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Overcoming failure in infrastructure risk governance implementation: large dams journey

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There is ample recognition of the risk inherent in our very existence and modes of social organization, with a reasonable expectation that implementing risk governance will result in enhanced resilience as a society. Despite this, risk governance is not a mainstream approach in the infrastructure sector, regardless of the increasing number of peer-reviewed published conceptualizations, mature procedures to support its application, or public calls to cope with systemic risks in our modern societies. This paper aims to offer a different view on the issue of risk governance, with focus in the analysis of the root causes of its relatively low degree of implementation in the infrastructure sector. We later analyze the impact of such essential causes, which we have grouped and labeled as the ontology, the concerns, the anathemas, and the forgotten, in the specific field of large dams. Finally, we describe the journey toward risk governance in the specific field of large dams, thus supporting the ultimate objective of this paper to facilitate an evidence-based approach to successful risk governance implementation within and outside the dam sector.

Keywords: governance; risk; systemic; infrastructure; dams

1. Infrastructure risk governance status and needs

Johnston and Hansen (2011) define governance as 'the collection of technologies, people, policies, practices, resources, social norms, and information that interact to support governing activities' and emphasize that the main challenge consists in how to design incentives and rules to address the enthusiasm and capabilities of those governed. For them, governance is broader than government and provides a second definition of governance in the same work as 'the interaction of processes, information, rules, structures and norms that guide behavior toward stated objectives that impact collection of people.' Consequently, they acknowledge as some of the main attributes of governance the scarcity of resources, the coordination of diverse participants and stakeholders, the processes of decision-making, and the resolution of conflicts.

Wilke (2007) sustained that the meaningful question is not whether there should be less or more government, escaping from the misleading discussion about big government versus small government, but rather to focus on how to make different forms of government and governance more intelligent. In this context, he defines

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'smart governance' as 'an abbreviation or ensemble of principles, factors, and capacities that constitute a form of governance able to cope with the conditions and exigencies of the knowledge society.' These exigencies of smart governance would be, in his view, linked to the issues of complexity, uncertainty, competence, and resilience. Wilke (2007) also affirms that the creation of new knowledge becomes paramount with the ascendance of innovation into a pole position in the global race for competitiveness, making it clear that, even when new knowledge exists, it has to fight for acceptance against resistance and a host of difficulties. As an overarching attribute, smarter forms of governance would be those better equipped to adopt and encourage innovation than others.

Risks have become a clear and serious topic of governance theory and practice. Aven and Renn (2010b), among others, have identified some of the characteristics of risk in the modern world and highlighted the fact that, while the technological development of the last decades has led to a reduction of individual risks, the vulnerability of many societies or groups in society has increased. In this context, they use the term 'emerging systemic risks' as risks 'that affect the systems on which the society depends: health, transport, environment, telecommunications, etc.' In fact, the issue of systemic risks and the required principles of governance to address them had been the object of a European Commission White Paper (2001), namely: openness, participation, accountability, effectiveness, coherence, proportionality, and subsidiarity.

In a more comprehensive definition, according to the International Risk Governance Council (2005) 'risk governance includes the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analyzed and communicated and management decisions are taken.' Later, Renn (2008) summarized the concept of risk governance as the 'translation of the substance and core principles of governance to the context of risk and risk-related decision-making,' a concept that has typically been decomposed into risk assessment, risk management, and risk communication. It is also worth mentioning the contribution of recent standards and frameworks, such as the ISO 31000:2009 (ISO 2009), standard on risk management to provide the conceptual basis to identify, assess, and manage risks – all activities in the core of risk governance.

Having defined governance, smart governance, systemic risks, and risk governance in a way that logically structures how these concepts relate to each other, we found that there is a lack of standards and procedures to analyze the effectiveness of risk governance. The Inter-American Bank of Development (BID 2014) has very recently published an index on governance and public polices as applied to disaster risk management in which they illustrate through case histories the scarcity of smart governance implementation. This certainly applies to key sectors linked to systemic risks such as large civil infrastructures.

In the words of van Asselt and Renn (2011), 'paradigms and reforms do not shift in the abstract, but shift in practice,' or quoting Boholm, Corvellec, and Karlsson (2012) 'risk governance is not a framework on which you built; it is something you learn how to do.' Consequently, bridging theory and practice remains a scientific and practical challenge for most.

There is indeed extensive work and a significant number of publications on the issue of risk and risk management, most of them focused on Enterprise Risk Management (Zhao, Hwang, and Low 2015), dealing with systemic risks, mainly from the financial point of view at very different scales for a broad variety of sectors. However, even among those corporations that have implemented different types of risk governance, as reported by Marks (2014), very few companies see their programs supporting the development and execution of strategy, and a significant percentage consider them inadequate.

However, systemic risks in our modern societies are not only driven by purely financial issues. Among others, earthquakes, floods, volcanic activities, tsunamis, wildfires, or terrorism are active hazards that can damage infrastructure systems and/or interrupt benefits they deliver. Such failures can range from merely annoying to decidedly catastrophic, with infrastructure interdependency an undeniable potential cause of failure in and of itself.

More specifically, the work by Little (2012) for the International Risk Governance Council (IRGC) is particularly relevant for the case of infrastructure-driven risk. He analyzes the paradigmatic and iconic cases of the Northeast Power Outage in 2003, the New Orleans Flood Defense System in 2005, and the Fukushima Nuclear Power Plant in 2011, under the framework of the IRGC (2010) 'factors for risk emergence.' The main conclusion highlighted by Little, after analyzing the root causes of three so different events, is that complex infrastructures systems are not inherently 'safe', no matter how well designed they are, residual risk remains. Consequently, for him, a new paradigm is needed to develop and incentivize organizational culture values and rewards actions to change the dynamics of infrastructure asset community. So far, such paradigms are providing very elusive solutions as a whole.

2. Root causes of infrastructure risk governance implementation failures

With the aim of changing the dynamics for the way systemic risks posed by large civil infrastructure are being managed, we have done an extensive literature review and informed it with our practical experience by analyzing the underlying issues or root causes preventing effective implementation of risk governance in the sector. We have grouped them in four main categories, namely the ontology, the concerns, the anathemas, and the forgotten, that are next presented.

