Chapter 5
Risk Governance: From Knowledge to Regulatory Action

Ortwin Renn

Governance Requirements for Complex Risks

In today's world of globalized trade, travel, and communication, an ever-larger number of risks have a transboundary impact, crossing national and regional frontiers: Large-scale electricity blackouts, chemical accidents, and risks related to emerging technologies have all affected various parts of the world. Even these risks seem limited, however, when compared to those that affect our living conditions globally. A highly topical example is that of cyberattacks. Other examples include pandemics, global energy security, the financial collapse, and the impacts of climate change.

The International Risk Governance Council (IRGC) has developed a framework for risk governance designed to assist societies in generating the necessary inter- and transdisciplinary knowledge to address and respond to such global risks (IRGC, 2005). To this end, the IRGC's framework maps out a structured approach that guides its user through the process of investigating global risk issues and designing appropriate governance strategies. The designers of this approach combine scientific evidence with economic considerations as well as social concerns and societal values and, thus, ensure that any risk-related decision draws on the broadest possible view of risk. They also state the case for an effective engagement of all relevant stakeholders. The idea is that governance comprises more than government: It includes all the actors and institutions that play a role in assessing, managing, communicating, and regulating risks. The IRGC framework is inspired by the concept of adaptive institutional learning (Armitage, Marschke, & Plummer, 2008). Such a learning process is based on both solid knowledge about risk reduction measures as well as flexible responses with feedback incorporation in complex situations. The role of risk knowledge in such a process is to provide interdisciplinary, inclusive, and integrative

O. Renn (✉)
Institute for Advanced Sustainability Studies, Potsdam, Germany
e-mail: ortwin.renn@iass-potsdam.de

J. Glückler et al. (eds.), *Knowledge for Governance*, Knowledge and Space 15,
https://doi.org/10.1007/978-3-030-47150-7_5

expertise for the various actors involved (Rosa, Renn, & McCright, 2013, pp. 99, 196): "Our risk knowledge … must be traced to an amalgam of actors and institutions, as well as to the outcomes of exercising individual reflexivity in terms of making intuitive sense of conflicting knowledge claims and evaluation criteria" (p. 197).

The IRGC framework has been tested for efficacy and practicability—for example, can the framework help ensure that all relevant issues and questions are being addressed, and does it support the development of appropriate risk governance strategies (IRGC, 2005)? Researchers conduct tests in the form of short case studies, applying the framework to different risks, including those related to genetically modified organisms, stem cells, nature-based tourism, and the European gas infrastructure (all case studies are described in detail in Renn & Walker, 2008a). The results from these tests have given input to several revisions to the framework (Renn & Klinke, 2014).

The framework offers two major innovations to the risk field: the inclusion of the societal context and a new categorization of risk-related knowledge (Renn, 2008).

Inclusion of the Societal Context: In addition to the generic elements of risk assessment, risk management, and risk communication, the framework adds two other phases to the risk governance cycle: preassessment and evaluation. The preassessment phase highlights the risk topic's framing and boundaries, for example what kind of risks and consequences to include in an analysis of genetically modified organisms (GMOs). Should analysts focus only on health and environmental impacts, or should they also consider risks of economic concentration or the creation of dependencies on large suppliers of GMOs? Risk evaluation is a process by which to determine the acceptability of a given risk (or risk education strategy). This is the place where plural values, multiple evaluation criteria, and social preferences play a large role in defining what acceptability means to whom. Linking the social and cultural context with risk evaluation, the framework reflects the important role of stakeholder involvement and the need for resolving risk-risk trade-offs.

Categorization of Risk-Related Knowledge: The framework also proposes a categorization of risk that is based on the different states of knowledge about each particular risk, distinguishing between *simple*, *complex*, *uncertain*, and *ambiguous* risk problems. The characterization of a particular risk depends on the degree of difficulty of establishing the cause-effect relationship between a risk agent and its potential consequences, the reliability of this relationship, and the degree of controversy with regard to both what a risk actually means for those affected and the values to be applied when judging whether or not something needs to be done about it. Examples of each risk category include, respectively, known health risks such as those related to smoking, the failure risk of interconnected technical systems such as the electricity transmission grid, atrocities such as those resulting from the changed nature and scale of international terrorism, and the long-term effects and ethical acceptability of controversial technologies such as nanotechnologies. For each category, the researcher then derives a strategy for risk assessment, risk

management, as well as the level and form of stakeholder participation, supported by proposals for appropriate methods and tools.

In the following sections, I will first introduce the characterization of risk knowledge according to the three components *complexity*, *uncertainty*, and *ambiguity*. This opens the path for explaining the various phases of the IRGC risk governance framework and its further development by Klinke and Renn (2012). I will then conclude by addressing the issue of stakeholder involvement and public participation, a major element of inclusive governance.

Three Characteristics of Risk Knowledge

Risk governance faces specific challenges raised by three risk characteristics that result from a lack of knowledge and/or competing knowledge claims about the risk problem: complexity, scientific uncertainty, and sociopolitical ambiguity (Klinke & Renn, 2010, 2018; Renn, Klinke, & van Asselt, 2011).

Complexity

Complexity refers to the difficulty of identifying and quantifying causal links between a multitude of potential candidates and specific adverse effects. A crucial aspect here concerns the applicability of probabilistic risk assessment techniques. If the chain of events between a cause and an effect follows a linear relationship (as, e.g., in car accidents, or when a building collapses due to a hurricane), simple statistical models are sufficient to calculate the probabilities of harm. Such simple relationships may still be associated with high uncertainty, for example, if only few data pieces are available or the effect is stochastic by its own nature (e.g., an earthquake). If the relationship between cause and effects becomes more complex, more sophisticated models of probabilistic inferences are required (Renn & Walker, 2008a). The nature of this difficulty may be traced back to interactive effects among these candidates (synergisms and antagonisms, positive and negative feedback loops), long delay periods between cause and effect, interindividual variation, intervening variables, and others. It is precisely these complexities that make sophisticated scientific investigations necessary, because the cause-effect relationship is neither obvious nor directly observable. Complexity requires sensitivity to both nonlinear transitions and scale (on different levels). Examples of highly complex risk include nested chemical facilities that may threaten nearby settlements, synergistic effects of potentially toxic substances in urban air, the failure risk of large interconnected infrastructures such as water and electricity grits, and the risks that critical loads pose to sensitive ecosystems within human settlements.

