373        |
| 22.2 GIS Background .....   | 373        |
| 22.2.1 GIS Technology and GIS Applications .....                        | 374        |
| 22.2.2 GIS Use in Risk and Hazard Studies .....                         | 375        |
| 22.2.3 Building a GIS Application For Risk Assessment Studies .....     | 376        |
| 22.2.4 Different Possibilities Using GIS for Hazard Assessment .....    | 379        |
| 22.3 Temporal GIS and System Updating .....                             | 384        |
| References .....  | 385        |
| <b>Index .....</b>  | <b>387</b> |



Natural Disasters and Sustainable Development

Casale, R.; Margottini, C. (Eds.)

2004, XIX, 397 p., Hardcover

ISBN: 978-3-540-42199-3