Chapter 1
Risks

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1 Why Are We Writing About This Topic?

Risk is our daily work and often our obsession – as risk researchers we are working on research projects which are intended to increase our knowledge about all aspects of risks. Being a "risk researcher" means looking at things through a specific perspective – the perspective of what negative consequences a natural or man-made event, a technology, a decision could probably have on the world we live in. Our perspective is a socio-scientific one. This means, we are analyzing what consequences do risks have on the society and what can we do to decrease or prevent them. This includes the possible actions of a single consumer as well as strategies of whole governments to manage risks. How are risks perceived by people? What kinds of knowledge are needed to deal with different kinds of risks? Who should be involved, and when? What to do if conflicts evolve about how to handle risks? How to communicate risks? It is our job to answer questions like these. We are dealing with these questions in many different thematic areas: food safety, climate change, chemicals, nanotechnology, electromagnetic fields, etc. These risks pose very different problems and it seems difficult to find general strategies to deal with them.

This first part of the book is meant to set the stage for the following chapters: We want to convey insights into current risk research on a general level, before diving into the more thematically specialized chapters of the book. This means, we illustrate what you need to know on risks and how to handle them with examples of our daily life and give you a broad picture of the different aspects of risk research. This knowledge will form the basis to guide you through the three remaining thematic chapters, where more targeted strategies of dealing with different types of risks are presented.

The following section of the chapter will inform you about what risk is and what characteristics, concepts, and perceptions of risk exist. Section 3 introduces

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an integrated concept of how to deal with risks to which modern societies are exposed and explains, the concept of "risk governance." Section 4 deals with problems arising though conflicting views, values, and knowledge gaps in the risk field. The last section identifies the condition for handling and managing risks more effectively, efficiently, and in accordance with democratic principles.

2 Risk as a Science Topic and Expected Impact on the Society

2.1 What Is Risk?

Health risks are front-page news. Be it BSE, surface ozone, or radiation from transmitter stations of mobile phones, the popular press puts out a constant stream of risk warnings and sensational reports. The recent risk-related food scandals from BSE to Acrylamide provide ample evidence that there is no simple recipe for understanding and managing risks. When we talk about risks, we may associate many different things: fears of specific hazards such as a terrorist attack, concerns regarding potential failures of complex technological systems like the ones we might face with nuclear energy systems, uncertain projections regarding financial gains or losses that we may experience in the stock market, worries about natural disasters such as the tsunami in South Asia in 2004, but also the thrill of adventure produced through bungee jumping or other extreme sports. Included in the portfolio of risk may also be worries about the competence and trustworthiness of those who manage these different types of risks (Jaeger et al. 2001: 16f.).

In view of worldwide divergent preferences, variations in interests and values and very few if any universally applicable moral principles, risks must be considered as heterogeneous phenomena that preclude standardized evaluation and handling. At the same time, however, risk management and policy would be overstrained if each risky activity would require its own strategy of risk evaluation and management. What risk managers need is a concept for evaluation and management that on the one hand ensures integration of social diversity and multidisciplinary approaches, and, on the other hand, allows for institutional routines and standardized practices. This chapter provides a concept of how to understand, assess, and manage risks with special reference to food safety and biodiversity.

The concept of risk can thus be understood as a kind of perspective to analyze the uncertain consequences of future developments and changes in societies. Risks are like a pair of "glasses" through which the modern world is looked at. As the world has experienced a fast rush of major changes in the last decades, an abundance of risk-related scandals and debates show that risk has become a predominant topic in modern societies (Beck 1986).

Three actual examples have been chosen to be analyzed in depth as case studies in the following chapters of this book:

1. The *loss of biodiversity* as a consequence of the global demographic and technological development

2. Food safety issues on the example of Dioxin TCDD in Baltic sea fish
3. The potential risks of *genetically modified food* to human health

To give an impression on the variety and diversity of risk issues that have to be handled, here are some additional examples of large-scale disasters that have dominated the headline news over the last years:

- The terrorist attack of September 11, 2001
- Natural hazards like the devastating tsunami on Christmas 2004
- The hurricane Katrina in 2005
- The appearance of new infectious diseases like the severe acute respiratory syndrome (SARS) and avian influenza
- Food scandals like bovine spongiform encephalopathy (BSE)

Many definitions of the term *risk* exist and are used by various disciplines and for various risk events: One of the most common ones goes back to the 1980s, and in this definition the term risk denotes the possibility of adverse effects from some action or event with respect to something that humans value (Kates et al. 1985: 21; Fischhoff et al. 1984; see also Renn 1992). This definition combines two dimensions: the likelihood or chance of potential consequences on the one hand, and the severity of these consequences, due to human activities, natural events or a combination of both, on the other hand. This definition implies that the concept of risk does not exclusively describe negative consequences. The judgment whether the implications are positive or negative depends on the values that people associate with them. If we think, for example, of climate change as a risk, the possible consequences like global warming might be perceived differently by different people. Northern Europeans might have a more positive view as they would profit from minor temperature increases as they could increase agricultural productivity and tourism, while people from Africa or Asia are already suffering from lower agricultural productivity and an increase in natural disasters like droughts, floodings, etc.

Risk needs to be distinguished from the term "hazard," for which no common accepted definition does exist as well. *Hazards* describe the potential for harm or other consequences of interest (IRGC 2005: 19). A hazard can hence be the potential of a specific dose of a chemical to produce harm. The difference between risk and hazard is that as long as nobody is exposed to the chemical or an agent like, e.g., acrylamide, there is no risk, only the potential for harm. Probability and exposure are characteristics of the risk. Renn provides a useful conceptual distinction of the two terms: "hazards characterize the inherent properties of the risk agent and related processes, whereas risks describe the potential effects that these hazards are likely to cause on specific targets such as buildings, ecosystems, or human organisms and their related probabilities" (ibid.).

In both natural science and engineering, *risk* is further qualified as the mathematical product of likelihood of occurrence and severity of impact, resulting in a mathematical probability function applied across the range of potential damages. Why is this mathematical definition of risk used in most scientific disciplines? Science is based on the principle of intersubjective validation. This means, it must be both scientifically validated (i.e., other scientists must be able to verify the results

when using the same methods) and expressed in numerical terms. Apart from the traditional elements of likelihood of occurrence and severity of damage with respect to health risks, risk taking also involves other risk-related and situation-related circumstances: For example, some components of risk are not covered in the traditional technical definition of risk[1]:

- The uncertainty that remains after assessing probabilities and potential for harm (there is, for example, still uncertainty about the long-term health effects of electromagnetic fields from mobile phones, etc.).
- The ubiquity describes the geographical spread of a damage.
- Persistence means the time, how long a damage lasts. The persistence of harmful effects is independent of their severity, even effects that seem not to be severe at first sight can turn out to be problematic due to their spread in time. For example, some chemicals, which do not seem to have severe negative effects at first sight, can turn out to be accumulating in the organism over years due to their persistence.
- Delayed effects over time, meaning that some risk consequences do not emerge immediately, but they appear after months or even years. This has, for example, been the case with the health effects of asbestos.
- The scope for institutional risk management and limitation (the range of possible management options can be limited by financial, political, or cultural reasons).

The technical concept of risks should not be confused with how individuals and social groups define and perceive risk. Many risk-related and situation-related factors play an important role in how risk is perceived by individuals, groups, or social institutions, which form the subjective factors in risk perception (Slovic 1987; Rohrmann and Renn 2000). The way risk is perceived differs, for example, depending on whether or not the individual has self-perceived control over the degree of risk involved with respect to personal control and management potential (Sjöberg and Drottz-Sjöberg 1994). Such subjective factors should not be deemed irrational. When we assess risk, it really does make a difference whether one can personally control the degree of risk (say, during leisure activities) or whether one must passively accept a given risk (e.g., passive smoking).

Risks consequently have to be understood as permanent companions of everyday life. As long as people value certain things or conditions and as long as they take decisions in the presence of uncertainty, they will face risks. Risks are hence a basic constituent of life.

2.2 Varying Concepts of Risk

When looking at risk, different disciplines and perspectives can be distinguished. These perspectives are listed below.

[1]The German Advisory Council on Global Change (WBGU) recommended a classification system based on seven generally applicable risk factors to define various types of risk. For each type of risk, a separate strategy was developed for assessment and management of those risks (WBGU 1998).

- *Technical concept*: this concept of risk, which is predominantly used by insurances, is expressed through the mathematical function of probability and harm. Harm refers to human health, environment, and capital assets.
- *Economic concept*: expresses risks in expected utilities, which can be losses or gains, and allows therefore a comparison between risks and benefits by weighting possible costs by the probability of their occurrence.
- *Ecological concept*: understands risks as a threat to ecosystem stability and sustainability.
- *Psychological concept*: subjectively expected utilities (based on individual perceptions of harm and likelihood and other qualitative factors such as contextual variables) are used by individuals to deal with risks.[2]
- *Sociological concept*: is a patchwork of different concepts, which have in common that they deal with social constructions of pending threats to all aspects of what individuals and groups value.
- *Cultural concept*: this concept deals with culture-specific rules and procedures for framing, analyzing, managing, and handling threats to society. Certain values are the basis. It works with mind-sets of individuals that are structured by cultural patterns.

All these concepts of risk emphasize different aspects of the risk phenomenon. They focus either on the type of harm or the qualification of uncertainties and ambiguities. In particular, the concepts differ in their approach or measure of uncertainty, in their definition of what constitutes undesirable outcomes and in their understanding of reality (ibid. 58). As a consequence, the different phases of risk governance need not only have to address the challenges outlined above, but also the varying concepts of risk in the different scientific disciplines.

2.3 Basic Components of Risk

For the analysis of traditional or systemic risks it is helpful to decompose the knowledge base of what we call risk into three major components. These components are *complexity*, *uncertainty*, and *ambiguity* (Klinke and Renn 2006).

2.3.1 Complexity

Often it is difficult to identify and quantify causal links between a multitude of potential causal agents and their specific adverse effects. The nature of this difficulty may be traced back to a number of different factors, which are subsumed under the term complexity: interactive effects among the causal agents (mutual strengthening

[2]This aspect is further developed in Sect. 5 on risk perception.

or weakening), positive and negative feedback loops, long delay periods between cause and effect, interindividual variation and intervening variables. These are only some of the multiple factors which give hints at complexity. It is precisely these factors that make high-level scientific investigations necessary, since the cause–effect relationships in complex risks are neither obvious nor directly observable. The global decrease in biodiversity is an impressive example for a risk that is characterized by high complexity. There are many factors, like the destruction of natural habits of endangered species, increasing land use for housing and industry, landscape fragmentation, intrusion of invasive species caused by globalized transport and travels, climate change, and environmental pollution, of which the interdependencies cannot completely be identified or quantified.