Scientific Uncertainty

Scientific uncertainty may result from unresolved complexity, in particular if the cause-effect models show large confidence intervals. It relates to the limitedness or even absence of scientific proof for a causal or functional relationship that makes it difficult to exactly assess the probability and possible outcomes of undesired effects (cf. Filar & Haurie, 2009). In the context of risk assessment**,** it is essential to acknowledge that human knowledge is always incomplete and selective, and, thus, contingent upon uncertain assumptions, assertions, and predictions (Funtowicz & Ravetz, 1992; Renn, 2008, pp. 75–77). It is obvious that the modeled probability distributions within a numerical relational system can only represent an approximation of the empirical relational system that helps elucidate and predict uncertain events. It therefore seems prudent to include additional aspects of uncertainty (van Asselt, 2000, pp. 93–138). Uncertainty may be linked to lack of reliable data, to imprecision in the analytical model, in the statistical treatment of the use of inductive statistical tools, or in the interpretation of ambiguous results (Funtowicz & Ravetz, 2008). Examples of high uncertainty include many natural disasters, such as earthquakes, possible health effects of air-borne pollutants below the threshold of statistical significance, acts of violence—such as terrorism and sabotage—and long-term effects of high social mobility on personal wellbeing and social cohesion.

Sociopolitical Ambiguity

While more and better data and information may reduce scientific uncertainty, more knowledge does not necessarily lessen ambiguity. Ambiguity thus indicates a situation of ambivalence in which different and sometimes divergent streams of thinking and interpretation about the same risk phenomena and their circumstances are apparent (cf. Zahariadis, 2003). Renn and Klinke (2015) distinguish between interpretative and normative ambiguity, which both relate to divergent or contested perspectives on the justification, severity, or wider "meanings" associated with a given threat.

Interpretative ambiguity denotes the variability of (legitimate) interpretations based on identical observations or data assessments results, for example an adverse or nonadverse effect. Variability of interpretation, however, is not restricted to expert dissent. Laypeople's perception of risk often differs from expert judgments because it is related to qualitative risk characteristics such as familiarity, personal or institutional control, or assignment of blame. Moreover, in contemporary pluralist societies diversity of risk perspectives within and between social groups is generally fostered by divergent value preferences, variations in interests, and very few, if any, universally applicable moral principles. This is all the more true if risk problems are complex and uncertain.

This leads to *normative ambiguity*, which alludes to different concepts of what can be regarded as tolerable, referring to aspects such as ethics, quality of life parameters, or distribution of risks and benefits. A condition of ambiguity emerges where the problem lies in agreeing on the appropriate values, priorities, assumptions, or boundaries to be applied to the definition of possible outcomes. Dealing with ambiguities requires governance approaches that emphasize mutual learning across different academic and practical communities as well as promote the cocreation of joint knowledge and practical applications. Examples for high interpretative ambiguity include exposure to low dose radiation (ionizing and non ionizing), low concentrations of genotoxic substances, food supplements, and—in the social domain—the gentrification of urban quarters or the loss of social cohesion in a disaster-prone community. Normative ambiguities can be associated, for example, with passive smoking, restricted mobility regimes in highly congested cities (such as congestion pricing), zoning laws for hazard-prone areas, or busing of schoolchildren from different social classes.

Most risks are characterized by a mixture of complexity, uncertainty, and ambiguity. Passive smoking may be a good example of low complexity and uncertainty, but high ambiguity. Nuclear energy may be a good candidate for high complexity and high ambiguity, but relatively little uncertainty. The use of IT in smart urban environments could be cited as an example for high complexity, uncertainty, and ambiguity.

Adaptive and Integrative Capacity of Risk Governance

The ability of risk governance institutions to cope with complex, uncertain, and ambiguous consequences and implications has become a central concern to scientists and practitioners alike. Adaptive and integrative governance on risk can be broadly understood as the ability of politicians and society to collectively design and implement a systematic approach to organizational and policy learning in institutional settings that are conducive to resolving complexity, uncertainty, and ambiguity in various risk arenas.[1]

This dynamic governance process is characterized by continuous and gradual learning and adjustment. Adaptive and integrative capacity in risk governance processes encompasses a broad array of structural and procedural mechanisms by which politics and society can handle collectively relevant risk problems. The main task is to collect robust knowledge about potential risk management measures by integrating systematic, experiential, and tacit knowledge (Renn, 2010) and by initiating a well designed but flexible learning process by which systematic collection of feedback and responses inform the adaptive processes of adjusting to new situations, surprises, or unforeseen events (Kerzner, 2017, pp. 613–620). In practical

[1] To the definition and understanding of adaptive capacity, see, for example, Webster, Gasser, Young, & Choucri (2008).

terms, adaptive and integrative capacity is the ability to design and incorporate the necessary steps in a risk governance process that allow risk managers to reduce, mitigate, or control the occurrence of harmful outcomes resulting from collectively relevant risk problems in an effective, efficient, and fair manner (cf. Brooks & Adger, 2004).

In 2005, the International Risk Governance Council proposed a process model of risk governance based the authors' work (IRGC, 2005; Renn, 2008; Renn & Walker, 2008a). With this framework, its designers structure the risk governance process in four phases: preassessment, appraisal, characterization/evaluation, and risk management. They conceptualized communication and stakeholder involvement as constant companions to all four phases of the risk governance cycle. Based on this framework and informed by many comments on the original framework (i.e., the edited volume by Renn & Walker, 2008b), Klinke and Renn (2012) modified the original IRGC proposal. The new framework the two authors suggested consists of the following steps: preestimation, interdisciplinary risk estimation, risk characterization, risk evaluation, and risk management, all related to risk governance institutions' abilities and capacities to use resources effectively (see Fig. 5.1).