Metaphorically, these are the obstacles in a race (Figure 1) that lasts forever: risk governance continuously matures while periodically addressing the essential issues that are in the basis of its success or failure.

Figure 1. Pictogram of root causes of failure in risk governance.

2.1. The ontology

As extensively documented by Aven (2010), the fact to be acknowledged is that there is no agreed definition of risk. As he points out, the concept of risk is mainly understood either as an expected value, a probability distribution, as uncertainty, or as an event, while the debate about the real nature of risk is still alive among risk professionals. Furthermore, Aven (2012a) extends this lack of consensus to the fields of risk analysis, risk assessment, and risk characterization (i.e. Society of Risk Analysis [SRA], founded in 1980, has not reached consensus after continued attempts). In his view, the risk field still suffers from a lack of clarity on many key scientific pillars beyond the fundamental issue of the risk itself.

Slovic (1987) argued that human beings have invented the concept of risk to help them understand and cope with the dangers and uncertainties of life. For him, dangers are real but there is no real or objective risk. Moreover, as a result, he envisions that whoever controls the definition of risk controls the risk management solution (Slovic and Weber 2002). Some years later, Aven (2012b) stated that 'the risk perspective chosen strongly influence the way risk is analyzed and hence it may have serious implications for the risk management and decision making.'

It is worth mentioning the conflicting views of Rosa (2010) and Aven and Renn (2010a), with regard to risk as social constructions versus real phenomena as well as with regard to the role of the magnitude or the probability of harm in the conception of risk. Rosa (2010) points out that the exclusion of concepts such as severity in favor of a broader definition enables us to view risks as on a continuum from desirable to undesirable. Such an approach supports risk as a way to describe why and when we take risks and if these risks are commensurate with benefits.

One more factor to consider, as stated by Aven and Renn (2010a), is that systemic risks face a number of specific problems due to the fact that they are often driven by a crisis and/or actions determined by public opinion. As such, risk governance frameworks need to consider both facts and sociocultural attributes.

In the day by day reality of many infrastructure owners and organizations, even before the ontology of risk becomes a real issue, we have faced the impact of what Funabashi and Kitazawa (2012) named the 'myth of absolute safety.' Unfortunately, the myth that 'if risk exists, it would equal zero' preclude meaningful discussions for many professionals in this field. By practice, we know that residual risk remains and it is in the understanding of this remaining risk that we make the key, safety-related decisions.

We understand that organizations must choose their own ontology to start with and then adjust their language as they learn it more thoroughly through application. Some might say that a more inclusive ontology also better fits the multiple uses that practitioners ultimately find for the risk. Conceptualization and perception of risks in these broader definitions play a fundamental role in governance by permitting risk to express the full human experience and not the negative dialog some would relegate it to.

2.2. The concerns: complexity, uncertainty, and ambiguity

When analyzing the benefits of linking risk and governance under the umbrella of risk governance, van Asselt and Renn (2011) identified the goal of providing a conceptual basis to deal with the factors of complexity, uncertainty, and ambiguity.

These factors are interrelated as complexity favors uncertainty and both favor ambiguity. They identified an urgent need to develop better approaches to understand and characterize non-simple risks or systemic risks.

Complexity refers (Renn 2008) to the difficulty of identifying and quantifying causal links between a multiple of potential candidates and specific adverse events. In the field of critical infrastructure at risk, Kröger (2008) addressed the issue of the need to extend modeling and simulation techniques in order to cope with the increasing complexity. At the same time, there is a broad acknowledgment, as referred by Ezell et al. (2010) that although no single model or methodology can meet the complexity challenge, multiple approaches, perhaps in combination, may help.

Wilke (2007), when analyzing smart governance systems in a very broad sense, points out that coping with uncertainty has been a topic in many disciplines from philosophy and economics to psychology and cognitive sciences. Furthermore, we can quote from him that 'all knowledge is constructed and contingent. It is, figuratively speaking, a thin layer of ice over a deep ocean filled with non-knowledge and contingent knowledge connected to contingent forms of no-knowledge. People walk on this ice, and some even dance, celebrating their splendid assets of knowledge.'

van Asselt and Vos (2008) have also defined what they call the uncertainty paradox, which is an umbrella term for situations in which uncertainty is acknowledged, but the role of science is framed as one of providing certainty. They further develop the interesting issue of uncertainty intolerance as one of the pillars of the paradox. As quoted by van Asselt and Vos (2008) from Forrester and Hanekamp (2006), under such paradox, a very high level of skepticism as to what science can deliver goes hand in hand with a very optimistic level of confidence regarding what science should be able to deliver.

Finally, Renn, Klinke, and van Asselt (2011) find that being complex and uncertain, systemic risks are also a cause of ambiguity, which refers to the existence of multiple societal values and their impact not only in characterizing risk but in the tolerability frameworks and decision-making processes. However, others (De Vries, Verhoeven, and Boeckhout 2011) vigorously argued the utility of the complex-, uncertain-, and ambiguous-based taxonomies for implementing risk governance frameworks. For them risk governance could be reformulated around the purpose to 'organize the efforts needed to translate uncertainty as far as possible into risk' and to ensure that this work gets done and who should pay for which part, allocating specific responsibilities to policy-makers, scientists, citizens, companies, etc.

From what we have experienced in the infrastructure sector, risks are commonly acknowledged, but uncertainty makes many engineering professionals uncomfortable and they many times retreat to conventional management systems to make decisions that mostly ignore risk and uncertainty. This is the uncertainty paradox at play. We also see that managers of infrastructures also deal with ambiguity, which can be individual or collective, but it reflects how their value systems influence and how they judge or bring context to risk-informed decisions. Furthermore, the relevance of value systems to risk governance comes into play with the use of Tolerable Risk Guidelines where ambiguity becomes a consideration as owners share responsibility with many stakeholders, and thus must consider the values they bring to decisions. One effective way that practitioners in risk governance deal with complexity is to align the level of detail and analytical effort with the seriousness of the question to answer. Sometimes, this requires the acceptance of simplifications.