2.3.2 Uncertainty

This term describes a state of knowledge in which the likelihood of any harmful effects or even these effects themselves, cannot be precisely described, although the factors influencing the issues are identified. Uncertainty is different from complexity, but is often a result from an incomplete or inadequate reduction of complexity in modeling cause–effect chains. It comprises different components such as statistical variation, measurement errors, ignorance and indeterminacy (van Asselt 2000). All of these have one feature in common: uncertainty reduces the strength of confidence in the estimated cause–effect chain. If complexity cannot be resolved by scientific methods, uncertainty increases. But even simple relationships may be associated with high uncertainty if either the knowledge base is missing or the effect is stochastic by its own nature.

Uncertainty can be further disaggregated into separate components. Two epistemic components are "target variability," meaning differences in the vulnerability of targets (e.g., the different reaction of male and female organisms on medication) and "systematic and random errors in modeling," which are mainly driven by extrapolation (e.g., from animals to humans or from large doses to small doses). In these cases, uncertainty can be reduced through the generation of new knowledge or the advancement of present modeling tools.

One example of uncertainty can be found in the food sector, especially in the food-supplier-chain, and the possible contamination through chemicals. It is estimated that around 70,000 chemicals do exist in the environment, and every consumer is exposed to them, for example, through the food chain. The exact effects of every single chemical are yet not well known and most foods contain more that one chemical at the time. This means that often cocktail effects can be observed, of which the consequences are often unknown.

Other components of uncertainty cannot be reduced because they are aleatory, i.e., driven by chance. These components are "genuine stochastic effects," "system boundaries," and "ignorance or nonknowledge" (IRGC 2005: 30). An actual example is the risk of an uncontrolled spreading of genetically modified plants in the environment.

2.3.3 Ambiguity

The existence of different (legitimate) interpretations based on identical observations or data assessments is called ambiguity. Most of the scientific disputes in risk analysis do not refer to differences in methodology, measurements or cause–effect functions, but to the question of what all this means for human health and environmental protection. An example: Emission data of greenhouse gases is hardly disputed. Most experts debate, however, whether a certain emission constitutes a serious threat to the environment or to human health. Ambiguity may come from differences in interpreting factual statements about the world or from differences in applying normative rules to evaluate a state of the world. In both cases, it exists on the ground of differences in criteria or norms to interpret or judge a given situation. High complexity and uncertainty favor the emergence of ambiguity. On the other hand, there are also quite a few simple and almost certain risks that can cause controversy and hence ambiguity. This is, for example, the case in the discussion of speed limits on German motorways in order to reduce the risk of accidents.

Ambiguity comprises two dimensions. One is *interpretative ambiguity*, which describes different interpretations about the implications of a given hazard. The associated question to this dimension is: What does an assessment result mean? A typical example for interpretative ambiguity is the risk of electromagnetic fields (EMF). Studies have shown that laypersons judge the risks concerning EMF differently and generally higher than experts.

The other dimension is *normative ambiguity*, and raises the question about the tolerability of the hazard. It is based on the idea that there are varying legitimate concepts of what can be regarded as tolerable, "referring, e.g., to ethics, quality of life parameters, distribution of risks and benefits, etc." (IRGC 2005: 31). For example, genetically modified organisms (GMO) encounter a high level of opposition in the area of food, but are widely accepted in the area of medical applications, because they are associated with the hope for health benefits.

2.4 Characteristics of Risks in the Modern World: New Challenges to Risk Governance

A number of *driving forces* have been identified which are shaping our modern world and have a strong influence on the risks we face (OECD 2003: 10ff.):

1. The demographic development
2. Globalization
3. The rapid technological change
4. Changes within the socioeconomic structures and global environmental change

The *demographic development*, including the increase of the world population, the growing population density, and visible trends toward urbanization, accompanied

by significant changes in the age structure of most industrial populations have led to more vulnerabilities and interactions among natural, technological, and habitual hazards. Demographic changes are also partially responsible for the strong interventions of human beings into the natural environment. Human activities, first of all the emission of greenhouse gases like CO_2, may cause global warming. As a consequence, they place growing stress on ecosystems and human settlements. In addition, the likelihood of extreme weather events increases with the rise of average world temperatures. Furthermore, these trends toward ubiquitous transformation of natural habitats for human purposes are linked to the effects of economic and cultural *globalization*: The exponential increase in international transport and trade, the emergence of worldwide production systems, the dependence on global competitiveness and the opportunities for universal information exchange testify to these changes and challenges. In terms of risks, these trends create a close web of interdependencies and coupled systems. Small disturbances have the potential to strongly increase through all the more or less tightly coupled systems. They might cause very high damages.

The development of globalization is closely linked to *technological change*. The technological development of the last decades has led to a reduction of individual risk, i.e., the probability to be negatively affected by a disaster or a health threat (for example, think of the eradication of many diseases in industrialized countries), but it has increased the vulnerability of many societies or groups in society: Among the characteristics of this technological development are the tight coupling of technologies with critical infrastructure, the speed of change and the pervasiveness of technological interventions into the life-world of human beings. All aspects that have been described as potential sources of catastrophic disasters (Perrow 1992; von Gleich 1999, 2003). Very typical examples for the restricted controllability of technological complexity are nuclear power plants, as have shown the catastrophe in Chernobyl. The youngest incidents in two German nuclear sites have not led to catastrophes but were impaired through delayed communication and unclear responsibilities.

In addition to the technological changes, *socioeconomic structures* have experienced basic transitions as well. In the last two decades efforts to deregulate the economy, privatize public services and reform regulatory systems have changed the government's role in relation to the private sector which had major effects on the procedures and institutional arrangements for risk assessment and risk management. Attitudes and policies are increasingly influenced by international bodies with conflicting interests and increasingly by the mass media.

These basic developments have induced a number of *consequences*:

- An increase of catastrophic potential and a decrease of individual risk, associated with an increased vulnerability of large groups of the world population with respect to technological, social, and natural risks.
- An increase in (cognitive) uncertainty due to the growing interconnections and the fast global changes.
- An increased uncertainty about a change in frequency and intensity of natural hazards due to global change.

- Strong links between physical, social, and economic risks due to the interconnections of these systems.
- An exponential increase in payments by insurances for compensating victims of natural catastrophes.
- The emergence of "new" social risks (terrorism, mobbing, stress, isolation, depression).
- An increased importance of symbolic connotation and attenuation of risks.

These recent trends and consequences of risks to society have led to the creation of a new risk concept – the concept of *emerging systemic risks*. These are risks "that affect the systems on which society depends – health, transport, environment, telecommunications, etc." (OECD 2003: 9). More specifically, systemic risks means the fact that risks to human health and the environment are embedded in a larger context of social, financial, and economic risks and opportunities. Systemic risks are at the crossroads between natural events (partially altered and amplified by human action), economic, social and technological developments and policy-driven actions both at the domestic and at the international level (OECD 2003; IRGC 2005; Renn and Klinke 2004). The most typical example for a systemic risk is global climate change. While it is a natural development that the climate system changes over time (think of the ice ages, for example), the actual developments are influenced by the large and still increasing amounts of human emissions of greenhouse gases. This leads to effects in the natural, economic, social, and technical systems, as they are all dependent on the climate and interdependent to each other.

Systemic risks lead to new challenges for risk management and risk governance, because the threat they pose to mankind is new and challenging. The interdependency of the natural and human systems, which enable the survival of close to seven billions of men, has never been as high as today. This is why these new threats are in the focus of actual risk research. New solutions to deal with risks must be found.

Among the most pressing challenges are:

- Finding more accurate and effective ways to characterize uncertainties in complex systems. Often, uncertainties cannot be completely resolved due to the interdependencies and complexities that characterize systemic risks. These uncertainties can be of a different nature, sometimes it is not possible to calculate the probability of a harmful event, sometimes it is even not possible to know all the factors that influence such an event. Hence, uncertainty can range from a simple lack of data to complete ignorance of the coherences. These different types must be characterized and decision rules have to be found how to deal with them.
- Developing methods and approaches to investigate and manage the synergistic effects between natural, technological, and behavioral hazards. This regards the organization and management of the knowledge of experts from many different disciplines, and at the interface of scientists and decision-makers responsible to implement the solutions. More collaboration and interdisciplinary is needed to be able to face risks that threat all relevant systems.

- Integrating the natural and social science concepts of risks to deal with both physical hazards and social risk perceptions. It is no longer sufficient to base decision only on the physical characteristics of hazards. Risk perceptions and values of the public have a high impact on the tolerability and acceptability of the risks and the solutions found to deal with them. Solutions to handle systemic risks might increasingly intervene in the everyday life, lifestyle, and freedom of people, so their concerns and perceptions have to be included when making decision.
- Expanding risk management efforts to include global and transboundary consequences of events and human actions. Decisions that are taken within one country will, in the context of systemic risks, have consequences for other countries as well (e.g., as regards to increase or decrease of greenhouse gas emissions). This means, that more people have to be included into the decision-making processes, i.e., more governments, more stakeholder groups, etc. More co-operation is needed, while the cultural differences between countries have to be respected.

In Chap. 3, we will present a framework that promises some solutions of how to deal with these challenges. But before this framework is explained in more detail, it is necessary to categorize the risks further that we are covering in this book.

2.5 The Integration of Perceptions and Social Concerns

Why do we need to include risk perceptions and concerns into the governance of modern risks? Risk consequences are judged differently by varying actor groups or individuals, depending on their "perception" of the risk. It does make no difference whether these consequences are intended or unintended. As the validation of the consequences depends on differing values and perceptions, risks can be described as mental or social "constructs" (OECD 2003: 67). This leads to:

– Different individual judgments about the severity and probability of risks
– Conflicts about how to handle them correctly
– The assessment if the measures are taken are acceptable, tolerable, or intolerable

"*Perceptions*" can be understood as the different images or mental models that are associated with risk by different cultures, groups, or individuals. It is these perceptions, i.e., what humans perceive of the world and what attitudes they develop toward it, that drives their behavior, not scientific facts. They result from common sense reasoning, personal experience, social communication, and cultural traditions (IRGC 2005: 31; Brehmer 1987; Drottz-Sjöberg 1991; Pidgeon et al. 1992; Pidgeon 1998). From an evolutionary perspective, humans have been using relatively consistent patterns of coping with dangerous situations. They can be reduced to four basic instinctive strategies, based on their perception of the risk: "*flight*, *fight*, *play dead* and, if appropriate, *experimentation* (on the basis of trial and error)" (IRGC 2005: 31).