Appropriate resources include institutional and financial means as well as social capital (e.g., strong institutional mechanisms and configurations, transparent decision making, allocation of decision making authority, formal and informal networks that promote collective risk handling, education), technical resources (e.g., databases, computer soft- and hardware, etc.), and human resources (e.g., skills, knowledge, expertise, epistemic communities, etc.). Therefore, the adequate involvement of experts, stakeholders, and the public in the risk governance process is a crucial dimension to produce and convey adaptive and integrative capacity in risk governance institutions.

Preestimation

A systematic reviewer of the preestimation stages would begin with *screening* as an exploration of a large array of actions and problems, searching for those with a specific risk-related feature. It is important to explore what major political and societal actors such as governments, companies, epistemic communities (e.g., the community of risk analysis specialists, associations for toxicology or epidemiology, or communities for disaster management), nongovernmental organizations, and the general public identify as risks and what types of problems they label as problems associated with risk and uncertainty. This is called *framing* and it specifies how society and politics rely on schemes of selection and interpretation to understand and respond to those phenomena that are socially constructed as relevant risk topics (Kahneman & Tversky, 2009; Reese, Gandy Jr., & Grant, 2001). Interpretations of risk experience depend on the frames of reference. The process of framing corresponds with a multiactor and multiobjective governance structure, since governmental authorities (national, supranational, and international agencies), risk and

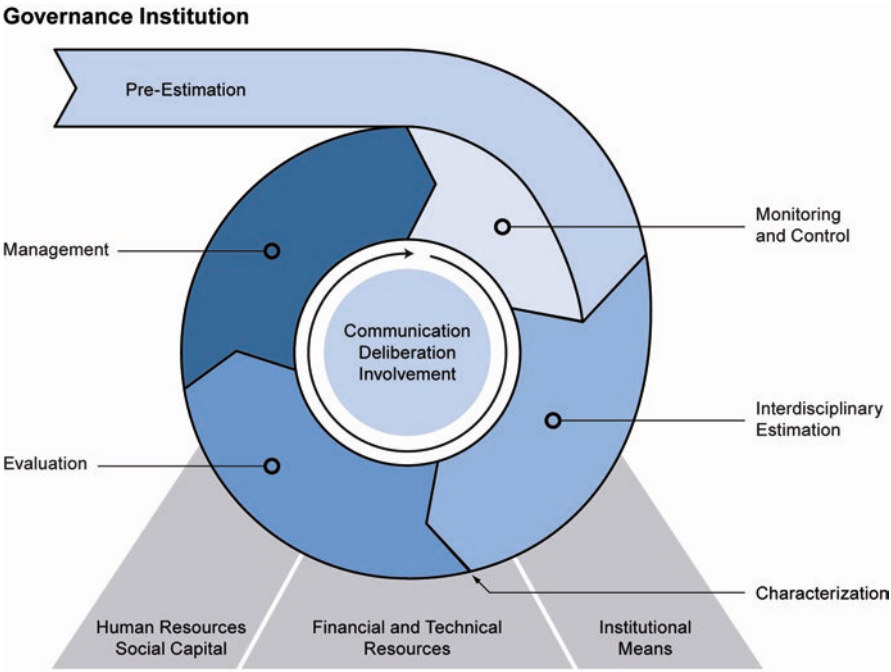

Fig. 5.1 Adaptive and integrative risk governance model. Adapted from Klinke and Renn (2012, p. 276). Copyright 2012 by the Journal of Risk Research. Adapted with permission of the Journal of Risk Research. (The adaptive and integrative risk governance model is based on a modification and refinement of the IRGC framework (IRGC, 2005, 2017))

opportunity producers (e.g., industry), those affected by risks and opportunities (e.g., consumer organizations, environmental groups), and interested bystanders (e.g., the media or an intellectual elite) are all involved and often in conflict about the appropriate frame to conceptualize the problem. What counts as risk may vary among these actor groups. Whether an overlapping consensus evolves about what requires consideration as a relevant risk depends on the legitimacy of the selection rule (Renn & Klinke, 2014).

Interdisciplinary Risk Estimation

Interdisciplinary risk estimation requires the cooperation of all disciplines that are necessary to generate a common understanding of all risk consequences (physical, monetary, social, cultural). The estimation process is comprised of two stages (cf. IRGC, 2005; Renn & Walker, 2008a):

1. *Risk assessment:* Experts of the natural and technical sciences produce the best estimate of the physical harm that a risk source may induce. Such harm could be

the collapse of buildings; discontinuation of central services to residents such as water, electricity, or information; breakdown of traffic; or inadequate infrastructural support.
2. *Concern assessment:* Experts of the social sciences, including economics, identify and analyze the issues that individuals or society as a whole link to a certain risk. This portfolio includes dysfunctional social services, risks of economic subsistence, but also risks based on perceptions of crime or insecurity. To identify and explore these risks, an analyst may use the repertoire of the social sciences such as survey methods, focus groups, econometric analysis, macroeconomic modeling, or structured hearings with stakeholders.

The second step in risk estimation is including the concerns and expectations of those involved in managing or governing risks. The main idea is here to collect the necessary knowledge from stakeholders and affected citizens about their preferences in terms of risk reduction and risk handling. Although analysts often forget this step, it is essential in order to match physical risk assessments with human perception (van Asselt & Renn, 2011). The instruments to perform such a concern assessment might include Group Delphi processes or hearings (Renn, 2008, pp. 336–337.).

Risk Evaluation

Actors in the risk governance process heavily dispute how best to classify a given risk and justify an evaluation about its societal acceptability or tolerability (see Fig. 5.2). In many approaches, they rank and prioritize risks based on a combination of probability (how likely is it that the risk will occur) and impact (the consequences should this take place). In the so-called traffic light model, analysts locate risks in the diagram of probability versus expected consequences and identify three areas: green, amber, and red (Renn, 2008, pp. 149–154.).

A risk falls into the green area if its occurrence is highly unlikely and its impact negligible. No further formal intervention is necessary in this case. Analysts view a risk is as tolerable when serious impacts might occur occasionally (amber area). The benefits are worth the risk, but risk reduction measures are necessary. Finally, they view a risk as intolerable when the occurrence of catastrophic impacts is most likely (red area). The risk's possible negative consequences are so catastrophic that they cannot be tolerated, despite the potential benefits.