We would certainly like to find more in practice what Wilke (2007) stated about uncertainty as an attribute of smart governance systems, which is 'neither a menace nor a weakness but should be treated instead as a normal condition of complex decision-making and governance.' The task is then, also in his words, to find 'efficient ways to cope with uncertainty without destroying uncertainty′s invigorating dynamic.'

In practice, an effective way to deal with complexity, ambiguity, and uncertainty is to consider quantitative risk results as part of a risk informed, not risk-based, decision framework.

2.3. The anathemas: quantitative analysis and tolerability frameworks

Aven (2010), in his book entitled 'Misconceptions of Risks,' highlights the risks of understanding risk, and more explicitly quantitative risk assessments expressed in a number of specific ways: as an expected value, a probability or a probability distributions, a probability distribution quantile, an uncertainty, an event, an expected disutility, an objective probability, a perception, related to negative consequences only or as objective, among other concerns. Aven (2012b) also cautions against the use of expected value by itself as risk and remarks stakeholder dissatisfaction with subjective probabilities.

Authors like Cox (2009) have deeply analyzed the issue of risk quantification. He brings together many actors that have expressed skepticism, disillusionment, distrust, and dissatisfaction with the quantitative risk analysis (QRA) paradigm while also referring to the arguments of professional risk analysts who perceive a great potential practical value. Furthermore, Cox (2009) reflects the fact that, increasingly, opponents of QRA portray it as part of the problem, rather than as a promising way to make more effective societal decisions in the presence of risk, uncertainty, and complexity.

On the other side, Ezell et al. (2010) defend the use of probabilistic risk analysis against critiques from the National Academies in USA, and even in fields such as terrorism risk, affirming: 'it highlights an opportunity for improved clarity and understanding of uncertainty when a mathematical language for capturing and expressing degree of belief – probability theory – is used.'

Krause et al. (1998) had explained how qualitative risk can fulfill a need in conjunction with quantitative estimates. Furthermore, Vlek (2010) supports that risk-analytic and precautionary-principled approaches, both highly criticized particularly in the presence of very large uncertainties for different reasons but with surprisingly parallel arguments, can be converging when both rationale are held against similar criteria and are developed as integrative and stepwise approaches. He states that the more an issue is societally important, spatially and temporally extensive, and influenced by uncertainties, the broader the risk assessment and decision procedure should be.

Aven and Renn (2010b) distinguish that, while acceptability refers to a morally satisfactory situation, the term tolerability entails that the risk should be further reduced if possible but not banned. In their view, for both acceptability and tolerability limits, society needs ethical criteria to determine the required thresholds. Furthermore, Aven and Renn (2010b) fear that once quantitative tolerability criteria are set, this need cannot be fulfilled. Abrahamsen and Aven (2012), using expected utility theory, made the case for the importance of not removing the authorities and not let the operators dictate the thresholds.

Finally, a number of authors as Black and Baldwin (2012) have recently discussed approaches and challenges for risk regulations.

In our experience, no single organization constrains themselves solely to numbers, and indeed those explicitly using numbers to inform their decisions have clear protocols and means to consider what is beyond the numbers to make decisions. We have observed situations which are not so openly and publicly outspoken when the issue gets even more anathematic: when quantitative (sometimes referred as probabilistic) risk analysis is used in combination with risk tolerance or acceptance criteria.

We have seen that traditional engineering standards and decision frameworks – such as compliance with design standards – is at its fundamental basis a judgment as to what is tolerable and acceptable to society. The same can be said for the establishment of standard deviations on material properties, the factors of safety against different failures, the frequency schedule for certain maintenance activities, emergency action plans, and many other aspects of infrastructure risk management. Collectively, these measures describe the reasonable actions a responsible owner should take given a risk. This is nothing less than what the tolerability of risk framework seeks to accomplish. Such frameworks, whether traditional or with tolerable risk, balance the need for safety (making systems reliable enough to assure safety) with the cost and effectiveness of safety actions.

With regard to the role of regulation linked to risk and tolerability frameworks, we see it as a permanent fear for some, aspiration for others, and very anathematic for different industries and sectors. On one hand, many claim for a need for clear regulations and, on the other, many in practice lobby against comprehensive and meaningful regulations, depending mainly on objective and subjective approaches to the issue of liability, corporate, or individual.

As a concluding remark, in our view, the discussion on the quantitative, tolerability, and regulatory issues has been unnecessarily polarized by a plethora of language misunderstandings and pretentious statements, and the results are too many times paralyzing the overall process of building risk governance. As a matter of fact, we envision risk governance practice as the solution to it, as a way to rule out anathematic issues of our conversations and focus on gaining comfortableness with risk concepts: what it is, how it is defined, and what place risk assessment has, and this can only be done by doing it.

2.4. The forgotten: people, communication, and decisions

Wilke (2007) alerts about the fact that new models and modes of governance do not come naturally and they need strategic investments in building capacities and competencies needed for governing complex and knowledge-intensive systems.

van Asselt and Renn (2011) remark that effective mutual communication is one of the key challenges in risk governance, central to the whole endeavor, at the core of any successful risk governance activity and with the potential, negatively framed, to destruct it. In any case, communication is a very broad aspect of governance, as other suggested risk communications guidelines (Löfstedt 2010) have tried to embrace.

Concerning this point, Aven and Renn (2010b) have alerted on the need to find a balance on how much participation is necessary and proportionate to the achievable objectives, as well as remarked on the interconnected nature of risk communication and trust. De Vries, Verhoeven, and Boeckhout (2011) report how, increasingly, assertive citizens do not believe in consensus reached in closed board meetings. We can find reported examples (Löfstedt 2010) where a consensual type of regulation, as well as the relatively high level of public trust in science and government agencies, could explain the willingness of the public to participate in risk governance (Boholm, Corvellec, and Karlsson 2012).

Furthermore, Boholm, Corvellec, and Karlsson (2012) have shown that institutional dynamics provide insights to understand how specific organizational arrangements shape specific approaches to risk governance. They put the focus on the rationale of organizational governance, as something that it is embedded in the intricacies of organizational practices, rather than the rationale of risk governance regimes, which are not necessarily seen as an activity in its own right.

