Managing Exposure to Pipeline's Risks: Improving Brazil's Risk-Based Regulatory Process

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Traditional risk-based decision-making processes have limitations that often compromise the management of technological hazards. Moreover, these processes have been criticized for frequently being centered on a narrow set of information that is provided by a few technical studies, such as quantitative risk assessments. Arguing that the management of exposure to hazards and risks (future) is as important as the decision about hazardous facilities (present), this research draws on the literature and a Brazilian case study to investigate alternatives to improve regulatory processes for gas and oil transmission pipelines.

The research is organized into three major components. Firstly, it investigates concepts and thinking outside the literature on risk regulation that offer opportunities to improve risk-based processes, such as governance and risk governance, environmental and social justice, vulnerability, resilience, complex systems, ethics, and the precautionary principle. This review is organized as a conceptual framework that identifies twelve groups of actions to improve risk-based approaches: pre-assessment of risks, concern assessment, communication and education, precautionary appraisal, public participation, integration of governmental actors, risk reduction at source, land-use control, specific routines for risk management, vulnerability assessment, resilience programs, and follow-up.

Secondly, the identified opportunities to improve risk-based approaches are assessed in the context of the Brazilian environmental licensing process for gas and oil transmission pipelines. The case study is explored through interviews and surveys with thirty-two key stakeholders, aimed at describing and understanding the situation. Insights from the interviews are explored through ten themes: the importance of the Brazilian environmental licensing process, limitations and missing aspects in the process, the economic and development agenda, the need for legitimization, technical information, sense of justice and inclusiveness, the application of quantitative risk assessments, the encroachment of pipelines' right-of-way, and the follow-up. In the second instance, an evaluation of the performance of the Brazilian case study is presented, based on twelve qualitative indicators drawn from the conceptual framework of the research. According to the assessments, the performance of the current process is deemed poor in ten of these indicators. Thirdly, a more comprehensive framework for the regulation of risks in Brazil is designed in the research, suggesting new measures (such as pre-management,

vulnerability assessment, and resilience plan) and new timing for some of the routines (such as quantitative risk assessment and risk management).

Finally, it is discussed how the implications of the proposed conceptual framework and findings from the case study contribute to the theoretical perspectives on technological risk regulation. The research advocates that (1) regulatory processes for technological hazards need to effectively incorporate ‘human systems’ into their routines as a way to become more holistic; (2) decision-making processes need to strengthen the transition from assessment of risks to management of exposure; (3) regulators need to shift focus to the management of exposure as opposed to the current facility-centered management of risks; (4) this transition is facilitated if the regulatory process has an independent routine for management; and (5) a resilience plan, encompassing components from risk management and land-use planning, articulates the interaction between people and hazardous facilities, that share a common space, towards better practices to effectively manage exposure to risks. Considering these five points, the research suggests an adaptation of the Risk Governance Model for the regulation of hazardous linear installations.

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IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute of Environment and Renewable Natural Resources
BELP	Brazilian Environmental Licensing Process
QRA	Quantitative Risk Assessment
ILP	IBAMA's Licensing Process
PL	Prior License (or permit)
IL	Installation License (or permit)
OL	Operation License (or permit)
PHA	Preliminary Hazard Analysis
RMP	Risk Management Program
RP	Resilience Plan
TR	Term of Reference
LUP	Land-use Planning
OGTP	Oil and Gas Transmission Pipelines
NGO	Non-Governmental Organization

Chapter 1 – Introduction

"Every chapter on disasters in this book has ended with a call for better regulation and re-regulation, since we need both new regulations in the face of new technologies and threats and the restoration of past regulations that had disappeared or been weakened since the 1960s and 1970s. The regulatory potential for avoiding disasters and reducing their consequences is obvious. Standards exist, or should exist, concerning the height and strength of levees, building standards, and the reliability and security of key parts of our infrastructure, such as the power grid and the Internet as well as our transportation system and ports. There may even be some existing regulations regarding the quantities of hazardous materials that are stored that could be strengthened. Regulation frequently fails because of political processes, but we have done better in the past and could do better in the future" (Perrow 2007: 295).