Drawing the lines between *acceptable* (green area), *tolerable* (amber area), and *intolerable* (red area) is one of the most controversial tasks in the risk governance process. The UK Health and Safety Executive developed a procedure for chemical risks based on risk-risk comparisons (Löfstedt, 1997). Some Swiss cantons such as Basle County experimented with Round Tables as a means to reach consensus on drawing the two demarcation lines, whereby participants in the Round Table represented industry, administrators, county officials, environmentalists, and

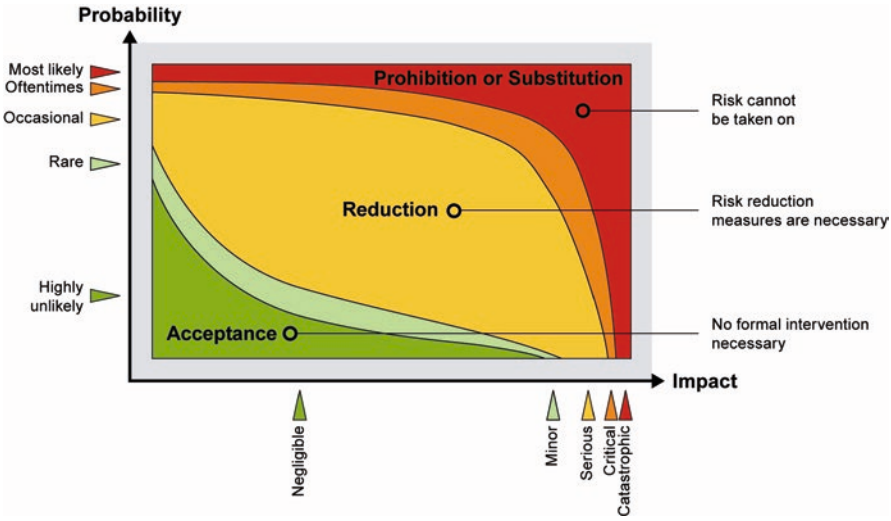

Fig. 5.2 Risk areas: intolerable (red), tolerable (amber), acceptable (green). Slightly modified version from the original illustration published in IRGC (2005, p. 37). Copyright 2005 by the International Risk Governance Council. Adapted with permission of the International Risk Governance Council

neighborhood groups. The Round Table was facilitated by a professional mediator charged with reaching a consensus between the various groups. Although such a consensus was difficult to achieve, all parties ultimately agreed to a solution by which the demarcation lines were only determined for a limited time, with the clear understanding that standards would be tightened if more risk reduction measures were to become available and further developed (RISKO, 2000).

Irrespective of the means selected to support this task, the judgment on acceptability or tolerability is contingent on making use of a variety of different knowledge sources. One needs to include the data and insights resulting from the risk assessment activity and additional data from the concern assessment.

Risk Management

Risk management analysts begin by reviewing all relevant data and information generated in the previous steps of interdisciplinary risk estimation, characterization, and risk evaluation. The systematic analysis of risk management options focuses on still tolerable risks (amber area) and those where tolerability is disputed (light green and orange transition zones). The other cases (green and red area) are fairly easy to deal with. Intolerable risks demand prevention and prohibition strategies as a means of replacing the hazardous activity with another activity leading to identical or similar benefits. The management of acceptable risks is left to private actors (civil society and economy). They may initiate additional and voluntary risk reduction

measures or seek insurance to cover possible but rather minor or negligible losses. If risks are classified as tolerable, or if experts disagree as to whether they are in the transition zones of tolerability, public risk managers must design and implement actions that make these risks either acceptable or at least tolerable by introducing reduction strategies. Based on the distinction in complexity, scientific uncertainty, and sociopolitical ambiguity, it is possible to design general strategies for risk management that can be applied to four distinct categories of risk problems, thus simplifying the process of risk management (Renn, 2008).

The first category refers to linear risk problems: They are characterized by their low scores across the dimensions of complexity, uncertainty, and ambiguity. They can be addressed by *linear risk management* because they are normally easy to assess and quantify. Routine risk handling within risk assessment agencies and regulatory institutions is appropriate for this category, since the risk problems are well known, sufficient knowledge of key parameters is available, and there are no major controversies about causes and effects or conflicting values. The management includes risk-benefit analysis, risk-risk comparisons, and other instruments of balancing pros and cons.

If risks are ranked high on complexity but rather low on both uncertainty (i.e., the complexity can be widely resolved by adequate scientific models) and ambiguity, they require the systematic involvement and deliberation of experts who represent the relevant epistemic communities that produce the most accurate estimate of these complex relationships. It does not make much sense to integrate public concerns, perceptions, or any other social aspects for resolving complexity unless specific knowledge from the concern assessment helps to untangle complexity. Complex risk problems therefore demand *risk-informed management,* which scientists and experts can offer by applying methods of expanded risk assessment, determining quantitative safety goals, consistently using cost-effectiveness methods, and monitoring and evaluating outcomes.

Risk problems that are characterized by high uncertainty but low ambiguity require *precaution-based management*. Because sufficient scientific certainty is currently either unavailable or unattainable, expanded knowledge acquisition may help to reduce uncertainty and, thus, to revert the risk problem back to first stage of handling complexity. If, however, uncertainty cannot be reduced by additional knowledge, risk management should foster and enhance precautionary and resilience-building strategies and decrease vulnerabilities in order to avoid irreversible effects. Appropriate instruments include containment, diversification, monitoring, and substitution. Because the focal point here is to find the adequate and fair balance between being overly cautious and overly reckless, a reflective processing involving stakeholders is necessary to ponder concerns, economic budgeting, and social evaluations.

Finally, if risk problems are ranked high on ambiguity (regardless of whether they are low or high on uncertainty), *discourse-based management* is required, a process that demands participative processing. This includes the need to involve major stakeholders as well as the affected public. The goals of risk management are to produce a collective understanding among all stakeholders and concerned

members of the public on interpretative ambiguity or to find legitimate procedures of justifying collectively binding decisions on acceptability and tolerability. It is important to achieve a consensus or compromise between those who believe that the risk is worth taking (perhaps because of self-interest) and those who believe that the pending consequences do not justify the potential benefits of the risky activity or technology.