For us, decisions are the most tangible product of governing activities, and decisions require engaged, thinking people. The fundamental role of the organization personnel (participation, capacity building, etc.), the challenge of communication (internally and externally to people and communities), and the imperative necessity of making better decisions are consequently, in our view, the forgotten. Nevertheless, we have found that when building risk governance, the focus of public debate has been very different.

Specifically when dealing with systemic risks, where public safety is a key decision metric, the market of risk governance is not driven solely or primarily by the economy, but by the larger community and people which includes the economy. The recognition of the role society has to play in decisions and the relationship between risk and these communities is what makes risk governance real and effective.

In summary, people, communication, and decisions are key factors, or indeed the key factors, in the sense that they are constituent parts of any organization. Furthermore, we have seen that in practice there is no form of risk governance if it is not embedded in the organizational governance.

3. The journey of the large dams sector toward risk governance

3.1. Introduction

Large dams make a good example of risk governance because they often exhibit systemic risk within complex systems of civil infrastructures where the uncertainty is large. More specifically, the sector of 'dam safety' encompasses a broad range of knowledge, industrial applications, professional practices, and investigative activities that are present in some degree regardless of the scale of the infrastructure system: from modest infrastructures of urban supply or irrigation to large continental flood protection systems, river control, and/or energy production systems. Furthermore, dam safety governance includes all types of geopolitical determinants, since large dams are present in almost every country.

Halpin and Escuder (2015) have documented the paradoxical fact that, following the trend of the civil infrastructure sector as a whole, in the dam safety industry, very few organizations have implemented risk-informed governance, regardless of how obvious the benefits may seem. As a matter of fact, the vast majority of industry worldwide are 'non-doers' in the sense of providing a rational framework for identifying, analyzing, evaluating, and managing risks.

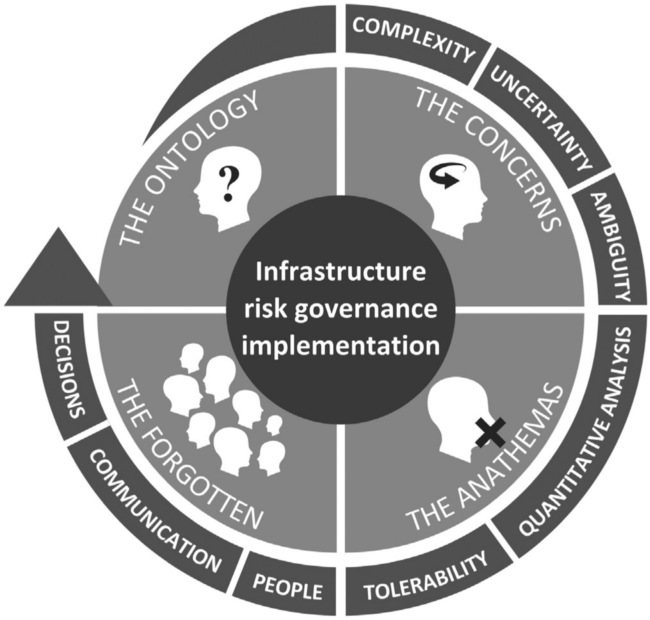

Figure 2. Pictogram on the path to succeed in infrastructure risk governance implementation.

In our view, there exist very real and observed root factors that have prevented dam industry from implementing risk governance in a meaningful way, which are common for the infrastructure sector (Section 2). Following the path illustrated in Figure 2, we are next describing the journey of the large dams sector toward risk governance implementation.

3.2. The journey toward risk governance

First publications relating risk and dam safety are dated more than 30 years ago (i.e. Baecher, Paté, and De Neufville 1980), though the impact of risk governance paradigm to dam safety has not been widely published before the second half of the nineties (e.g. ANCOLD 2003; Bowles, Anderson, and Glover 1998; Hartford and Baecher 2004; among others). The intensity of the debate can be followed though a significant number of conferences and workshops worldwide (Escuder-Bueno et al. 2011).

At a first glance, it may seem that industry has a common understanding of risk in dam safety, and indeed the International Commission on Large Dams (ICOLD 2005) has tried to balance and reflect such common understanding about the fundamentals of risk and its identification, analysis, evaluation, and management. In reality, we can find multiple examples of unclosed discussions on the ontological issue.

Park et al. (2013) when dealing with dam safety do not find sensing, anticipation, adaptation, and learning as intrinsically linked to the risk governance paradigm. They have also expressed explicit concerns on how risk analysis deals, in the field of dam safety, with complexity, uncertainty, and resilience.

With regard to the issue of quantitative risk analysis, discussions and arguments are indeed more diverse. Lund (2008) summarizes the different sensibilities by sustaining that probabilistic risk or decision analysis is the most rigorous engineering approach to difficult decision-making problems involving uncertainty. Lund also acknowledges that it may be rational not to use probabilistic risk analysis, not to develop a full probabilistic risk analysis, or not to rely entirely on its results. He also alerts of the dangers of overselling probabilistic risk analysis.

On the issue of tolerability guidelines linked to quantitative risk outcomes, as those published and followed by ANCOLD (2003), USBR (2011), or United States Army Corps of Engineers (USACE) (2014a), we can also find diverging point of views. For instance, Regan (2010) defends that it is impossible to draw a single line that separates a tolerable level of risk, as for him every dam has unique benefits and risks. Other authors, e.g. Zielinski (2014), also raise their concerns about the way tolerability lines may be defined and used.

In summary, both quantitative risk analysis and tolerability guidelines have certainly become anathemas in the industry, not as much openly discussed as internally questioned by individuals and organizations.

With regard to the role of people, we certainly do not find relevant references focused on pointing out how organizations have or have not facilitated steep learning curves, mutual enrichment in practitioners, or brought innovation. Moreover, despite the fact that smart risk governance is geared toward making the right decisions and making these decisions incrementally better, we do not find published references on practical achievements, confirming their 'forgotten' status in the industry. The same applies to risk communication and trust.

As a final example of the current state of the matter, we can mention that the session devoted to 'Advances in Dam Safety, Security, and Risk Management' (USSD 2013) and the session entitled 'Towards improving and harmonizing dams governance in Europe' (ICOLD, 2013) provided just very few examples of risk governance frameworks used to make decisions in the industry.