1.1 Introduction

Decisions about technological hazards are based predominantly on the outputs of a quantitative risk assessment (QRA). The advantages of QRAs are widely discussed in the literature (e.g., Stern and Fineberg 1996; Cox 2002; CSChE 2004; Purple 2005; Smith 2005) and their application is enforced in diverse countries (e.g., McColl et al. 2000; Cahen 2006; Cozzani et al. 2006; Kirchhoff and Doberstein 2006). However, scholars from a variety of disciplines, particularly the social sciences, regularly assert that QRAs are not equipped with a complete set of tools that permit them to accommodate the full complexity of decisions involving the economic, social, and environmental considerations related to the installation and operation of hazardous facilities, especially in urban areas (O'Brien 2000; Garvin 2001; Healy 2001; Ball 2002; Klinke and Renn 2002; Slovic et al. 2002; Hansson 2003; Starr 2003; Frewer 2004; Choi et al. 2005; Martuzzi 2005; Thompson et al. 2005; Allio et al. 2006; Aven et al. 2007; Cox 2007; Asveld and Roeser 2009).

In the context of QRAs, risk is understood as the anticipated outcome of the interaction between an accidental event and a given human population, presented in the form of *risk rates* (Molak 1997; HSE 2006). These rates express the likelihood of an individual losing their life as a consequence of an abnormal event associated with the operation of an industrial facility or other technological system. Decision makers confront the numbers calculated in the risk analysis with pre-established standards to evaluate whether an enterprise is safe enough to function in an urban area (Kirchsteiger 1999; Kirchhoff and Doberstein 2006; Aven 2007). Usually, if the numbers shown are below a pre-determined threshold, the technological project is considered safe and the project (or any of its stages) is approved. If the numbers are higher than this threshold, the project often undergoes a redesign to bring the risk rates down to an acceptable level.

This approach, commonly identified in the literature as *risk-based decision- making process* and applied by engineers and other technical disciplines, has considerable limitations when viewed from a social science perspective. The social science literature contextualizes these limitations by emphasizing the distinctions between *technological systems* and *human systems*. Technological systems are installations or facilities (roads, rails, pipelines, industries, power plants, etc.), whereas the human systems of interest to the risk analysis are the organized people, and their activities, living near to or interacting with those technological systems (building, street, neighborhood, city, etc.). In risk-based approaches, decisions are made mainly considering the inputs from the technological system, as though the human system was a static or simplified component in the analysis. However, social scientists (Perrow 1984; Beck 1992; Asveld and Roeser 2009) remind us that human systems are both dynamic and complex; and that human and technological systems are often linked so that they need to be evaluated in an integrated way. QRAs describe, with considerable detail, the technological systems, scrutinizing the facility's project to gather information to understand how and under what conditions it can fail, what the consequences of this failure would be, and how the surrounding area would be affected (CSChE 2004). As described by Coze (2005: 623), a "technical risk study relies on cause and effect relationships that are determined through the use of general laws relating to the engineering and physical science (laws of physics, chemistry, electricity, . . .) and interactions are in that sense often deterministic (in the sense developed in the science of nature and engineering)". In contrast, there is little attention paid to the human system in conventional risk-based decision-making (TRB 2004; Asveld and Roeser 2009; Bea et al. 2009). For instance, Perrow argues that "[o]ne unfortunate implication of quantitative risk assessment is that the public should be excluded from discussions that affect them" (1984: 314). In fact, in many cases QRAs only estimate the population number by indirect means, such as the use of aerial photos to count buildings and, then, indexes to translate the number of buildings to an estimate of the number of people living in the area.

If one seeks to pursue the safety of human systems, an understanding of the population in regulatory processes cannot be narrowed down solely to the identification of numbers. This perspective acknowledges that the quantification of the risks contributes to decision making, but this information should not be the only input to the regulatory process. As pointed out by Renn (2008: 16), "the interactions between human activities and consequences are more complex, sophisticated and unique than the average probabilities used in technical risk analyses are able to capture". QRAs are important exploratory tools, needed to provide concrete guidance in the definition of the immediate planning during the regulatory processes. QRAs aid planners and regulators in their activities, indicating likely concerns and incompatibilities between the human and technological systems. However, advances in the social sciences have also much to contribute to this matter, especially in the mid and long term, where elements such as effective public participation, comprehensive socioeconomic assessment, and extensive communication help in grounding decisions and facilitating transitions in regulatory processes and management. The lack of a holistic view comprising these two hemispheres, social and technological, can lead to undesirable outcomes if decision makers outbalance the importance of one system over another.