Risk Communication

All four phases must be accompanied by intensive risk communication efforts. Communication should not be limited to sharing information but must include an effort to create both a common understanding of the problems and challenges as well as a joint agreement on the most acceptable risk reduction solutions. Such a concept of communication requires a transdisciplinary approach to problem solving that involves the strong participation of all relevant stakeholders in the creation of knowledge and risk reduction options and a mutual learning process in which all actors share their knowledge and insights (Hirsch-Hadorn et al., 2008; Newig, Kochskämper, Challies, & Jager, 2016). In this understanding, communication should already have begun during the preestimation phase. It should convey the basic concepts and what these concepts entail in terms of opportunities and risks. Analysts can arrange feedback channels on the internet as to evaluate the responses of stakeholders and affected citizens. During the risk estimation phase, the communication process should emphasize the process by which the research and planning team conducts the risk assessments. The main goal here is to promote trust in the risk-handling authorities (Löfstedt, 2005).

It might be helpful to ask stakeholders and citizens for additional knowledge that public officials may not possess. More input from the public is to be encouraged during the evaluation phase. First of all, the process of how tradeoffs are assigned and justified must be made transparent to all stakeholders as well as the general public. Furthermore, depending on the degree of ambiguity, it might be useful to have procedures in place that systematically collect feedback and concerns with respect to the planned urban risk management measures. During the management phase, it is essential to familiarize all affected persons with the chosen or deliberated risk reduction measures, in particular those that rely on the cooperation of the affected public (such as evacuation or sheltering plans). Instruments for making risk reduction plans known to the public are open meetings, brochures, websites, TV shows, and other popular forms of information transfer (Earle & Cvetkovich, 1994).

Although risk communication implies a stronger role for risk professionals to provide information to the public rather than vice versa, it should be regarded as a mutual learning process. Concerns, perceptions, and experiential knowledge of the targeted audience(s) should thus guide risk professionals in their selection of topics and subjects: It is not the task of the communicators to decide what people need to know, but to respond to the questions of what people want to know (this is normally referred to as the “right to know” concept). The step from risk communication to

stakeholder and public involvement is only gradual and should be seriously considered any time that risk communication addresses issues of major concerns and contesting claims.

Inclusive Governance: The Need for an Effective Involvement of Experts, Stakeholders, and Civil Society

The effectiveness and legitimacy of the risk governance process depends on the management agencies' capacity to resolve complexity, characterize uncertainty, and handle ambiguity by means of communication and deliberation. In the following, I introduce a particular procedural mechanism of communication and deliberation to address each of the specific challenges raised by complexity, scientific uncertainty, and sociopolitical ambiguity. I illustrate the various steps of involvement of larger stakeholder groups in Fig. 5.3.

Instrumental Processing Involving Governmental Actors (Linear Mode)

Dealing with linear risk issues, which are associated with low scores of complexity, scientific uncertainty, and sociopolitical ambiguity, requires hardly any changes to conventional public policymaking. The data and information of such linear (routine) risk problems are provided by statistical analysis, law or statutory requirements determine the general and specific objectives, and the role of public policy is to ensure that all necessary measures of safety and control are implemented and enforced. The aim is to find the most cost-effective method for a desired regulation level. If necessary, deliberators may include stakeholders, as they have information and knowhow that may provide useful hints for increased efficiency.

Epistemic Processing Involving Experts and Stakeholders (Complex Mode)

Resolving complex risk problems requires dialogue and deliberation among experts and representatives of stakeholder groups with special knowledge and experience. Involving members of various epistemic communities who demonstrate expertise and competence is the most promising step for producing more reliable and valid judgements about the complex nature of a given risk. Epistemic discourse is the instrument for discussing the conclusiveness and validity of cause-effect chains relying on available probative facts, uncertain knowledge, and experience that can

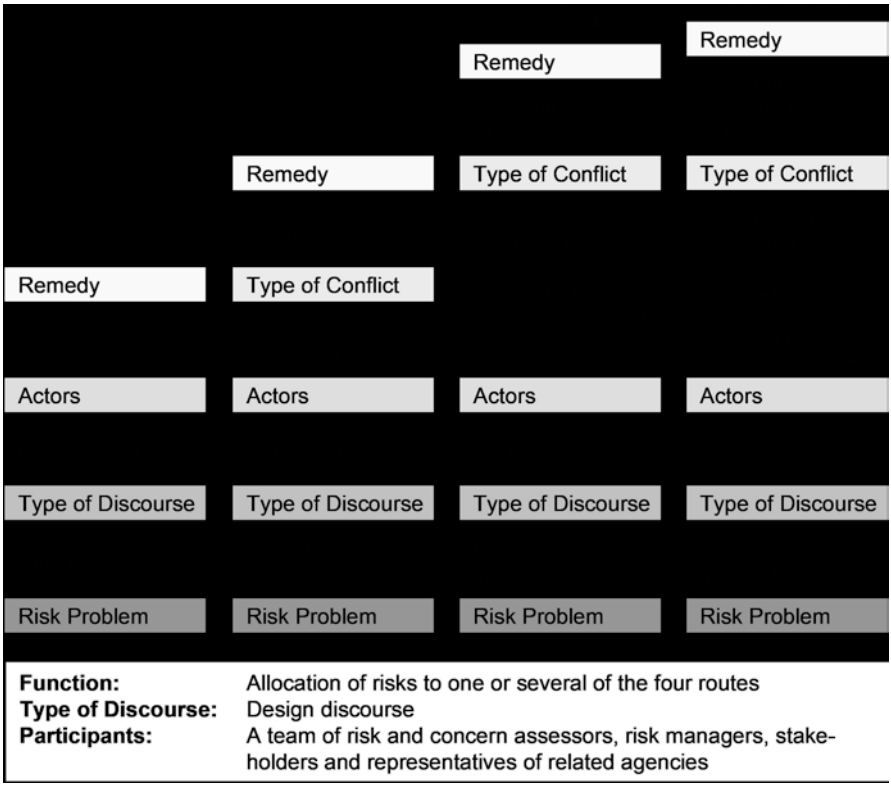

Fig. 5.3 The risk management escalator. Modified version from the original illustration published in IRGC (2005, p. 53). Copyright 2005 by the International Risk Governance Council. Adapted with permission of the International Risk Governance Council