As the nature of risk has changed with the growing complexity of the world (Sect. 2), these basic, instinct driven patterns of risk perception have been enriched by cultural and social influences. These perceptions influence the estimations and acceptability or risks and play therefore an important role in contemporary risk governance. Today, there exists a variety of scientific approaches that deal with risk perception, using different perspectives and concepts.

One of the initial concepts of "perceived risk" was first established by the psychologists Fischhoff, Lichtenstein, and Slovic in 1978.[3] This concept is known as the "*psychometric approach*" and uses qualitative evaluation patterns that go beyond the technical factors that are usually used by risk assessors, i.e., occurrence probability and extent of damage. Here, two classes of qualitative perception patterns are used: risk-related patterns (which refer to the properties of the source of the risk, e.g., the perceived "dread" of a consequence or if a risk is known or unknown to the observer) and situation-related patterns (which refer to the peculiarities of the risky situation, e.g., voluntariness of exposure to a risk, controllability, or distribution of risks and benefits) (IRGC 2005: 32; Fischhoff et al. 1978; Slovic 1987, 1992). The psychometric approach is based on four intentions:

- To establish "risk" as a subjective concept, not an objective entity
- To gain a better understanding of the cognitive structure of risk judgments, usually employing multivariate statistical procedures such as factor analysis, multidimensional scaling or multiple regression
- To add social/psychological aspects to risk assessment and management
- To accept preferences of "the public" (i.e., lay people, not experts) as additional yardsticks for evaluating risks

Based on psychometric studies, a new concept of classifying risk perceptions has emerged which is referred to as "*semantic risk patterns*." Five patterns can be described (Renn 2004; IRGC 2005: 32):

Pattern 1: Risks posing an immediate threat (e.g., nuclear energy or large dams)
Pattern 2: Risks being understood as a blow of fate (e.g., natural disasters)
Pattern 3: Risks presenting a challenge to one's own strength (e.g., risky sports activities like freeclimbing)
Pattern 4: Risks as a gamble (e.g., lotteries, stock exchange, or insurances)
Pattern 5: Risks as an early indication of insidious danger (e.g., food additives, ionizing radiation, viruses)

These semantic patterns help individuals to deal with new situations by associating them to similar and therefore "known" patterns. As an example, *genetically modified tomatoes* would be subsumed under the pattern "risk as an early indication of insidious danger." This risk could be described by high levels

[3]For a comprehensive review and documentation of this body of research see Rohrmann (1995), overviews are provided by Fischhoff et al. (1993), Guerin (1991), Jungermann and Slovic (1993), Pidgeon et al. (1992), and Renn (1986, 1990).

in the characteristics involuntariness, unknown risk, and a perceived low level of personal or institutional controllability. Together with risks of the first category (related to a very high level of "dread"), these types of risks are confronted with the danger of stigmatization[4] and lead therefore very often to low levels of tolerability and acceptance. Another example is the loss in biodiversity. This can also be placed in pattern 5. The risk has already taken worldwide dimensions but proceed continuously without a major event.

The described approaches show that the acceptability of a specific risk does not only depend on its level of occurrence probability and the extent of damage, but also on a number of qualitative characteristics that influence risk.

3 Analysis of the Risk Issues Involved

3.1 How to Deal with Systemic Risks?

We have learned in the first two chapters that risks are getting more complex, uncertain and ambiguous in today's world, due to the described trends of the demographic development, globalization, technological developments, and the changing socioeconomic structures and that therefore qualitative risk characteristics, such as individual perceptions, have to be take into account when handling these systemic risks. Dealing with these risks and with the way their consequences are interlinked, is captured with the term "risk governance." "*Governance*" has gained considerable popularity in such different research fields as international relations, comparative political science, policy studies, sociology of environment and technology and risk research. It describes the structures and processes of collective decision making, including governmental as well as nongovernmental actors (Nye and Donahue 2000). On the global level, governance describes a horizontally organized structure of functional self-regulation encompassing state and nonstate actors bringing about collectively binding decisions without superior authority (Rosenau 1992; Wolf 2002).

"*Risk governance*" involves the "translation" of the substance and core principles of governance to the context of risk and risk-related decision making (IRGC 2005: 22f.). In relation to the challenges of modern systemic risks, this means that there is a need for an integrated analytic framework that incorporates the views and perceptions of the various actor groups and includes the integration of scientific, economic, societal, and cultural aspects of the risks.

[4]The concept of "stigma" cannot be treated here since this would exceed the scope of this document. For more information see Kunreuther and Heal (2003).

3.2 The "Traditional" Understanding of Risk Governance

The scientific preoccupation with risk governance has its roots in the traditional understanding of *risk analysis*. Being strongly based on natural science concepts with a technical understanding of risk (risk as product of probability of occurrence and degree of harm), three components of risk governance are traditionally differentiated:

- Risk assessment
- Risk management
- Risk communication

Risk assessment describes the tasks of identifying and exploring the types, intensities and likelihood of the (normally undesired, negative) consequences related to a risk. In most cases, the results are expressed in quantified terms. Consequently, risk assessment can be defined as a tool of gaining knowledge about risks and is mainly located in the scientific area. The aim of risk assessment can thus be identified to describe a risk as precisely as possible and, if appropriate, to quantify it (OECD 2003: 66). The main challenges during the risk assessment phase are high levels of complexity and scientific uncertainty.

For example, in the case of pesticide residues in food, the assessment of the health risk of the residues of a single pesticide is comparatively unproblematic – through the characterization of dose–response relationships. But the concomitance of the residues of multiple pesticides together with additional multiple stressors from the environment and the assessment of their combined effects on human health poses a problem to risk assessors because of the complexity of the dose–response relationships of multiple residues. Other examples are the uncertainty of the effects of genetically modified organisms (GMO) shown in the GM tomato case (book Chap. 4) or the complex interplay of factors that cause the decrease of biodiversity (book Chap. 2). As a consequence, the measurement, statistical description and modeling of such types of risks can pose serious problems to the risk assessors.

Risk management, on the other side, describes the task to prevent, reduce or alter the consequences identified by the risk assessment through choosing appropriate actions. Accordingly, it can be defined as a tool for handling risks by making use of the outcomes of the risk assessment process. This task is located in the area of decision-makers – mainly in the field of politics, but in the economic sector as well. The main challenge to risk management is the existence of ambiguity, as it concerns the interpretation of the scientific findings and judgments about the tolerability or acceptability of a specific risk. This is specifically true for the judgment of genetically modified foods and feeds.

The obvious distinction between risk assessment (the scientific knowledge related to a specific risk) and risk management (the decision making of how to handle risks) often becomes blurred, if one takes a closer look into the risk governance processes. While risk assessment concentrates on the risk agent or the source of the

agent themselves, and tries to identify the extent of damage as well as the probability of its occurrence, risk management has to take into account a much wider field (IRGC 2005: 21; Stern and Fineberg 1996; Jasanoff 1986: 79f.; 2004). It comprises preventive as well as reactive action. But risk management depends on the knowledge input from risk assessment. This is a crucial point, because the outcome of the risk assessment phase might on the one hand be very directive, which means, leaving only one option for the action to be taken. This could, for example, be the case if the assessment of the health effects of a specific pesticide results in the finding that it is genotoxic already in very low doses, and the only option for preventing harmful health consequences is a complete ban of the product. If this is the case, decision making is already included in the risk assessment phase. On the other hand, risk management does not only have to consider risk assessment outcomes, but also might, for example, have to alter human wants and needs, e.g., to prevent the creation or continuing of the risk agent, or to suggest alternatives or substitutes to a specific risk agent. It can also comprise activities to prevent exposure to a risk agent by isolating or relocating it or take measures to increase the resilience of risk targets.[5] This means, the issues that have to be taken into account by risk managers are often going far beyond the direct consequences of a risk. The case of the regulation of genetically modified organisms illustrates this complex task: The risk managers do not only have to consider the possible negative health effects that might be a consequence of, e.g., the consumption of genetically modified food, but also indirect consequences like possible losses in biodiversity due to the spread of genetically modified species, ethical concerns raised by religious or moral beliefs regarding the principle of a fundamental manipulation of living organisms, or effects of the ban (or public funding on the other hand) on the competitiveness of the national economy.

Risk communication is the third key element in the traditional understanding of risk governance. Its task was initially defined as bridging the tension between expert judgment and the public perceptions of risks, which often vary to a large extend (Sect. 5).

The "Committee on Risk Perception and Communications" defines it, "as an interactive process of exchange of information and opinion among individuals, groups, and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risk, that express concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management" (US National Research Council 1989).

The communication studies distinguish models which analyze the communication processes between different institutions. As one of the first, Harold Lasswell (1948)

[5]Resilience in this context means a protective strategy to strengthen the whole system against consequences of a certain risk, to decrease its vulnerability. This strategy is mostly taken in the case of unknown or highly uncertain risks. A well-known example from the health system is the vaccination in order to strengthen the immune system. Other possible measures are to design systems with flexible response options, or to improve the emergency management (IRGC 2005: 79).

described the single elements of the communication process with one simple question: "Who says what in which channel to whom with what effect?" (Fig. 1.1).

This simple question was revived from Shannon and Weaver (1949) and transferred into a mathematical model. The linear model was actually designed for the fast transmission of electronic signals for the Bell Telephone Company. Because of the simple usage and the description of the communication process between encoder and decoder, the model was transferred into general communications studies and the analysis of risk communication, too.

The model from Shannon–Weaver (Fig. 1.2) is too static and shows only the linear or one-way-communication process. This can lead to false interpretations, because human communication cannot be defined as linear, but as action, reaction, acceptance, and attitude.

Schramm (1954) adds the feedback component to the traditional one-way-communication-model. This was the foundation of the two-way-communication-model (Fig. 1.3).