Even when it is acknowledged that it is important to address both technological and human systems to analyze risks, in exploring the literature on technological risks from both the technological (engineering disciplines) and human (social sciences) perspectives, it is possible to observe that the bridge linking these two sides of the same problem is still weak and incomplete. On the one hand, the social science literatures have provided considerable philosophical reflections on the regulation of risks (Beck 1992; Perrow 1999; Asveld and Roeser 2009), but with still limited elaboration on practical applications and implications. For instance, from the human system perspective, Perrow's argument that it is important to "reduce the size of vulnerable targets" to better cope with disasters can be considered a conceptual ideal (2007: 1). However, the control of these targets has several practical implications that are not fully addressed in his argumentation[1]. Perrow's claim for deconcentration of population in hazard-prone areas implies measures that relate to aspects of local land-use patterns, urban development, tolerability to risks, etc., which are omitted from his argument. Instead, these details are discussed in the body of literature related to regulatory processes (MIACC 1998; Amendola 2002; TRB 2004; Cozzani et al. 2006). From the technological system perspective, the engineering disciplines have drawn attention to the development of ways to better understand, design, construct, and operate their technological systems, in a manner that also ensures safety (Muhlbauer 1992; Molak 1997; Papadakis 1997; Purple 2005). However, regardless of any effort from the engineering disciplines to accommodate the social perspective into their considerations, engineers usually do not work with the possibility of not having their projects implemented. On the contrary, engineers often believe that for any technological threat there is always a technical solution (reinforcement of structures, installation of air and water filters, limitation of the inventory of hazardous materials, etc.), and that the technological development fosters progress and the betterment of society. Here again, the discussion of the implications and conditions that technical facilities should meet takes place in another body of literature that of regulatory processes.

By addressing gaps in the analysis of technological risks from contrasting engineering and social sciences perspectives, the processes for regulation of technological risks offer a unique opportunity to articulate understandings of both the technological and human systems towards the outcome of best practices to address technological hazards. Regulatory processes can incorporate effective instruments to transform the ideal of safety on a common ground that mutually embraces the considerations of the engineering disciplines and the social sciences. Regulatory processes can demand technical rigor from developers at the same time as they

[1] Hopkins (1999: 93), for instance, claims that Perrow's natural accidents theory is "of very limited policy relevance".

discuss ways to avoid exposure[2] to risks within the local community. Furthermore, a comprehensive regulatory process should also be able to accommodate the transformation these two systems may experience over time, such as the population growth following the implementation of the technological system or the development of new sources of risk in a relatively stable shared space. In fact, the management of exposure to risks (future) is seen as important as the decisions about the hazardous facilities themselves (present). Changes in the boundary conditions[3] can make a traditional risk assessment obsolete in a few years, especially in regions with disorganized or unplanned urban growth patterns. As argued by Renn (2008: 16), "the institutional structure of managing and controlling risks is prone to organizational failures and deficits that may increase the actual risk". Rather than simply reassessing the risks by carrying out a new QRA, risk regulation can benefit from discussions that are happening in the social sciences to avoid, or at least to better understand and manage, changes in the human system that can impact the technological system, and vice-versa. Risk-based regulations too often focus on the control of the technological system and the ways it interacts with the human system to the detriment of perspectives in which the human systems are the agent driving the changes in the risk profiles.

Recent scholarship on risk governance provides more comprehensive frameworks for technological risk regulatory processes (Millstone et al. 2004; Klinke et al. 2006; IRGC 2007; Renn 2008). For instance, Renn (2008) stresses the need to pursue concern assessments and enforce communication protocols throughout the entire decision-making process, measures long advocated in the social sciences. Millstone et al. (2004) argue that transparent regulatory models are framed by their social and political contexts, where socioeconomic profiles need to inform the scientific choices guiding risk assessments. These frameworks bring a more contextual perspective to the decisions as they recognize the importance of the human systems in the decision making for technological risks. They also shed light on the practical challenges to the implementation of many claims in current philosophical debates on the regulation of technological hazards. And finally, they enforce solid technical practices in the estimation, evaluation, and management of the risks of a hazardous facility.