be tested for empirical traceability and consistency. The objective of such a deliberation is to find the most cogent description and explanation of the phenomenological complexity in question as well as a clarification of dissenting views (i.e., by addressing the question of which environmental and socioeconomic impacts specific community action plans are expected to produce). The deliberation among experts might generate a profile of the complexity of the given risk issue on selected intersubjectively chosen criteria. It may also reveal more uncertainty and ambiguity hidden in the case than the initial appraisers had anticipated. It is advisable to include natural as well as social scientists in the epistemic discourse, in order to anticipate potential problems with risk perception. If this were done, fewer unsuspected controversies would occur.

Reflective Processing Involving Stakeholders (Uncertainty Mode)

Characterizing and evaluating risks as well as developing and selecting appropriate management options for risk reduction and control in situations of high uncertainty pose particular challenges. How can risk managers characterize and evaluate the severity of a risk problem when the potential damage and its probability are unknown or highly uncertain? Scientific input is therefore only the first in a series of steps during a more sophisticated evaluation process. It is crucial to compile the data and information relevant to the different types of uncertainties to inform the process of risk characterization. The risk characterization's outcome provides the foundation for a broader deliberative arena, which out to include not only policy makers and scientists, but also directly affected stakeholders and public interest groups including representatives of the affected public, in order to discuss and ponder the "right" balances and trade-offs between potential over- and under-protection. This reflective involvement of stakeholders and interest groups is aimed at finding a consensus on the extra margin of safety that potential victims would be willing to tolerate and potential beneficiaries of the risk would be willing to invest in order to avoid potentially critical and catastrophic consequences. The reflective involvement of policy makers, scientists, stakeholders, and public interest groups can be accomplished by a spectrum of different forms, such as negotiated rule making, mediation, round table or open forum, or advisory committee (cf. Beierle & Cayford, 2002; Rowe & Frewer, 2000; Stoll-Kleemann & Welp, 2006).

Participative Processing Involving the Public (Ambiguity Mode)

If risk problems are associated with high ambiguity, it is not enough to demonstrate that risk regulation addresses the issues of public concerns. In these cases, the evaluation process must also be open to public input and new forms of deliberation. This begins with revisiting the question of proper framing. Is the issue really one of risk, or of lifestyle or future vision? Often, both the benefits and risks are contested. The debate about smart cities may illustrate the point that observers may be concerned not only about technical risks of network failures or privacy issues being violated by information transfer, but also about the acceptability of the desired goal to reduce choices for individuals by means of paternalistic design of choice situations (Kahneman, 2012; Thaler & Sunstein, 2008). Thus, the controversy is often much broader than simple risk management. The aim here is to find an overlapping consensus on the dimensions of ambiguity that must be addressed in comparing risks and benefits and balancing pros and cons. High ambiguity would require the most inclusive strategy for involvement, because both directly affected and indirectly affected groups should have an opportunity to contribute to this debate. Resolving ambiguities in risk debates necessitates the public's participatory involvement to

openly discuss competing arguments, beliefs, and values. The set of possible forms to involve the public includes citizen panels or juries, citizen forums, consensus conferences, public advisory committees, and similar approaches (cf. Abels, 2007; Beierle & Cayford, 2002; Hagendijk & Irwin, 2006).

Wider Governance Issues

When considering the wider environment of risk handling in modern societies, many classes of influential factors come into play. I can mention only a few here. For example, the distinction between government and governance I introduced in the first section of this document can be helpful in describing and analyzing cases of risk handling in different countries and contexts (Zürn, 2000). In addition, analysts must address the interplay between economic, political, scientific, and civil society actors when looking beyond just governmental or corporate actions. Furthermore, looking at organizational capacity opens a new set of wider risk governance issues that relate to the interplay between the governing actors and their capability to fulfill their role in the risk governance process.

In Fig. 5.4, I present external influencing factors that I cannot place within the risk framework itself, and have additionally placed illustrations for each level within this figure. I have selected four cases: listeria, gas transportation, acrylamide, and genetically modified organisms (for each case, see Renn & Walker, 2008b). The listeria case concerns the risk of nonpasteurized milk, which is traditionally used by local cheese manufacturers, specifically in France and Mexico. This risk can be resolved completely within the core risk governance framework, as it is well manageable within the four phases outlined above. The case of gas transportation from Russia to Western countries involves additional aspects such as the risk of political dependence on Russia or the possibility of terrorist attacks on the pipelines (Vatansever, 2017). Managing the risk of gas pipelines requires governing institutions to wield specific skills, assets, and strategies that go beyond risk assessment and management. The case of acrylamide is an example of how strongly an issue can depend on the cooperation of different societal actors. Acrylamide is a natural carcinogen that has been found in baked food items such as French-fried potatoes and crispbread. Food regulators, producers, NGOs, and various science communities have extensively negotiated to define the risks and adopt appropriate risk reduction measures (Bonneck, 2017). Finally, the case of genetically modified organisms (GMOs) underlines how the social and political culture influence the debate about the role of GMOs have to play in the future.