Following the model of Schramm (1954), a two-way-communication should be used, in which the risk communicator directly contacts the target group and collects

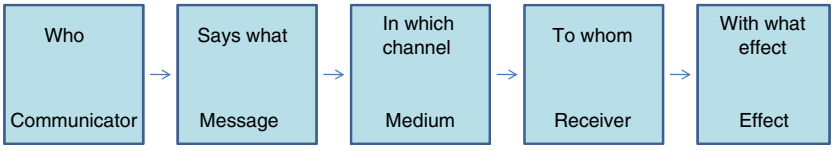

Fig. 1.1 Elements of the communication process (adapted and modified from Lasswell 1948)

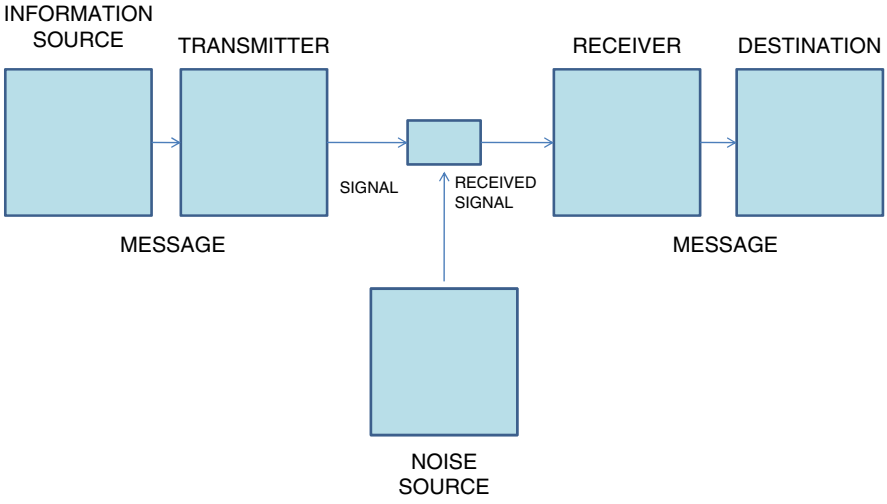

Fig. 1.2 Shannon–Weaver Mathematical Model (adapted and modified from Shannon and Weaver 1949)

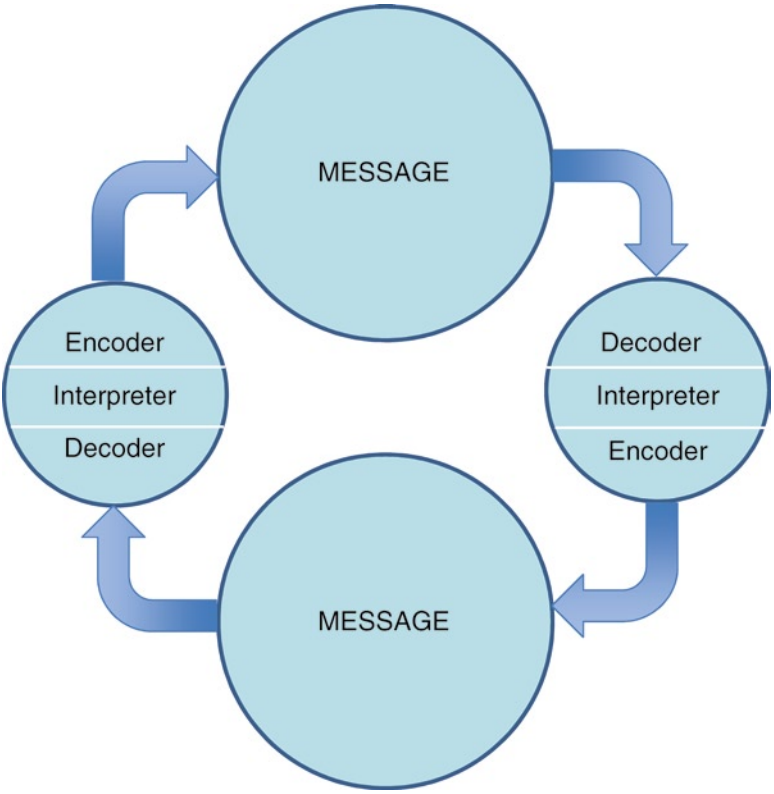

Fig. 1.3 Conservation model from Schramm (1954, adapted and modified)

their feedback. This target group should bring in arguments, ideas, impressions, judgments or statements (Renn and Kastenholz 2000: 30). Accordingly, after Schramm, the main characteristic of the two-way communication is the permanent transfer of the roles from being the sender or the active listener. Communication channels could be public events, forums, panels, exhibitions, printed material, or the internet, in which a feedback to the publisher is planned:

> Two-way communication is clearly a prerequisite for all forms of successful communication, but it is often hard to implement and requires flexibility and the willingness to adapt to public concerns on the side of the communicating institution (Renn and Kastenholz 2000: 30).

Actors on risk issues could access to strategies according to risk type and purpose. The essential element is an exhaustive analysis of the risk, and – similar to any other management process – the detailed definition of the goals and tasks.

In a review of risk communication approaches, William Leiss identified three phases in the evolution of risk communication practices (1996: 85ff.), which are briefly presented in Table 1.1.

Four major functions of risk communication and their goals can be identified (Morgan et al. 1992; OECD 2002; IRGC 2005: 55ff.). These four functions aim at

Table 1.1 Phases in risk communication

No.	Type	Characteristics
Phase 1	*One-way communication*	– Convey probabilistic thinking to the public – Application of risk comparisons – Educate the laypersons to acknowledge and accept risk management practices – Failed to convince audiences
Phase 2	*One-way-communication* Convey a persuasive message to the public	– Emphasize persuasion and focus on efforts of public relations to convince people that parts of their behavior were unacceptable – Some successes to change unhealthy behavior, but most people did not believe the messages – Altogether, this phase has had little effect
Phase 3	*Two-way communication* All members including the risk managers are involved	– To build up mutual trust by responding to the concerns of the public and relevant stakeholders – To assist stakeholders in understanding the rationale of risk assessment results and risk management decisions – To help stakeholders to make informed choices about matters of concern to them

Table 1.2 Functions and goals of risk communication

No.	Function	Goal
1	*Education and enlightenment*	Informing the public about risks, including risk assessment results and the handling of the risks according to risk management strategies
2	*Risk training and inducement of behavioral changes*	Helping people to cope with risks
3	*Promotion of confidence in institutions responsible for the assessment and management of risks*	Giving people the assurance, that those responsible for risk assessment and risk management act in an effective, efficient, fair, and acceptable manner
4	*Involvement in risk-related decisions and conflict resolution*	Giving stakeholders and representatives of the public the opportunity to participate in the risk-related decisions

helping all affected actors, i.e., stakeholders as well as the general public, to make informed choices when facing a risk (Table 1.2):

These four major functions pose a number of challenges to those responsible for risk communication (IRGC 2005: 57). They have to explain the concept of probability and stochastic effects to a broad audience. Otherwise, wrong interpretations of probabilities or exposure effects might lead to overreactions up to the stigmatization of a risk source (or to the opposite as well, as can be illustrated by the comparison of the risks of driving a car, which is often underestimated, and to travel by plane, which is most of the times overestimated). Dealing with stigma-

tized risk agents or with highly dreadful consequences is another challenge for risk communication. Risks, such as nuclear energy, can produce high levels of mobilization and very emotional reactions in the public. The example of the stigmatization of genetically modified food illustrates, that risk communication also has to take into account much more general convictions as well, such as ethical, religious, and cultural beliefs.

Risk communication, in this traditional understanding, is seen as a separate issue, which has as its main task to "educate the public" (IRGC 2005: 54), i.e., to communicate the results of experts' assessments to the wider public. In this understanding, risk communication follows the two phases of risk assessment and risk management, and is more one-way information than two-way communication, that takes into account varying perceptions and concerns.

The situation we are currently facing is a situation of change. The traditional risk analysis approach with its three described components is being increasingly criticized. In the view of a growing number of risk governance experts, in this "traditional" triangle, the *interfaces of the three components* risk assessment, risk management and risk communication are not adequately designed. The crucial point in the relationship of risk assessment and risk management is the general question of the influence of policy on science and vice versa. In the last two decades, the question was raised repeatedly of how to protect scientific risk assessment from inappropriate policy influences.[6] The institutional separation of these two tasks, like it has been implemented, for example, in the food sector, is a first step into this direction, but the implementation is still in a very early phase.[7]

This is why in the last years, a number of new models and approaches of risk governance have emerged resp. are emerging. These models are predominantly of theoretical and analytical nature. So the actual situation can be described as a situation of paradigm shift and the new models are currently in a phase of testing, improvement, and revision. One of these innovative models of risk governance is described in the following section.

3.3 The Need for an Integrated Framework of Risk Governance

The new challenges of systemic risks and recent tendencies in the handling of these risks, which have led to highly controversial conflicts about how to handle these risks, have shown that the three "generic" categories of risk governance, as they have been described above, are not sufficient to analyze and improve the risk governance processes. The characteristics of modern systemic risks (Sect. 4) require

[6]For the area of food safety, cf. Trichopoulou et al. (2000).

[7]For the area of food safety, cf. Dreyer et al. (2009).

new concepts, which are able to deal with the described challenges. This means, that besides the "factual" dimension of risk (which can be measured by risk assessors) the "socio-cultural" context has to be included as well, as systemic risks are characterized by affecting the whole "system" that humans live in.

The International Risk Governance Council (IRGC) has developed a proposal for an integrated framework for risk governance to help analyzing how society could better address and respond to such risks. To this end, the IRGC's framework maps out a structured approach which guides its user through the process of investigating global risk issues and designing appropriate governance strategies. This approach combines scientific evidence with economic considerations as well as social concerns and societal values and, thus, ensures that any risk-related decision draws on the broadest possible view of risk. The approach also states the case for an effective engagement of all relevant stakeholders.

Drawing on learning from a selection of current approaches to what has often summarily been termed "risk analysis" or "risk management," the framework offers a full risk handling chain ranging from how risk is identified, assessed, managed, and monitored to how it is communicated. This chain, which is in reality rarely sequential, breaks down into four main phases. The principal distinction between the knowledge gaining tool (assessment sphere) and the decision-making tool (management sphere) can still be identified. But there are also new elements, which combine these two generic steps.

The different components, which form the risk governance cycle, are briefly presented (Fig. 1.4).