In our view, it can be due to a number of factors potentially driving the problem, namely:

- The lack of familiarity with the underlying risk concepts, perceived as purely theoretical, sophisticated, arbitrary and indeed very mathematical by some, and simply not understood by others.
- The difficulties in dealing with complexity, ambiguity, and particularly with uncertainty in a very broad sense, from failing to recognize the subjective nature of the analysis inputs, to the uncertainty of the related decisions.
- The existence of the 'uncertainty paradox,' where practitioners recognize uncertainty exists but see their role as providing certainty in the form of increasingly more quantitative and complex numerical results.
- The hidden fear to new external regulations in the form of tolerability guidelines, especially when linked to skeptically observed risk numerical outcomes.
- The human resistance to change, as change is uncomfortable, individually and organizationally, despite the fact that risk governance is primarily for the reason of more effective decisions

Despite these factors would need to be analyzed in the future through a scientific analysis, out of the scope of this paper, professionals currently 'in the journey' may find useful to contrast them with their own experience.

3.3. Two particular journeys: USACE and MAGRAMA

We now present two particular journeys toward risk governance, presenting and describing the path that has followed to implement risk governance, as well as the experienced and ongoing difficulties related to the issues of ontology, concerns, anathemas, and the forgotten.

Part of the interest of putting together both stories relies on the different stages in their implementation process, as well as the different sizes of both organizations and overarching legal systems.

It is out of the scope of this paper to evaluate the suitability of the implemented governance framework by both organizations, and we do not go beyond the facts relating to what extent the implementation was taken and the experienced difficulties.

Furthermore, when describing the facts and difficulties, we cannot avoid a certain degree of subjectivity, as we have experienced them in first person. Still both stories present elements of potential interest, in our view, for those that may be currently in similar journeys or considering it.

3.3.1. United States Army Corps of Engineers (USACE)

USACE, the owner and self-regulator of 708 large dams and regulator of over 2500 levee systems in the United States, provides a broad spectrum of risk management, in which has pioneered the implementation of different risk analysis techniques (Davis, Faber, and Stedinger 2008), as well as hydropower, water supply, navigation, and environmental benefits within USA. A major challenge of infrastructure management in USACE has been the replacement of the experience and institutional knowledge of its engineers gained during the agency's major construction era but now passed for several decades.

Characteristics of the infrastructure under USACE governance have been described in previous publications by the authors (e.g. Halpin and Escuder 2015). From a risk perspective, the infrastructure is diverse, spanning over five orders of magnitude in probability of failure, consequences of failure, and annualized risk. Approximately one-third of the portfolio is actionable for undesirable risks and the remaining two-thirds described with tolerable or desirable risks. Historically, management solely via compliance via a traditional 'one-size-fits-all' engineering standards was viewed as not improving understanding or decisions, nor was it cost effective. With well over 2000 risk assessments completed, USACE has considerable experience evaluating dam and levee infrastructure.

In the last 10 years, USACE has built a bench of practice and expertise in risk-informed engineering and science via new national technical centers for Risk Management, Modeling, Mapping, and Consequence Estimation, and Infrastructure Modification (USACE 2014b). The agency is working strategically with other agencies, industry, and international partners to further build the bench of professionals to support risk governance – the demand remains greater than the supply. Procedurally, the agency has leveraged this talent to create and implement policies and procedures (USACE 2014a; Engineering Regulation ER 1110-2-1156, and FEMA 2015, Federal Guidelines on Dam Safety Risk Management) which complement traditional engineering standards by infusing risk concepts in decision-making and communication, including a governance approach which is collaborative, encourages debate, and deals directly and transparently with uncertainty.

USACE has followed an adaptive learning process to implementing risk governance which acknowledged a set of skills, policies, and procedures that were not perfect, but sufficient to begin a journey with. Ten years later, the bench of professionals has grown to several hundred engineers and scientists, policies and technologies are state of the art, and risk-informed decisions have reshaped the very cultural of the agency.

We next describe how USACE navigated through some of the main difficulties in implementing risk governance:

- The ontological question regarding governance with risk and uncertainty has evolved significantly from one that was initially a business of calculating small numbers to a recognition that fundamental understanding and decision-making are improved through the debate and critical thinking that accompanies risk assessment. Infrastructure designed and constructed as individual components can now be evaluated as a system. Comparisons and priorities between systems are more clear, and cost-effective risk reduction decisions are the norm. Policies and standards are growing beyond deterministic-only approaches to one where the incorporation of risk analysis in policies supports making consistent sense of the vast diversity in infrastructure systems and the environments they inhabit. The language of risk is maturing and spreading from dams and levees to other business lines in USACE (2015).
- Tolerability of risk concepts for individual and societal loss of life risks was initially a significant adjustment for USACE, mainly because the prior half century relied upon a benefit–cost ratio as the primary decision (maybe only) metric. However, the idea of informing decisions in a collaborative manner with many perspectives at the table and risk as the common language is appealing to even the traditionalists that have long been concerned with the inability to monetize and equilibrate all decision factors.
- If there is an anathema for risk governance in USACE, it is not from the dam and levee programs where it is employed, but from the competing programs and decisions that can become a casualty of their own less compelling evidence and justifications. The inequities of confidence and investment between decisions with and without risk governance in USACE are stark and ultimately are raising the decision culture across the board (USACE 2015).
- A final challenge, still pending, is that risk and uncertainty must be communicated and socialized if it is to be addressed, and that is often a difficult and humbling position for the engineers and scientists that designed the infrastructure. This new understanding of the infrastructure must be effectively communicated to decision-makers, stakeholders, and particularly the community downstream the dam, namely because the responsibility to invest and enact risk reduction is shared now in a larger group, not just the infrastructure owner.

As a concluding remark, key to the implementation of risk governance in USACE was a decision to build new, small national organizations that could help shape and implement agency's decision-making and be leveraged to build a broader bench of competencies through training, and policy and methodology development. Among them, the Risk Management Center is in our view the core governance feature that has made the path very difficult to revert.