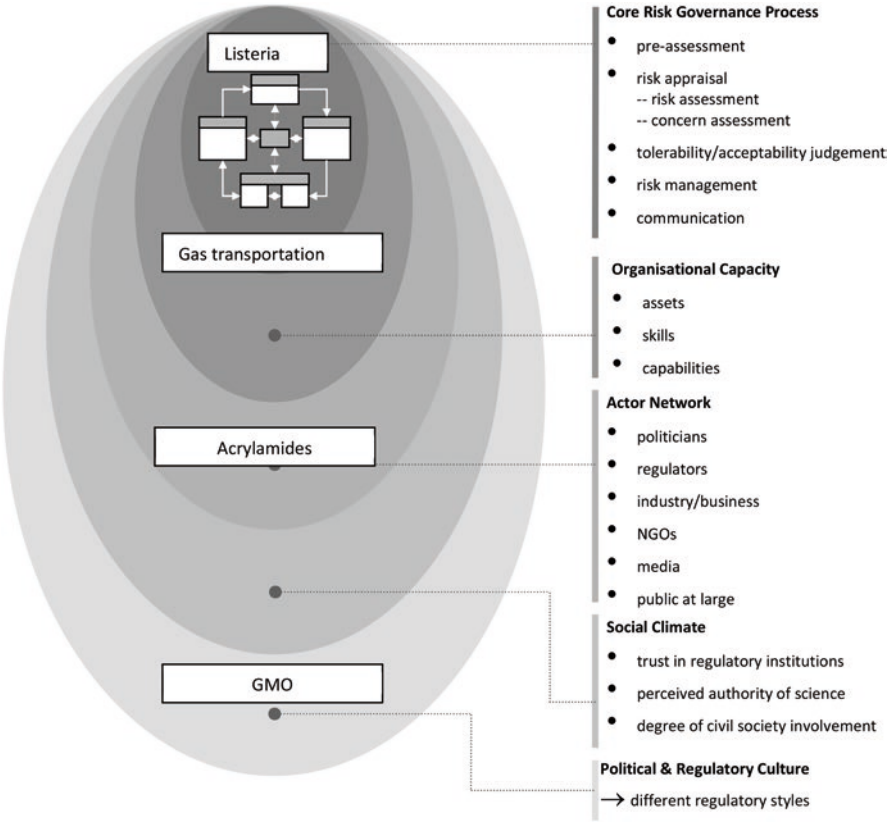

Fig. 5.4 Wider governance issues. Source: Design by author

Conclusion

One of the main functions of a comprehensive risk governance framework is to assist risk or concern assessors and managers in exploring and handling risks and to promote effective and fair approaches for improving, and enhancing the visibility of, the present risk governance processes. With the framework I present here, I aim to offer guidance and advice on how to approach the complexities, uncertainties, and ambiguities of risk issues and to promote a wider understanding of their interconnectedness and transgressional nature, particularly in relation to newly emerging systemic risks. To this end, the framework integrates different sources of knowledge that include scientific, experiential, anecdotal, and tacit aspects and includes effective and appropriate engagement of stakeholders—not least to ensure that both risk appraisal and risk management strategies command the widest possible acceptance and support.

I have designed the framework, on the one hand, to include enough flexibility to allow its users to do justice to the wide diversity of risk governance structures and, on the other hand, to provide sufficient clarity, consistency, and unambiguous orientation across a range of different risk issues and countries. I do not intend the framework to serve as a recipe or a checklist that can guarantee that analysts have considered all relevant aspects when analyzing a risk and its governance process and structures. However, by building into conventional risk analysis and management such "soft" issues as societal values, concerns, and perceptions of risk, and by taking into account the interactions between the various actors involved in the process, the risk governance framework can contribute to the development of more inclusive and effective risk governance strategies and the enhancement of decision making under uncertainty.

References

Abels, G. (2007). Citizen involvement in public policy-making: Does it improve democratic legitimacy and accountability? The case of pTA. *Interdisciplinary Information Sciences, 13*(1), 103–116. https://doi.org/10.4036/iis.2007.103

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. *Global Environmental Change, 18*(1), 86–98. https://doi.org/10.1016/j.gloenvcha.2007.07.002

Beierle, T. C., & Cayford, J. (2002). Democracy in practice: Public participation in environmental decisions. *Perspectives on Politics, 1,* 181–182. https://doi.org/10.1017/S1537592703450159

Bonneck, S. (2017). *Gesellschaftlicher Umgang mit Risiken: Fallstudie zur Steuerungsleistung gesellschaftlicher Institutionen in Bezug auf Bewältigung von Unsicherheit (Risk Governance)* [Societal handling of risk: Case study on the governance of societal institutions for managing uncertainty] (Doctoral dissertation). University of Stuttgart, Germany. https://doi.org/10.18419/opus-9139

Brooks, N., & Adger, W. N. (2004). Assessing and enhancing adaptive capacity. In B. Lim & E. Spanger-Siegfried (Eds.), *Adaptation policy frameworks for climate change: Developing strategies, policies and measures* (pp. 165–181). Cambridge, UK: Cambridge University Press.

Earle, T. C., & Cvetkovich, G. (1994). Risk communication: The social construction of meaning and trust. In B. Brehmer & N. E. Sahlin (Eds.), *Future risks and risk management* (pp. 141–181). Amsterdam: Kluwer.

Filar, J. A., & Haurie, A. (2009). *Uncertainty and environmental decision making: A handbook of research and best practice*. New York: Springer US.

Funtowicz, S. O., & Ravetz, J. R. (1992). Three types of risk assessment and the emergence of post-normal science. In S. Krimsky & D. Golding (Eds.), *Social theories of risk* (pp. 251–273). Westport: Praeger.

Funtowicz, S. O., & Ravetz, J. R. (2008). Values and uncertainties. In G. Hirsch-Hadorn, H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesmann, & E. Zemp (Eds.), *Handbook of transdisciplinary research* (pp. 361–368). Dordrecht: Springer.

Hagendijk, R., & Irwin, A. (2006). Public deliberation and governance: Engaging with science and technology in contemporary Europe. *Minerva, 44,* 167–184. https://doi.org/10.1007/s11024-006-0012-x

Hirsch-Hadorn, G., Biber-Klemm, S., Grossenbacher-Mansuy, W., Hoffmann-Riem, H., Joye, D., Pohl, C., Wiesmann, U., & Zemp, E. (2008). The emergence of transdisciplinarity as a form

of research. In G. Hirsch-Hadorn, H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesmann, & E. Zemp (Eds.), *Handbook of transdisciplinary research* (pp. 19–42). Dordrecht: Springer.