The first phase, "*pre-assessment*" captures, and brings to the open, both the variety of issues that stakeholders and society may associate with a certain risk as well as existing indicators, routines, and conventions that may prematurely narrow down, or act as a filter for, what is going to be addressed as risk. It includes four elements: *Problem framing* describes the different perspectives on the conceptualization of the issue: the question of what the major actors (e.g., governments, companies, the scientific community, and the general public) select as risks. For example, is the global warming through climate change a risk, an opportunity or just fate? This element defines the scope of all the subsequent elements. *Early warning* comprises the institutional arrangements for the systematic search for new hazards. New phenomena such as, for example, the increase in extreme weather situations are taken as indicators for the emergence of new risks. *Screening* (or monitoring) describes the action of allocating the collected information on new risks into different assessment and management routes. This means, criteria like hazard potential, ubiquity, persistence, etc., are collected, systematically analyzed and amalgamated (Is the risk new? Is it an emergency? etc.) and related to potential social concerns. Finally, scientific conventions for risk assessment and concern assessment are defined (What methods will be used to assess the risk? etc.).

The second phase, "*risk appraisal*," provides the knowledge base for the societal decision on whether or not a risk should be taken and, if so, how the risk can possibly be reduced or contained. Risk appraisal thus comprises a scientific assessment of

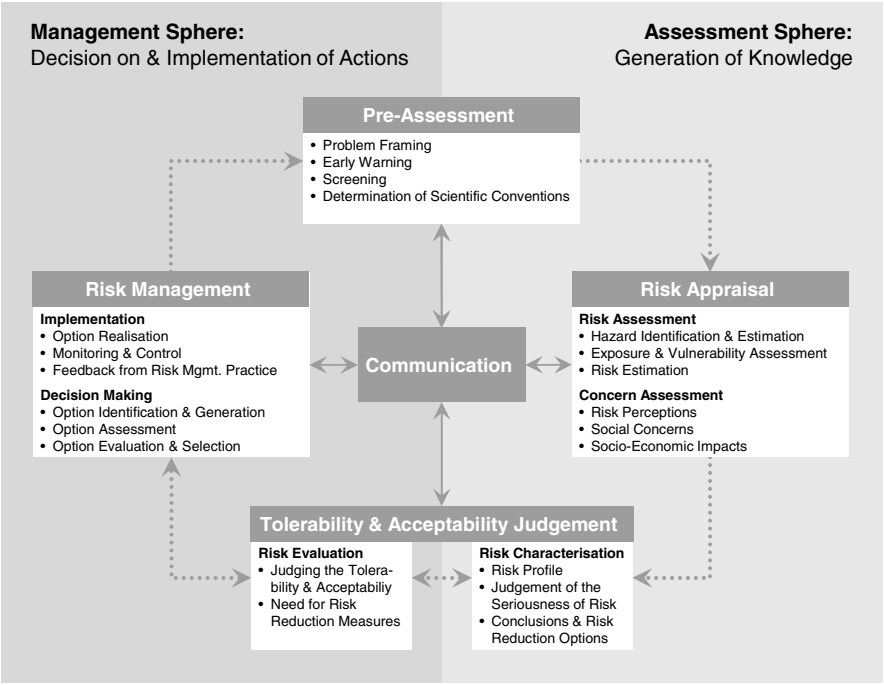

Fig. 1.4 IRGC Risk Governance Framework – General Model (IRGC 2005, adapted and modified, p. 365)

both the risk and of questions that stakeholders may have concerning its social and economic implications. This element consists of three generic components: *Hazard identification and estimation*, which describes the methods of recognizing the potential for adverse effects and for assessing the strength of cause–effect relationships. *Exposure/vulnerability assessment* defines the modeling of the diffusion plus the exposure pathways and the effects on the risk targets. In this step, those people are identified, that are (especially) affected by the risk, for example, people with a compromised immune system, very old and very young people, are vulnerable related to an influenza pandemia. The component *risk estimation* can be divided into two parts: quantitative estimation describes the probability distribution of adverse effects, while qualitative estimation comprises the construction of whole scenarios of combinations of different hazards, exposures, and qualitative factors. *Concern assessment* is also understood as a source of knowledge and includes the varying risk *perceptions and concerns* of all affected actors in the risk context (Sect. 5 on risk perception). *Socioeconomic impacts* and possible *economic benefits* are also considered in this step.

The third (and most controversial) phase, "*risk characterization and evaluation*" makes a judgment call on whether or not a risk is acceptable or – in view of the benefits it provides and if subject to appropriate risk reduction measures – at least tolerable.

Input for this decision comes both from compiling scientific evidence gained in the appraisal phase (risk characterization) and from assessing broader value-based issues and choices that also bear on the judgment (risk evaluation). Risk characterization includes the creation of a *risk profile* (including the outcomes of risk assessment), the *judgment on the seriousness of the risk* (including questions like: Are there effects on the equity of risk and benefits? Does the public acceptance exist?) and *conclusions and risk reduction options* (including suggestions for tolerable and acceptable risk levels). In the Risk Evaluation step, societal values and norms are applied to the judgment on tolerability and acceptability. In this step, the need for risk reduction measures is determined (this includes the choice of a specific technology, the determination of the potential for substitution, risk–benefit comparisons, die identification of political priorities and compensation potential, conflict management strategies, and the assessment of the potential for social mobilization). In this step in between scientific and policy-making contexts, the options for risk management are generated.

One possibility to classify risks is the "*traffic light model*," a figure that is often used for classifying different natural and man-made risk areas. It supports assessment and management processes. This figure locates tolerability and acceptability in a risk diagram, with probabilities on the *y*-axis and extent of consequences on the *x*-axis (Fig. 1.5). In this variant of the model, the red zone signifies intolerable risk, the yellow one indicates tolerable risk in need of further management actions (in accordance with the "as low as reasonably practicable" ALARP – principle) and the green zone shows acceptable or even negligible risk.

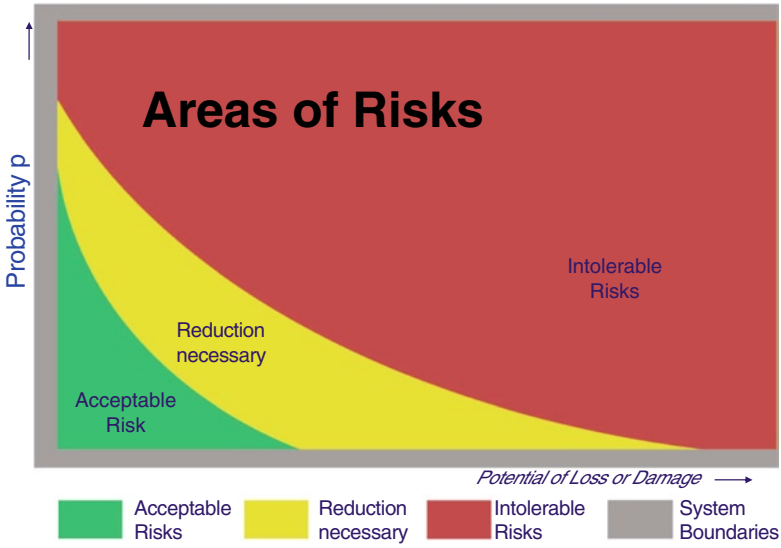

Fig. 1.5 Acceptable, tolerable, and intolerable risks (Traffic Light Model, adapted and modified, from IRGC 2005, p. 150)

This figure may help in situating risks within the dimensions of acceptability and tolerability by using e.g., psychometric characteristics or semantic patterns.

The fourth phase, "*risk management*," designs and implements the actions and remedies required to tackle risks with an aim to avoid, reduce, transfer or retain them. Based on the development of a range of management options, risk management decisions are taken and put into practice. Depending on these outcomes, risk management has to fulfill two tasks: *Implementation* of the generated options includes the *option realization*, the *monitoring and control* of the consequences and the collection of *feedback from risk management practice*. The *decision making* includes option identification, generation and option assessment, and is accordingly interdependent with the tolerability and acceptability judgment step. The arrow between "Tolerability and Acceptability Judgment" and "risk management" goes into both directions. In most cases, the risk is only reduced, but will not reach the level Zero. After the analysis of the measures a second judgment might be necessary, in order to check if the risk is now acceptable.

The final element of the risk handling chain, "*risk communication*," is of crucial importance in all phases of addressing and handling risk. It is placed in the center of the whole governance cycle. It should enable stakeholders and civil society to understand the risk itself and the rationale of the results and decisions from the risk appraisal and risk management phases when they are not formally part of the process. Even more importantly, when they are themselves involved in risk-related decision making, risk communication must also help them to make informed choices about risk, balancing factual knowledge about risk with personal interests, concerns, beliefs, and resources.

Risk communication has to deal with long-term and delay effects of risks, which often compete with short-term advantages in the view of different actor groups. Similar challenges are to provide an understanding of synergistic effects with other lifestyle factors or other risks and to address the problem of remaining uncertainties and ambiguities. The communication of such complex coherences demands a great deal of social competence, as it has to face the differing concerns, perceptions, and experiential knowledge of the different audiences addressed. On an international level, risk communication has additionally to cope not only with intercultural differences but with differences between various nations and cultures as well.

In this understanding, risk communication does not stand at the end of the risk governance process, but is an important element of all phases of the cycle. It is to be understood as a mutual learning process. The perceptions and concerns of the affected parties is meant to guide to risk assessors and risk managers in their selection of topics.

The framework is currently being tested for efficacy and practicability – i.e., 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. Tests are conducted 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. The results from these tests will serve as input to any necessary revisions to the framework.

3.4 Risk Management Styles According to Different Regulatory Styles of Risk Governance

Risk management has to cope with risks, which have been identified as simple or as problematic either due to complexity, to high unresolved uncertainty or due to ambiguity. Risk management strategies have to be adopted to these types of risk problems. The specific management strategy, the appropriate instruments and the degree of stakeholder involvement have to be chosen according to these criteria. But additionally, the governance process depends from the specific political culture that predominates in the corresponding region or, what is less obvious, in a specific risk domain (IRGC 2005: 61).

As far as the scientific input is concerned, a tendency to a development into the direction of an identical or at least similar language toward risk governance can be observed (Rohrmann and Renn 2000; Löfstedt and Vogel 2001). But additionally to scientific input, risk management is influenced by other components like systematic knowledge, legally prescribed procedures and social values (IRGC 2005: 62). This effects the outcomes of risk management. It may, for example, influence inclusion or selection rules, interpretative frames, or the handling of evidence.