Benefits of implemented risk governance, as highlighted by an independent external peer review (USACE 2013), allows USACE to explore a vastly uncertain environment in a rationale, transparent, and confident manner, whereas the traditional approach borrowed a false confidence based on unrealistically certain standards and numbers which never accomplished the 'one-size-fits-all' objective. Risk governance has not only been achievable and economically, socially, and environmentally worthwhile in the USACE infrastructure management, it is considered the best lens with which engineers and scientists have to explain the benefits and risks of infrastructure to society. To date, over seven billion dollars has been saved or cost avoided through the implementation of risk-informed governance (USACE 2014b).

3.3.2. Spanish Ministry of Agriculture, Food and Environment (MAGRAMA)

Spain ranks first among the European Union countries and fourth in the world according to number of large dams, resulting in a water regulatory capacity which is today approaching 50% of all renewable water resources. Most Spanish dams, 72%, (64% gravity, 5% arch dams, 3% buttress) are concrete or masonry, as opposed to 28% which are embankment dams (17% earth, 11% rockfill). Such population of dams, providing the reservoir water volume which is of critical value for the existence itself of the country, is in the average growing old as today 25% of the dams are over 50 years old, and 60% over 30 years old.

Around one-third of the total Spanish large dams are owned and operated by MAGRAMA through the surrogated authorities given to the River Basin Authorities (RBAs) which, in addition, hold the authority to enforce and develop integrated water resources planning and management, flood control and environmental protection, among other activities. Characteristics of the dams themselves and of other infrastructure under MAGRAMA governance through the State Office of Water (DGA) and RBAs have been described previously by the authors (Halpin and Escuder 2015).

Overarching European Directives such us Directive on Floods (EC 2007) and Directive on Critical Infrastructures (EC 2008) and specific Dam Safety pieces of legislation explicitly encourage to an effective identification, analysis, evaluation, and management of risk. However, the current implementation of risk governance systems to dam safety has been limited in space and time framework (e.g. Pilot Case of Duero RBA from 2008 to 2011, as described by Ardiles et al. 2011).

However, if MAGRAMA had not carried Pilot Case of Duero River Basin, in all probability, there would be no SPANCOLD (2012) Technical Guide on Risk analysis applied to management of dam safety. It today serves as a reference guide toward risk governance for many operators in Spain and other countries (Moralo García et al. 2015; Setrakian et al. 2015) and it is the key manual for capacity building in the matter in Spain.

We next describe how MAGRAMA navigated through some of the main difficulties in implementing risk governance:

- The ontological question regarding the safety of dams remains an open one among Spanish experts in dam safety and Duero RBA works focused the debate without closing it.
- Testimony collected ranging from that of confirms extensive preoccupation with the treatment of the uncertainty as well as the complexity of the operations of dam systems, being important that Duero RBA works started with some very detailed case studies to develop a minimum but reasonable consensus on the procedures, simplifications, etc.
- The appropriateness of even carrying out quantitative analyses also lacks a clear consensus, and the fact that such analyses may be linked to tolerability recommendations creates misgivings in and out of the public sector. The decision was to adopt a set of standards from ANCOLD (2003) and USBR (2011), and postpone the important but not critical issue of adopting MAGRAMA tailored ones.
- The role of people, with more than 120 personnel involved in the Duero RBA works, transparency in communication, with multiple public meetings and publications issues, and the importance of the decisions taken, from decommissioning one of the dams to complete re-scheduling of the investment priorities, were widely recognized.

Finally, in our view, the Duero RBA experience can be considered as an ignition point, as this experience is going to be extended and improved to Ebro and Tajo RBAs, two of the most important and extensive of the country. Furthermore, important public and private owners and operators of dams, such as the regional government of Extremadura or the water supply company to the metropolitan area of Madrid, are implementing risk governance programs while building personnel and new corporate capabilities.

4. Summary and final remarks

In this article, we have reviewed many of the valuable contributions, conceptual and theoretical, which today refer to as smart governance in one of its most relevant current applications, governance of risk.

We have addressed these contributions in a way that allows us to understand the overall issue, and subsequently to analyze at the infrastructure sector level, the root causes of failure in implementation of risk governance in practice. Namely, the ontology, concerns, anathemas, and the forgotten issues, in our view, explain a great part of it.

We have then analyzed the vast sector of large dams and their safety, under this newly formulated view and presented two successful examples with differing scales and geopolitical determinants. One of the most impactful conclusions regarding dam safety involves the contrast between the amount of activity and energy devoted to theoretical questions and the scarcity of apportionments for implementation.

The debates over ontological questions, management of uncertainty, the impact of complexity and ambiguity, the validity of quantification, or the legitimacy of tolerability criteria not only should never be discounted prematurely, but should continue. Debate – intense, legitimate, and well-intentioned – should be a fundamental value in our advancement and should never be a reason for our not being in the vanguard of what society expects from all of us who strive to serve it.

Based on our experience in all areas of risk governance of dam safety, and in the analysis on the root causes of the relatively low degree of risk governance implementation in the sector, we believe that the smarter way to advance and serve the goal of building safer societies involves a delicate but necessary balance between theory and practice, between pragmatism and robustness, between proactivity and prudence, between teaching and learning, between dynamism and consolidation of best practices.

We would like to end the paper quoting the philosopher Amin Maalouf (2011):

> the relevant question is not whether our attitudes and behavior have progressed in comparison to those of our ancestors; it is whether they have changed enough to face the enormous challenges of the contemporary world.

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References

Abrahamsen, E. B., and T. Aven. 2012. “Why Risk Acceptance Criteria Need to Be Defined by the Authorities and Not the Industry?” *Reliability Engineering and System Safety.* 105: 47–50. doi:10.1016/j.ress.2011.11.004.

ANCOLD (Australian National Committee on Large Dams) 2003. *Guidelines on Risk Assessment*.Tasmania: ANCOLD.