IRGC (International Risk Governance Council). (2005). *Risk Governance—Towards an Integrative Approach* (White Paper No. 1, with an Annex by P. Graham). Geneva: IRGC. Retrieved from https://irgc.org/wp-content/uploads/2018/09/IRGC_WP_No_1_Risk_Governance__reprinted_version_3.pdf

IRGC (International Risk Governance Council). (2017). *Introduction to the IRGC risk governance framework*. Revised version. Lausanne: EPFL International Risk Governance Center. https://doi.org/10.5075/epfl-irgc-233739

Kahneman, D. (2012). *Thinking, fast and slow.* New York: Penguin.

Kahneman, D., & Tversky, A. (2009). *Choices, values, and frames*. New York, NY: Cambridge University Press.

Kerzner, H. (2017). Project management: A systems approach to planning, scheduling, and controlling. Hoboken: John Wiley & Sons.

Klinke, A., & Renn, O. (2010). Risk governance: Contemporary and future challenges. In J. Eriksson, M. Gilek, & C. Rudén (Eds.), *Regulating chemical risks: European and global challenges* (pp. 9–28). Dordrecht: Springer.

Klinke, A., & Renn, O. (2012). Adaptive and integrative governance on risk and uncertainty. *Journal of Risk Research, 15*(3), 273–292. https://doi.org/10.1080/13669877.2011.636838

Klinke, A., & Renn, O. (2018). Distributed responsibility in risk governance. In P. A. Wilderer, O. Renn, M. Grambow, M. Molls, & K. Mainzer (Eds.), *Sustainable risk management* (pp. 19–31). Cham: Springer.

Löfstedt, R. E. (1997). *Risk evaluation in the United Kingdom: Legal requirements, conceptual foundations, and practical experiences with special emphasis on energy systems* (Discussion paper No. 92). Stuttgart: Center of Technology Assessment in Baden-Württemberg.

Löfstedt, R. E. (2005). *Risk management in post-trust societies.* London: Palgrave Macmillan. https://doi.org/10.1057/9780230503946

Newig, J., Kochskämper, E., Challies, E., & Jager, N. W. (2016). Exploring governance learning: How policymakers draw on evidence, experience and intuition in designing participatory flood risk planning. *Environmental Science & Policy, 55,* 353–360. https://doi.org/10.1016/j.envsci.2015.07.020

Reese, S. D., Gandy Jr., O. H., & Grant, A. E. (2001). *Framing public life: Perspectives on media and our understanding of the social world.* Mahwah: Lawrence Erlbaum Associates. https://doi.org/10.4324/9781410605689

Renn, O. (2008). *Risk governance: Coping with uncertainty in a complex world*. London: Earthscan. https://doi.org/10.4324/9781849772440

Renn, O. (2010). The contribution of different types of knowledge towards understanding, sharing and communicating risk concepts. *Catalan Journal of Communication & Cultural Studies, 2*(2), 177–195. https://doi.org/10.1386/cjcs.2.2.177_1

Renn, O., & Klinke, A. (2014). Risk governance: Application to urban planning. *A|Z ITU Journal of the Faculty of Architecture, 11*(1), 5–19. Retrieved from http://www.azitujournal.com/jvi.aspx?pdir=itujfa&plng=eng&un=ITUJFA-66588

Renn, O., & Klinke, A. (2015). Complexity, uncertainty and ambiguity in inclusive risk governance. In T. J. Andersen (Ed.), *The Routledge companion to strategic risk management* (pp. 13–30). London: Routledge.

Renn, O., Klinke, A., & van Asselt, M (2011). Coping with complexity, uncertainty and ambiguity in risk governance: A synthesis. *AMBIO, 40,* 231–246. https://doi.org/10.1007/s13280-010-0134-0

Renn, O., & Walker, K. (2008a). Lessons learned: A re-assessment of the IRGC framework on risk governance. In O. Renn & K. Walker (Eds.), *The IRGC risk governance framework: Concepts and practic*e (pp. 331–367). Dordrecht: Springer.

Renn, O., & Walker, K. (2008b). *The IRGC risk governance framework: Concepts and practice*. Dordrecht: Springer.
RISKO. (2000). Mitteilungen für Kommission für Risikobewertung des Kantons Basel-Stadt: Seit 10 Jahren beurteilt die RISKO die Tragbarkeit von Risiken [Notes of the Commission for Risk Assessment of the Cantone of Basle City: For 10 years the Commission RISKO assesses the tolerability of risk]. *Bulletin of the City of Basle, 3,* 2–3.
Rosa, E. A., Renn, O., & McCright, A. M. (2013). *The risk society revisited: Social theory and governance.* Philadelphia, PA: Temple University Press.
Rowe, G., & Frewer, L. J. (2000). Public participation methods: A framework for evaluation. *Science, Technology, & Human Values, 25,* 3–29. https://doi.org/10.1177/016224390002500101
Stoll-Kleemann, S., & Welp, M. (2006). *Stakeholder dialogues in natural resources management: Theory and practice.* Heidelberg: Springer. https://doi.org/10.1007/978-3-540-36917-2
Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth and happiness.* New Haven: Penguin.
van Asselt, M. (2000). *Perspectives on uncertainty and risk: The PRIMA approach to decision support.* Boston: Kluwer.
van Asselt, M., & Renn, O. (2011). Risk governance. *Journal of Risk Research, 14,* 431–449. https://doi.org/10.1080/13669877.2011.553730
Vatansever, A. (2017). Is Russia building too many pipelines? Explaining Russia's oil and gas export strategy. *Energy Policy, 108,* 1–11. https://doi.org/10.1016/j.enpol.2017.05.038
Webster, D. G., Gasser, L., Young, O. R., & Choucri, N. (2008). *Adaptive governance: The dynamics of Atlantic fisheries management*. Cambridge, MA: MIT Press.
Zahariadis, N. (2003). *Ambiguity and choice in public policy: Political decision making in modern democracies.* Washington, D.C.: Georgetown University Press.
Zürn, M. (2000). Democratic governance beyond the nation-state: The EU and other international institutions. *European Journal of International Relations, 6,* 183–221. https://doi.org/10.1177/1354066100006002002