Consequently, cultural diversity and the historical development of the political culture in the different countries have led to varying policy-making styles. They have, for example, influenced and shaped the relevant institutions. A number of common approaches for specific settings has been identified and is illustrated in Table 1.3 (IRGC 2005: 63).

Giving consideration to political and regulatory culture allows reference to how different countries or organizations within countries handle and regulate risks. Although management styles may become more homogeneous (particularly in industry), there is no common, global methodology in risk handling. The same risk may be processed differently and be subject to a different management decision depending on such factors as national culture, political tradition, and social norms. Accordingly, in some environments, a top-down ("vertical governance") approach will dominate; in others, an inclusive "horizontal governance" will be the norm.

4 Stakeholder and Public Involvement

4.1 Stakeholder Involvement and the Synthesis of Conflicting Perspectives

The risk governance process, as it has been described above, implies decision-making processes, which affect various groups of actors. On a general level, there is the distinction between the risk producers on the one hand, and those who are exposed to the risks on the other hand. It is obvious, that between these two groups, conflicting interests are to be expected. Both groups can be further divided into subgroups with

Table 1.3 Characteristics of Policy-making styles (*source*: IRGC 2005: 63)

Style	Characteristics	Risk management
1. *Adversarial approach*	• Open to professional and public scrutiny • Need for scientific justification of policy selection • Precise procedural rules • Oriented toward producing informed decisions by plural actors	• Main emphasis on mutual agreements on scientific evidence and pragmatic knowledge • Integration of adversarial positions through formal rules (due process) • Little emphasis on personal judgment and reflection on the side of the risk managers • Stakeholder involvement essential for reaching communication objectives
2. *Fiduciary approach (patronage)*	• Closed circle of "patrons" • No public control, but public input • Hardly any procedural rules • Oriented toward producing faith in the system	• Main emphasis on enlightenment and background knowledge through experts • Strong reliance on institutional in-house "expertise" • Emphasis on demonstrating trustworthiness • Communication focused on institutional performance and "good record"
3. *Consensual approach*	• Open to members of the "club" • Negotiations behind closed doors • Flexible procedural rules • Oriented toward producing solidarity with the club	• Reputation most important attribute • Strong reliance on key social actors (also nonscientific experts) • Emphasis on demonstrating social consensus • Communication focused on support by key actors
4. *Corporatist approach*	• Open to interest groups and experts • Limited public control, but high visibility • Strict procedural rules outside of negotiating table • Oriented toward sustaining trust to the decision-making body	• Main emphasis on expert judgment and demonstrating political prudence • Strong reliance on impartiality of risk information and evaluation • Integration by bargaining within scientifically determined limits • Communication focused on fair representation of major societal interests

distinct interests of their own, the so-called stakeholder. They are defined here "as socially organized groups that are or will be affected by the outcome of the event or the activity from which the risk originates and/or by the risk management options taken to counter the risk" (IRGC 2005: 49). In general risk issues affect the four main stakeholders in society. These are *political*, *business*, *scientific,* and *civil society*

representatives (as far as they are socially organized). Additionally, other groups that play a role in the risk governance process, can be defined: the *media*, *cultural elites* and *opinion leaders*, and the *general public*, either in their role as nonorganized *affected* public, or as the nonorganized *observing* public (ibid.).

As governance aims at reaching acceptance of the outcomes of the decision-making process, the interests of all these different actors have to be met. At the same time, however, the number of options and the procedures how they are selected have to be restricted, as time and effort of the participants of the governance process have to be regarded as spare resources and therefore treated with care. Consequently, an inclusive risk governance process, as it is required when facing new risks, can be characterized by *inclusion* of all affected parties on one hand, and *closure* concerning the selection of possible options and the procedures that generate them, on the other hand.

Inclusion describes the question of what and whom to include into the governance process, not only into the decision making, but into the whole process from framing the problem, generating options, and evaluating them to coming to a joint conclusion. This goal presupposes that, at least, major attempts have been made to meet the following conditions (IRGC 2005: 49f.; Trustnet 1999; Webler 1999; Wynne 2002):

- Representatives of all four major actor groups have been involved (if appropriate)
- All actors have been empowered to participate actively and constructively in the discourse
- The framing of the risk problem (or the issue) has been co-designed in a dialog with the different groups
- A common understanding of the magnitude of the risk and the potential risk management options has been generated and a plurality of options that represent the different interests and values of all involved parties have been included
- Major efforts have been made to conduct a forum for decision making that provides equal and fair opportunities for all parties to voice their opinion and to express their preferences
- There exists a clear connection between the participatory bodies of decision making and the political implementation level

Two goals can be reached with the compliance of these requirements: the so-included actors have the chance to develop faith in their own competences and they start to trust each other and to have confidence in the process of risk management.

While these aims can be reached in most cases where risks are able to be governed on a local level, where the different parties are familiar with each other and with the risk issue in question, it is much more difficult to reach these objectives for risks that concern actors on a national or global level, and where the risk is characterized by high complexity or where the effects are, for example, not directly visible or not easily referred to the corresponding risk agent. Sometimes, one party may have an advantage from performing acts of sabotage to the process, because their interests profit from leaving the existing risk management strategies into place.

Consequently, inclusive governance processes need to be thoroughly monitored and evaluated, to prevent such strategic deconstructions of the process.

Closure, on the other hand, is needed to restrict the selection of management options, to guarantee an efficient use of resources, be it financial or the use of time and effort of the participants in the governance process. Closure concerns the part of generating and selecting risk management options, more specifically: Which options are selected for further consideration, and which options are rejected. Closure therefore concerns the product of the deliberation process. It describes the rules of when and how to close a debate, and what level of agreement is to be reached. The quality of the closure process has to meet the following requirements (IRGC 2005: 50; Webler 1995; Widson and Willis 2004):

- Have all arguments been properly treated? Have all truth claims been fairly and accurately tested against commonly agreed standards of validation?
- Has all the relevant evidence, in accordance with the actual state-of-the-art knowledge, been collected and processed?
- Was systematic, experimental, and practical knowledge and expertise adequately included and processed?
- Were all interests and values considered, and was there a major effort to come up with fair and balanced solutions?
- Were all normative judgments made explicit and thoroughly explained? Were normative statements derived from accepted ethical principles or legally prescribed norms?
- Were all efforts undertaken to preserve plurality of lifestyle and individual freedom and to restrict the realm of binding decisions to those areas in which binding rules and norms are essential and necessary to produce the outcome?

If these requirements are met, there is at least a real chance to be able to achieve consensus and a better acceptance of the outcomes of the needed risk assessment options, when facing risk problems with high complexity, uncertainty, and ambiguity. The success of the stakeholder involvement strongly depends on the quality of the process. Consequently, this process has to be specifically designed for the context and characteristics of the corresponding risk. The balance of inclusion and closure is one of the crucial tasks of risk governance.

4.2 Coping with the Plurality of Knowledge and Values

The different social groups enter the governance process with very different preconditions regarding their knowledge about the risk characteristics. In the first chapter it has been set out, that the perception of risks varies greatly among different actor groups. Even among different scientific disciplines, the concepts of risk are highly variable. All the varying types of knowledge and the existing plurality of values have to be taken into consideration, if acceptable outcomes of the risk

governance process are aspired. The only possibility to include all these plural knowledge bases and values, are to embed procedures for participation into the governance process.

Depending on the nature of the risk, and the available information about the risk, different levels of public and stakeholder participation seem appropriate to guarantee the quality of the process, if time and effort of the participating groups are regarded as spare resources. In the context of the described risk governance framework, suggestions for the participation of the public and stakeholders have been made depending on the nature of the risk (IRGC 2005: 51f.). Four types of "*discourses*," describing the extent of participation, have been suggested.

In the case of *simple risk problems* with obvious consequences, low remaining uncertainties and no controversial values implied, like many voluntary risks, for example, smoking, it seems not necessary and even inefficient to involve all potentially affected parties to the process of decision making. An "*instrumental discourse*" is proposed to be the adequate strategy to deal with these risks. In this first type of discourse, agency staff, directly affected groups (like product or activity providers and immediately exposed individuals) and enforcement personnel are the relevant actors. It can be expected that the interest of the public into the regulation of these types of risk is very low. However, regular monitoring of the outcomes is important, as the risk might turn out to be more complex, uncertain or ambiguous than characterized by the original assessment.

In case of *complex risk problems* another discourse is needed. An example for complexity-based risk problems are the so-called cocktail effects of combined pesticide residues in food. While the effects of single pesticides are more or less scientifically proven, the cause and effect chains of multiple exposure of different pesticides via multiple exposure routes are highly complex. As complexity is a problem of insufficient knowledge about the coherences of the risk characteristics, which is in itself not solvable, it is more important to produce transparency over the subjective judgments and about the inclusion of knowledge elements, in order to find the best estimates for characterizing the risks under consideration. This "*epistemological discourse*" aims at bringing together the knowledge from the agency staff of different scientific disciplines and other experts from academia, government, industry, or civil society. The principle of inclusion is bringing new or additional knowledge into the process and aims at resolving cognitive conflicts. Appropriate instruments of this discourse are Delphi, Group Delphi, or consensus workshops (Webler et al. 1991; Gregory et al. 2001).

In the case of risk problems due to *high unresolved uncertainty*, the challenges are even higher. The problem here is: How can one judge the severity of a situation when the potential damage and its probability are unknown or highly uncertain? This dilemma concerns the characterization of the risk as well as the evaluation and the design of options for the reduction of the risk. Natural disasters like tsunamis, floods, or earthquakes are, for example, characterized by high uncertainty. In this case, it is no longer sufficient to include experts into the discourse, but policy makers and the main stakeholders should additionally be included, to find

consensus on the extra margin of safety in which they would be willing to invest in order to avoid potentially – but uncertain – catastrophic consequences. This type is called "*reflective discourse*," because it is based on a collective reflection about balancing the possibilities for over- and under-protection. For this type of discourse, round tables, open space forums, negotiated rule-making exercises, mediation or mixed advisory committees are suggested (Amy 1983; Perritt 1986; Rowe and Frewer 2000).