Ardiles, L., D. Sanz, P. Moreno, E. Jenaro, J. Fleitz, and I. Escuder. 2011. “Risk Assessment and Management of 26 Dams Operated by the Duero River Authority in Spain”. *Dam Engineering*. 21 (4): 313–328. Willmington Publishing. ISSN 0958-9341.

van Asselt, M. B. A., and O. Renn. 2011. “Risk Governance.” *Journal of Risk Research* 14 (4): 431–449. doi:10.1080/13669877.2011.553730.

van Asselt, M. B. A., and E. Vos. 2008. “Wrestling with Uncertain Risks: EU Regulation of GMOs and the Uncertainty Paradox.” *Journal of Risk Research* 11 (1): 281–300. doi:10.1080/13669870801990806.

Aven, T. 2010. *Misconceptions of Risk*. Chichester: Wiley. ISBN: 978-0-470-68388-0.

Aven, T. 2012a. “Foundational Issues in Risk Assessment and Risk Management.” *Risk Analysis* 32: 1647–1656. doi:10.1111/j.1539-6924.2012.01798.x.

Aven, T. 2012b. “The Risk Concept: Historical and Recent Development Trends.” *Reliability Engineering and System Safety* 99: 33–44. doi:10.1016/j.ress.2011.11.006.

Aven, T., and O. Renn. 2010a. “Response to Professor Eugene Rosa’s Viewpoint to Our Paper.” *Journal of Risk Research.* 13 (3): 255–259.

Aven, T., and O. Renn. 2010b. *Risk Management and Governance*. Berlin: Springer. doi:10.1007/978-3-642-13926-0.

Baecher, G. B., M. E. Paté, and R. De Neufville. 1980. "Risk of Dam Failure in Benefit-cost Analysis." *Water Resources Research* 16 (3): 449–456.
BID (Inter-American Bank of Development) 2014. "*iGOPP: Índice De Gobernabilidad y de Políticas Públicas en Gestión del Riesgo de Desastres* [Index of Governance and Public Policy in Disaster Risk Management]." Washington, DC: Banco Interamericano de Desarrollo. División de Medio Ambiente, Desarrollo Rural y Administración de Riesgos por Desastres. Nota Técnica IDB-TN-720.
Black, J., and R. Baldwin. 2012. "When Risk-based Regulation Aims Low: Approaches and Challenges." *Regulation and Governance* 6 (1): 2–22. doi:10.1111/j.1748-5991.2011.01124.x.
Boholm, A., H. Corvellec, and M. Karlsson. 2012. "The Practice of Risk Governance: Lessons from the Field." *Journal of Risk Research* 15 (1): 1–20. doi:10.1080/13669877.2011.587886.
Bowles, D. S., L. R. Anderson, and T. F. Glover. 1998. "The Practice of Dam Safety Risk Assessment and Management: Its Roots, Its Branches and Its Fruit." Proceedings of Eighteenth USCOLD Annual Meeting and Lecture, Buffalo, NY.
Cox, L. A., Jr. 2009. *Risk Analysis of Complex and Uncertain Analysis*. New York: Springer. doi:10.1007/978-0-387-89014-2.
Davis, D., B. A. Faber, and J. D. Stedinger. 2008. "USACE Experience in Implementing Risk Analysis for Flood Damage Reduction Projects. Universities Council on Water Resources." *Journal of Contemporary Water Research & Education* 140: 3–14. doi:10.1111/j.1936-704X.2008.00023.x.
De Vries, G., I. Verhoeven, and M. Boeckhout. 2011. "Taming Uncertainty: The WRR Approach to Risk Governance." *Journal of Risk Research* 14 (4): 485–499. doi:10.1080/13669877.2011.553728.
EC (European Commission) 2001. "European Governance: A White Paper." Brussels, July 25, 2001. COM(2001) 428 final.
EC (European Commission). 2007. "*COUNCIL DIRECTIVE 2007/60/EC OF THE EUROPEAN PARLIAMENT And Of The COUNCIL of 23 October 2007 on the Assessment and Management of Flood Risks*."
EC (European Commission) 2008. "*COUNCIL DIRECTIVE 2008/114/EC of 8 December 2008 on the Identification and Designation of European Critical Infrastructures and the Assessment of the Need to Improve Their Protection*."
Escuder-Bueno, I., E. Matheu, L. Altarejos-García, and J. Castillo-Rodríguez. 2011. *Risk Analysis, Dam Safety, Dam Security and Critical Infrastructure Management*. Leiden: CRC Press. ISBN: 9780415620789.
EurCOLD (European Club of ICOLD) 2013. "Sharing Experience for Safe and Sustainable Water Storage." 9th European Club Symposium Proceedings, Venice.
Ezell, B. C., S. P. Bennett, D. von Winterfeldt, J. Sokolowski, and A. J. Collins. 2010. "Probabilistic Risk Analysis and Terrorism Risk." *Risk Analysis* 30 (4): 575–589. doi:10.1111/j.1539-6924.2010.01401.x.
FEMA (Federal Emergency Management Agency) 2015. *Federal Guidelines for Dam Safety Risk Management*. FEMA P-1025. Washington, DC: US Department of Homeland Security.
Forrester, I., and J. C. Hanekamp. 2006. "Precaution, Science and Jurisprudence: A Test Case." *Journal of Risk Research* 9 (4): 297–311. doi:10.1080/13669870500042974.
Funabashi, Y., and K. Kitazawa. 2012. "Fukushima in Review: A Complex Disaster, a Disastrous Response." *Bulletin of the Atomic Scientists* 68 (2): 9–21. Sage.
Halpin, E., and I. Escuder. 2015. "Smart Governance of Infrastructure Programs: Facing the Next Generation of Challenges and Succeeding." Proceedings of the 25 ICOLD Congress, Stavanger, Norway.
Hartford, D. N. D., and G. B. Baecher. 2004. *Risk and Uncertainty in Dam Safety*. London: Thomas Telford Ltd., CEA Technologies, Dam Safety Interest Group.
ICOLD (International Commission on Large Dams) 2005. *Risk Assessment in Dam Safety Management: A Reconnaissance of Benefits, Methods and Current Applications*. Committee on Dam Safety. Bulletin 130. Paris: International Commission on Large Dams.

IRGC (International Risk Governance Council) 2005. *Risk Governance: Towards an Integrative Approach, White Paper No. 1, O. Renn with an Annex by P. Graham*. Geneva: International Risk Governance Council.