However, both the transparent and the risk governance models have some conceptual limitations in the ways they address the management of exposure to hazardous facilities by human populations in the long term. For instance, the transparent model is built on a linear sequence of events that starts with risk assessment policy, moves to risk assessment and evaluation, and finally finishes with risk management (Millstone et al. 2004: 25). As discussed later in this thesis, this sequence often stresses the role of the technological systems over

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[2] Renn (2008: 69) defines *exposure* as "the contact of the hazardous agent with the target (individuals, ecosystems, buildings, etc.); while *vulnerability* describes "the various degrees of the target to experience harm or damage as a result of exposure".

[3] The term is commonly applied in mathematics and defined by the Free Dictionary as "the set of conditions specified for the behavior of the solution to a set of differential equations at the boundary of its domain". In the context of this research, it refers to the set of conditions that depicts the current reality of the human and technological system, as well as their interaction, in a given space.

the human in the regulatory processes. Since this arrangement is centered on the information about risks, QRAs can take a preeminent role in decisions that, that at times, is not appropriate. The risk governance model provides a more holistic approach, with more evident interface to inform and be informed by human systems. The framework builds on the transparent model to propose a framework that starts with pre-assessment of risks, moves to risk and concern assessments, followed by risk evaluation, and finally implements risk management measures (Renn 2008: 365). Eventually, the risk management of a previous regulatory process informs the beginning of a subsequent cycle, providing background information for new pre-assessment of risks. In the risk governance framework, communication protocols have a coordinating role integrating all four steps. However, the risk governance model has limitations for addressing risks related to hazardous facilities and installations. The framework integrates many aspects of local social perspectives, including assessment of vulnerability and exposure, but it is not clear in the model what procedures monitor and control such variables after the decisions are made (North 2008). As discussed later in this research, temporal aspects become an issue for this model if its routines are not sufficiently flexible to accommodate changes in the human or technological systems, changes that are very likely to occur in ten, twenty, or thirty years. A second limitation is the absence of an explicit mechanism to integrate risk decisions with local land-use policies, a recurrent claim in other bodies of social sciences literature. The regulation of the use and occupation of land near hazardous facilities has to be a central element in the implementation of a sound and realistic management of risks and exposure (MIACC 1998; Christou et al. 1999; Boholm and Löfstedt 2004; TRB 2004; Cozzani et al. 2006). Although the model suggests a more comprehensive approach in the implementation of risk management, it is still not clear how human systems and the land they occupy inform these practices.

1.2 Statement of the research question

A major practical implication of the considerations raised above is the lack of effectiveness in the control of human exposure to hazards from non-continuous (point-based, such as nuclear power plants) or linear technological installations (e.g, transmission pipelines). Often regulators taking care of the technological systems are not driven by a true understanding of human systems when planning their projects and facilities; on the other hand, frequently local planners do not account for the threats posed by technological systems when they plan their cities. Frequently, this lack of interaction compromises safety. Considering that the bridge linking the agendas from the social sciences and the engineering disciplines can be strengthened, that the regulatory processes of technological risks are appropriate arenas to pursue this integration, and that current regulatory frameworks have important limitations accounting for the management of exposure, this research explores a vast literature on risk-related topics (such as Webler 1999; Davies 2001; Healy 2001; Adams and Thompson 2002; Starr 2003; Apostolakis 2004; Bryson 2004; Wester-Herber and Warg 2004;

Perrow 2007; Boholm 2008; Ersdal and Aven 2008; Lidskog 2008; Davidson 2009; Hansson 2009; Roeser and Asveld 2009) and a case study to investigate opportunities to improve risk-based decision-making processes. To pursue these opportunities, it proposes the following research question:

> ***__Research Question__**: How can risk-based decision-making processes regulating technological installations be improved to better manage ongoing risk exposure?*