If risk problems are due to *high ambiguity*, the most inclusive strategy is required, as not only the directly affected groups have something to contribute to the debate, but also the indirectly affected groups. If, for example, decisions have to be taken concerning the use or the ban of genetically modified foods and their production, the problem if going far beyond the mere risk problem, but touches also principal values and ethical questions, and questions of lifestyle or future visions. A "*participative discourse*" has to be organized, where competing arguments, beliefs, and values can be openly discussed. This discourse affects the very early step of risk framing and of risk evaluation. The aim of this type of discourse is to resolve conflicting expectations through identifying common values, defining options to allow people to live their own visions of a "good life," to find equitable and just distributions rules for common resources, and to activate institutional means for reaching common welfare so that all can profit from the collective benefits. Means for leading this normative discourse are, for example, citizen panels, citizen juries, consensus conferences, ombudspersons, citizen advisory commissions, etc. (Dienel 1989; Fiorino 1990; Durant and Joss 1995; Armour 1995; Applegate 1998).

In this typology of discourses, it is presupposed, that the categorization of risks into simple, complex, uncertain, and ambiguous is uncontested. But, very often, this turns out to be complicated. Who decides whether a risk issue can be categorized as simple, complex, uncertain, or ambiguous? To resolve this question, a *meta-discourse* is needed, where the decision is taken, where a specific risk is located and in consequence, to which route it is allocated. This discourse is called "*design discourse*," and is meant to provide stakeholder involvement at this more general level. Allocating the risks to one of the four routes has to be done before assessment starts, but as knowledge and information may change during the governance process, it may be necessary to reorder the risk. A means to carry out this task can be a screening board that should consist of members of the risk and concern assessment team, risk managers, and key stakeholders. Figure 1.6 provides an overview of the described discourses depending on the risk characteristics and the actors included into these discourses. Additionally, it sets out the type of conflict produced through the plurality of knowledge and values and the required remedy to deal with the corresponding risk.

Of course, this scheme is a simplification of real risk problems and is meant to provide an idealized overview for the different requirements related to different risk problems. Under real conditions, risks and their conditions often turn out to be more interdependent among each other and the required measures more depending from unique contexts. This is why actually, the effectiveness of these types of stakeholder involvement are tested in "reality" in a series of very differing risk fields.

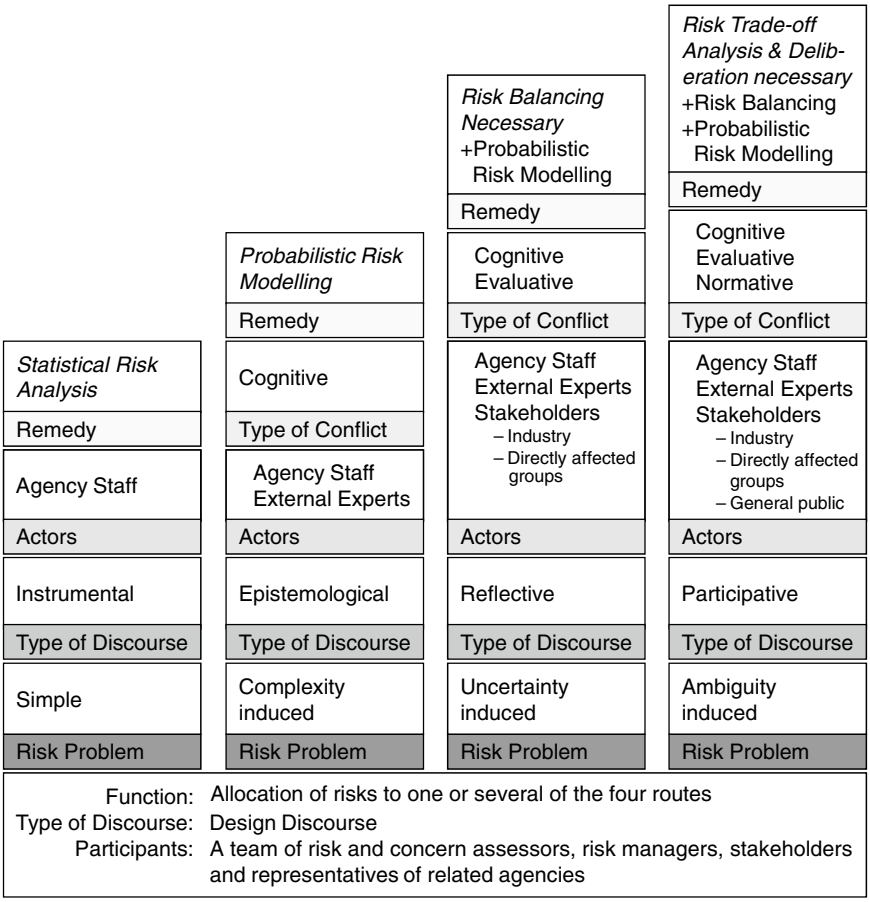

Fig. 1.6 The risk management escalator and stakeholder involvement (IRGC 2005, adapted and modified, p. 280)

4.3 International Challenges When Dealing with Transboundary Risks

It has been foreshadowed in the last paragraph that those responsible for the governance of risks and those affected by risks do normally not face such ideal structures, where they can easily decide which governance routes and measures to take to deal with the problems of complexity, uncertainty, and ambiguity. Often, the risks individuals, companies, regions or countries have to face do not depend on their own choices. Additionally, they often do not only face one risk at a time. For example consumer groups are facing an in-depth discussion about genetically modified food, and a new issue like nanotechnology arises where the public awareness of the risk is at early stage. As a consequence, they have to find strategies

to deal with a series of interrelated risks that are often ill-defined or outside of their control (IRGC 2005: 48).

Globalization has contributed to the fact, that *interdependencies* in many cases do not require spatial proximity. For example, diseases through aggressive viruses like the avian flu can easily spread to other regions through single contacts. Another example from the thematic area of the decrease of biodiversity, is the involuntary spread of a risk of invasive species (be it animals or plants). On the one hand, expensive measures are taken to preserve the habitats of endangered species in order to protect them from extinction. But then, on the other hand, it can occur that foreign species are introduced involuntarily via global transports, etc. This species then sometimes displaces the ones that have been tried to preserve. This has, for example, happened in the US Great Lakes region with some species of fish through the invasion of zebra mussels and other species through cargo ships.[8]

These are only two examples for the various challenges when facing the interdependencies produced through transboundary risks. The level of interdependencies adheres to another problem that is typical for global systemic risks: The "goods" (or, as described in this chapter, "what humans value") that are endangered through the risk are often *common goods*, which means that no one can be excluded from its use or profit. Public health is a nonmaterial example for such a common good. The more interdependencies there are within a particular risk situation the smaller is the probability that risk reduction measures are taken. A characteristic of common goods is, that everyone can profit from their use, even if one does not invest in their maintenance. From an individual point of view, a rational actor (be it an individual, a company, a country or any other entity) would act as "*free riders*," i.e., benefit from the use of the good but not contribute to its maintenance. In terms of risk problems, such an actor would not invest in risk reduction measures, while he would profit from the risk reduction measures conducted by other actors. From a collective point of view, each actor would have been better off had all actors invested in the maintenance of the good. The more interdependencies there are, the less an individual actor feels accountable for investing in risk reduction measures.[9] Weak links between the affected parties contribute to this suboptimal behavior. Anthropogenic climate change through the burning of fossil fuels and the production of greenhouse gases is a classical example, but the depletion of biodiversity can also be understood as a free-rider effect of a global dimension.

The global nature of systemic risks and the high level of interdependencies ask for a balanced strategy of consensual, coercive, and incentive-based measures. *Consensual* measures are, for example, international agreements, international standards or gentleman's agreements. *Coercive* measures can be government's regulations and examples for *incentive-based* measures are emission certificates.

[8]Cf. for example http://www.greatlakesforever.org/html/trouble/species.html.

[9]A global overview over game theory and the problem of common goods would exceed the scope of this chapter. For a more formal theoretic treatment of the problem cf. Kunreuther and Heal (2003); for the free-rider problematic cf. Cornes and Sandler (1996). The "tragedy of the commons" is classically described in Hardin (1968).

Which kinds of measures are appropriate depends on the degree of decentralization, the political culture, and the associated regulatory styles.

One possible solution for the management of the described effects due to interdependencies and the resulting individual rationality and losses in accountability due to weak links might be *public private partnerships (PPP)* (IRGC 2005: 48). PPPs can be defined as an agreement or co-operation between the public and the private sector and is often understood as a variation of privatization. It is very often applied for the development and maintenance of infrastructure measures. PPPs seem to be particularly adequate if the risks to be dealt with are associated with competing interpretations (ambiguities) as to what type of co-operation is required between different scientific communities and risk management agencies in order to be able to deal with various types of knowledge and competing values.

A possible way to structure such partnerships is to have government standards and regulations coupled with third party inspections and insurance in order to enforce these measures. It is thus a management-based regulatory strategy that will not only encourage the addressees of the regulation, often the corporate sector, to reduce their risks from, for example, accidents and disasters. It forces the actors of the private sector to do their own planning as to how they can meet the given standards or regulations and so shift the decision making from the government regulatory authority to the private company. This might be of advantage as the companies can choose the means and measures that most fit for the purpose within their specific environmental context, and may lead to a optimized allocation of resources compared to more top-down forms of regulation.

In the case of risks resulting from large plants (be it power plants or chemical sites, etc.), for example, the combination of third party inspections together with private insurance can turn out to be a powerful combination of public oversight and market mechanisms and can thus convince many companies of the advantages of implementing the necessary measures to make their plants safer and encourage the remaining ones to comply with the regulation to avoid being caught and prosecuted.

Consequently, PPPs are an effective means for the internalization of external effects, i.e., the problem of weak links produced through a high level of interdependencies are strengthened by accounting responsibility for the consequences of risk-producing actions to single actors.

5 Premises for Successful Risk Governance

5.1 Organizational Capacity to Deal with Risks

In Chap. 2, a short overview over the different phases and aspects of risk governance and their interrelations has been given. This chapter aims for answering the question which specific steps are needed to handle systemic risks. In Chap. 3 some core challenges, like varying values and cultural settings as well as interdependencies, for the governance process have been set out. But one important question has been

left open so far: Do the governing actors have the capability to deal with systemic risks as proposed above? If so, what are the prerequisites to fulfill their proposed roles? How has the interplay between the different actors to be designed?