IRGC (International Risk Governance Council) 2010. *The Emergence of Risks: Contributing Factors*. Geneva: International Risk Governance Council. ISBN: 978-2-9700672-7-6.

ISO (International Organization for Standardization) 2009. *ISO 31000:2009. Risk Management: Principles and Guidelines*. Geneva: ISO.

Johnston, E., and D. Hansen. 2011. "Design Lessons for Smart Governance Infrastructures." In *American Governance 3.0: Rebooting the Public Square*? edited by A. Balutis, & T. Buss. ICMA: National Academy of Public Administration.

Krause, P., J. Fox, P. Judson, and M. Patel. 1998. "Qualitative Risk Assessment Fulfils a Need." *Applications of Uncertainty Formalisms* 138–156. Berlin: Springer. 10.1007/3-540-49426-X_7

Kröger, W. 2008. "Critical Infrastructures at Risk: A Need for a New Conceptual Approach and Extended Analytical Tools." *Reliability Engineering and System Safety* 93 (12): 1781–1787. doi:10.1016/j.ress.2008.03.005.

Little, R. G. 2012. *Managing the Risk of Aging Infrastructure*. Lausanne: International Risk Governance Council, Public Sector Governance of Emerging Risks, Infrastructure Case.

Löfstedt, R. E. 2010. "Risk Communication Guidelines for Europe: A Modest Proposition." *Journal of Risk Research* 13 (1): 87–109. doi:10.1080/13669870903126176.

Lund, J. R. 2008. "A Risk Analysis of Risk Analysis." *Journal of Contemporary Water Research and Education.* 140: 53–60.

Maalouf, A. 2011. *Disordered World: Setting a New Course for the Twenty-first Century.* London: Bloomsbury Publishing. ISBN: 9781408815984.

Marks, N. 2014. "Governance, Risk Management and Audit. the Risk of Ineffective Risk Management." https://normanmarks.wordpress.com/2014/10/11/the-risk-of-ineffective-risk-management/.

Moralo García, J., J. M. Alonso Muñoz, F. J. Baztán Moreno, I. Escuder Bueno, A. Morales Torres, and J. T. Castillo Rodríguez. 2015. *Institutional Reinforcement for the Dam Safety Program, Risk Analysis and Emergency Planning for Fierze, Komani and Vau Dejes Dams in Albania* (in Spanish). Proceedings of X National Spanish Congress on Dams, Spain, Seville.

Park, J., T. P. Seager, P. S. C. Rao, M. Convertino, and I. Linkov. 2013. "Integrating Risk and Resilience Approaches to Catastrophe Management in Engineering Systems." *Risk Analysis.* 33 (3): 356–367. doi:10.1111/j.1539-6924.2012.01885.x.

Regan, P.J. 2010. "Dams as Systems: A Holistic Approach to Dam Safety." In: 30th Annual United States Society on Dams (USSD) Conference. Sacramento, CA.

Renn, O. 2008. *Risk Governance: Coping with Uncertainty in a Complex World*. London: Earthscan. ISBN: 9781844072910.

Renn, O., A. Klinke, and M. B. A. van Asselt. 2011. "Coping with Complexity, Uncertainty and Ambiguity in Risk." *Ambio* 40 (2): 231–246. doi:10.1007/s13280-010-0134-0.

Rosa, E. A. 2010. "The Logical Status of Risk: To Burnish or to Dull." *Journal of Risk Research* 13 (3): 239–253. doi:10.1080/13669870903484351.

Setrakian, M., I. Escuder-Bueno, A. Morales-Torres, and D. Simarro. 2015. "Safety Investments in Horcajo Dam (Spain): a Process Informed by the Application of SPANCOLD Guidelines on Risk Analysis." International Commission on Large Dams 25 Congress. Stavanger, Norway.

Slovic, P. 1987. "Perception of Risk." *Science* 236: 280–285.

Slovic, P., and E.U. Weber. 2002. "Perception of Risk Posed by Extreme Events." Conference on Risk Management Strategies in an Uncertain World. Palisades, New York.

SPANCOLD (Spanish National Committee on Large Dams) 2012. *Risk Analysis Applied to Management of Dam Safety.* Technical Guide 8. Vol. 1. Madrid: SPANCOLD.

USACE (United States Army Corps of Engineers) 2013. *Final Report, Independent External Peer Review of the USACE Dam Safety Program, W912QR-10-D-0031 Task Order C0002*. Louisville District (LRL): U.S. Army Corps of Engineers.

USACE (United States Army Corps of Engineers) 2014a. *Engineering and Design: Safety of Dams- Policies and Procedures*. ER 1110-2-1156. Washington, DC: U.S. Army Corps of Engineers.

USACE (United States Army Corps of Engineers) 2014b. *First Progress Report on USACE Technical Centers Supporting the Dam and Levee Safety Programs*. Washington, DC: U.S. Army Corps of Engineers.

USACE (United States Army Corps of Engineers) 2015. Campaign Plan.

USBR (United States Bureau of Reclamation) 2011. *Dam Safety Public Protection Guidelines: A Risk Framework to Support Dam Safety Decision-making*. Denver, CO: Department of the Interior, Bureau of Reclamation.

USSD (United States Society on Dams) 2013. "Changing times: Infrastructure Development to Infrastructure Management." Proceedings of the International Commission on Large Dams 81st Annual Meeting Symposium, Seattle, WA, USA. ISBN: 978-1-884575-62-4

Vlek, C. 2010. "Judicious Management of Uncertain Risks: I. Developments and Criticism of Risk Analysis and Precautionary Reasoning." *Journal of Risk Research* 13 (4): 517–543. doi:10.1080/13669871003629887.

Wilke, H. 2007. *Smart Governance: Governing the Global Knowledge Society*. Chicago, IL: University of Chicago Press. ISBN: 9783593382531.

Zhao, Liming, B. Hwang, and S. P. Low. 2015. *Enterprise Risk Management in International Construction Operations*. Singapore: Springer. doi:10.1007/978-981-287-549-5.

Zielinski, P. A. 2014. "Setting Individual and Societal Risk Criteria for Safety of Dams." Canadian Dam Association (CDA) 2014 Annual Conference, Alberta, Banff.