It is certainly idealistic to assume that societies, when they face new and emerging risks, have developed the institutional and organizational capacity that is needed to perform the tasks described in the governance framework. The realities of the political context can be exemplified for the very first step in the governance cycle, the process of risk framing (IRGC 2005: 58f.): Bringing specific risk issues on the political agenda and consequently to the media as well, is a common means to wield power or to collect votes during election campaigns. In this manner, it influences the governance process from the beginning. Public dissent due to varying risk perceptions or media hypes in the context of a certain risk are often used to push individual interests (of political parties, for example) (Shubik 1991). Such influences together with the potential of mobilization of the wider public, can lead into the playing up of some risks while other risks might be concealed or downplayed due to individual motivations.

As a consequence, many political systems have reacted by establishing independent risk assessment and sometimes management agencies, in order to prevent such exertions of influence. The establishment of numerous national and the European food standards agencies is the most cited example for the institutional restructuring of risk governance. In the mid-1990s, when the transmission of the cattle disease Bovine Spongiform Encephalopathy (BSE) to man was discovered in the UK, in the shape of a new variant of the Creutzfeldt–Jakob disease (vCJD), a policy of reassurance and inadequate scientific attention led to the biggest food scandal in the twentieth century, as measured its consequences: "no debate inside the European Union (EU) was more influential to everyday life than BSE; no other food scandal had a bigger impact on the public discourse of eating habits or regarding questioning conventional farming practices" (Dressel 2002: 60). This scandal led to several institutional changes within the EU and was the motor of the establishment of the European Food Standards Agency (EFSA) and several national food standards agencies or independent risk assessment agencies, like the Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung, BfR) in Germany, and the Food Standards Agency (FSA) in the UK (Dressel 2002; Dreyer et al. 2006).

5.2 Prerequisites of Good Governance

What lessons can be leant from this and other failings in the governance of risks? First, it is important to make sure that the governance process is based on the best available knowledge and practice. Second, institutions and organizations have to be strengthened so that they are empowered and have the resources to perform their tasks in the most possible effective, efficient, and fair manner (IRGC 2005: 58).[10]

[10]Cf. also the next chapter on the prerequisites of good governance.

To make sure, that the responsible institutions and organizations are able to act in that way, three analytic categories can be used to assess institutional capacity (ibid. Paquet 2001):

- The knowledge bases and the structural conditions for effective risk management build the *assets* of the governance institutions. This category includes *rules, norms and regulations*, available *resources* (financial as well as infrastructure, but also access to and processing of information), *competencies and knowledge* (in terms of education and training), and the level of *organizational integration* of the aforementioned types. Organizational integration can be understood as the prerequisite for the effective use of the other types and in a mathematical sense as a multiplying factor.
- *Skills* describe the quality of the institutional and human performance in exploring, anticipating and dealing with existing and emerging risks, here understood as often unpredictable external conditions. They should enable political, economic, and civic actors to use effectively, and enhance the impact of, the described assets. Skills include *flexibility* (i.e., openness to make use of new ways in dynamic situations), *vision* (making use of new methods that are normally used in other contexts, e.g., foresight, scenario planning, etc.) and *directivity* (expand the risk context into a reframing of the whole perception if the way of life and thus driving change that impacts on the outside world instead of restricting oneself to the prevention or mitigation of external effects).
- The framework, in which assets and skills can be exploited for the development and exploitation of successful risk governance policies is built by the last category, the *capabilities*. Consequently, they build the structure and include *relations* (manage the inclusion through linking users and sources of knowledge; those carrying the authority and those bearing the risk), *networks* (constitute close co-operative structures between self-organization and hierarchy between and among groups of principally equal actors) and *regimes* (establish the rules, the frameworks and are formed through the two types above).

As a prerequisite for the building and functioning of these three categories, *risk education and training* have to be seen as fundamental resources for making use of the "human capital" in order to handle global, emerging and systemic risks. Such education and training measures should aim at a broad and multidisciplinary knowledge base instead of specialized in-depth knowledge, to be able to deal with the challenges of interdependencies, complexity, uncertainty and ambiguities. The often predominating technical focus in scientific education therefore needs to be expanded to health, safety, and environmental aspects, i.e., enabling to actors to take up a "bird's eye perspective" (IRGC 2005: 61).

5.3 Principles of the Governance of Systemic Risks

The term risk governance, as it has been set out in this chapter, denotes not only the governmental actions taken toward the mitigation or prevention of risk consequences,

but the whole interplay of all relevant actors – and all actions that are undertaken to handle risks. The integration of so many different views and interests, values and norms creates a very complex structure, which is difficult to comprehend for the public and great parts of the affected groups as well. In order to ensure the functioning of such a complex and interdependent formation, where direct links between the different parties and tasks are often absent or too weak due to international or global dimensions of the risk problems, some general principles have to be set up to support a governance process with outcomes that are accepted or at least tolerated.

On the European level, the Commission has carried out this task in order to strengthen its democratic structures while working on solutions to the major problems confronting European societies, like demographic changes, health risks like smoking, food safety scares, crime, and unemployment. Anyway, interest as well as confidence and trust into the work of the European institutions have decreased during the last years. At the same time, the Europeans expect the governments and the European Union to take the lead in reducing risks which emerge in the context of globalization, growth of the population, and the economic development. This is particularly true for the handling of international systemic risks. For the improvement of people's trust and confidence into the performance of the European institutions, the European Commission has worked out a White paper (European Commission 2001), in which a number of principles of good governance are described, which should help them to carry out the task needed for the governance of, for example, systemic risks (ibid. 10f.):

- *Openness*: The institutions responsible for the assessment and management of risks should work in an open and transparent manner. This means they should actively communicate to the affected and interested parties and the stakeholders about their tasks, lay open their structures and what and how decisions are taken. This includes the use of a language that is accessible and understandable for the general public, in order to improve the confidence in complex structures and decisions.
- *Participation*: Inclusion of stakeholders and the affected and interested public is set as a crucial task of risk governance. Acceptance in decisions about the handling of risks, and confidence in the outcomes of governance processes depend on the inclusion of the interested parties throughout the whole governance chain.
- *Accountability*: Roles and responsibilities of the different actors in the governance process have to be made clear. From a European point of view, it has to be made clear, which institutions carry out which tasks and where they have responsibility on national and international level. Additionally, the specific tasks of the involved parties in the different stages of the risk governance process have to be made clear.
- *Effectiveness*: Risk governance policies have to be effective and timely, have to deliver what is needed on the basis of clear objectives, an evaluation of future

impact and, where available, of past experience. Time and effort have to be treated as spare resources. Measures have to follow the principles of proportionality and appropriateness.

- *Coherence*: Policies and actions have to be coherent and easily understood. As the range and complexity of institutions is constantly growing, interdependencies between different sectors are increasing, regional and local authorities are increasingly involved in European policies, etc. These tendencies require political leadership, including a strong responsibility from institutional side, to guarantee consistent procedures within this complexity.
- *Proportionality and subsidiarity*: Throughout the whole governance process, the choice of the level at which the action is taken (from European to local level) and the selection of the instruments used must be considered in the proportion to the objectives pursued.

The compliance with these principles poses high challenges to those who design and those who carry out the different steps of the risk governance process. It is possible that the adherence to one principle complicates the adherence to another. So, for example, more inclusion and participation might be seen as ineffective by some actors. So the main challenge is to find a balance, i.e., to decide which level of participation is really necessary, which decision have to be taken on European level, and which on national or regional level, and who decides if the chosen measures are proportionate to the achievable objectives.

6 Chapter Summary

This first introductory chapter was meant to give the reader an overview over current risk science, crucial elements of risk governance and an impression of where the new developments and approaches are leading us when thinking about risks and how to deal with them.

It was suggested to look at risk governance not as a linear process of risk analysis, risk management, and risk communication of ready-made results, as taught us the traditional approach of risk analysis, but as a circular process, including public risk perceptions, values, and concerns. A framework, developed by the IRGC, has been presented which takes into account these "human factors" of risk, and which understands risk governance as a cycle with the possibility of feedback loops and proposes a set of specific discourses for stakeholder involvement according to the risk characteristics (simple, complex, uncertain, or ambiguous).

This chapter should have equipped the reader with the needed knowledge of approaches, frameworks, models, and tendencies to be able to better understand the commonalities and differences of the following chapters, dealing with such different risk fields as genetically modified foods, food risks from dioxins and the loss of biodiversity. So, when reading these more case study type chapters, keep the presented analytic structure in mind.

Glossary

ALARP – principle: A term often used in the milieu of safety-critical and high-integrity systems. The ALARP principle says that the residual risk shall be "*A*s *L*ow *A*s *R*easonably *P*racticable."

Ambiguity: Giving rise to several meaningful and legitimate interpretations of accepted risk assessment results.

Closure: Describes the restriction of the selection of management options, to guarantee an efficient use of resources, be it financial or the use of time and effort of the participants in the governance process.

Complexity: Refers to the difficulty of identifying and quantifying causal links between a multitude of potential causal agents and specific observed effects.

Governance: Describes the structures and processes of collective decision making, including governmental as well as nongovernmental actors.

Hazard: A source of potential harm or a situation with the potential to cause loss.

Inclusion: Describes the question of what and whom to include into the governance process, not only into the decision making, but into the whole process from framing the problem, generating options and evaluating them to coming to a joint conclusion.

Persistence: Describes the timescale, how long a damage lasts.

Risk: An uncertain consequence of an event or an activity with respect to something that humans value. The judgment, if these consequences are seen as positive or negative depends on the values that people associate with them.

Risk analysis: Used by a number of organizations dealing with risk as a collective term for risk assessment, risk management, and risk communication.

Risk assessment: The task of identifying and exploring, preferably in quantified terms, intensities and likelihood of the (negative) consequences of a risk.

Risk governance: Includes totality of actors, rules, conventions, processes, and mechanisms concerned with how risk information is collected, analyzed, and communicated and how management decisions are taken.

Risk management: The creation and evaluation of options for initiating or changing human activities or structures with the objective of increasing the net benefit of human society and preventing harm to humans and what they value.

Social amplification of risk: Describes "an overestimation or underestimation of the seriousness of a risk caused by public concern about the risk or an activity contributing to the risk" (IRGC 2005: 81).

Systemic risks: Risks that affect in complete the various systems on which society depends, i.e., health, transport, energy, telecommunications, etc. These risks are at the

crossroads between natural events (which can be partially altered and increased by human actions), economic, social, and technological developments and policy-driven actions.

Ubiquity: Geographical dispersion of a damage.

Uncertainty: A state of knowledge in which, although the factors influencing the issues are identified, the likelihood of any harmful effect or these effects themselves, cannot be precisely described.

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