It is important to mention that this research acknowledges that management of exposure has been already addressed by disciplines in the social sciences, especially geography[4] (O'Keefe et al. 1976; Burton et al. 1978; Chambers 1989; Beck 1992; Watts and Bohle 1993; Hewitt 1997; Cutter et al. 2003; Pelling 2003; Cardona 2004; Wisner et al. 2004; Perrow 2007). It also recognizes that there is scholarly work that has also addressed the need to change some of the philosophical assumptions behind the regulation of hazards and risks (Perrow 1984; Beck 1992; Renn 2008; Asveld and Roeser 2009). However, the focus stressed in this research question is not ways to diminish or control exposure per se (as discussed in the literature of vulnerability, panarchy, and resilience); or elaborations on the broad relationship of the coupled human-technological system (as discussed in the literature of strategic environmental assessment, complex systems, and ethics). Rather, it addresses how regulatory processes that apply technological risk analysis can be improved in light of practices and discussions outside of the specific literature on risk assessment and management. This implies the assumption of some boundaries during the discussions that reflect the specificity of the research question as well, but it does not imply, at any time, abandoning the relevant contributions these two other bodies of literature can bring to this research.

Acknowledging such boundaries stresses the need to understand that exposure to technological risk is local and context-dependent, since boundary conditions are unique to a given region or group of people, as broadly discussed in the literature (Watts and Bohle 1993; Hewitt 1997; Cutter et al. 2003; Cardona 2004; Wisner et al. 2004; Asveld and Roeser 2009). As pointed out by Castree (2003: 182), "[p]lace matters and its importance is multifaceted"; it "stresses how 'outside' processes impact on the 'inside' of places". The body of literature from geography tends to corroborate this, with its focus on the reality that: (a) physical, social, and environmental conditions vary by location; and (b) set of regulations and institutions in place to perform the decisions also varies by location, and affects the outcome of societal processes. For instance, the first set of factors can be seen in urbanization patterns. Cities in developed nations are different from cities in developing countries; cities in North America are different from cities in Europe; and cities in Africa are different from cities in South America. Local conditions vary considerably from place to place. The second group refers to the setup or arrangements in place to regulate risks. There is a large body of literature in the social sciences that points out that not only do the boundary conditions vary from case to case, but also the

[4] For instance, the scholarship on the management of floodplain and hazard-prone areas.

ways that regulators decide and manage risks are often different from jurisdiction to jurisdiction. The variability in the approach to the regulation of technological risks is expected and reflects the cultural, institutional, and political particularities of each jurisdiction or nation (Amendola 2002).

Finally, as this research acknowledges both the importance of contextual particularities in the regulation of risks as well as some conceptual limitations in these regulatory frameworks, these two planes are addressed in this thesis. A simple way to do this is to interpret the research question as comprising two parts, the first relating to theory and the second to the implications of theoretical models in a given context. In other words, both theory and practice need to be examined. This research carries out an analysis of theories, concepts, and thinking in the social sciences, exploring elements to design opportunities for change. Given that locations and local regulations differ, contextual implications are also anticipated and tested by way of a detailed examination of the Brazilian regulation of gas and oil transmission pipelines[5]. Two sets of sub-questions guide the search for answers in the literature and the organization of these ideas into measures to be tested in the Brazilian case.

Sub-Questions	
1 - Theory	*1.1 – What are the theories and thinking that can help in the regulation of technological risks?* *1.2 – What are the elements of such theories and thinking that help in the regulation of technological risks?* *1.3 – How do these elements help in the regulation of technological risks?* *1.4 – How can these elements be organized to contribute to the improved regulation of technological risks?*
2 - Brazilian Case (environmental licensing of gas and oil transmission pipelines)	*2.1 – How does the Brazilian regulatory framework consider technological risks?* *2.2 – Are the current routines of the Brazilian regulatory framework appropriate to regulate technological risks?* *2.3 – What are the missing aspects of the Brazilian regulatory framework?* *2.4 – How can the Brazilian regulatory framework benefit from theory to better manage risk exposure?* *2.5 – To what extent do the case study results corroborate and/or suggest alterations of the theoretical models for the regulation of hazardous installations?*

Among the many technological systems that could offer context for this research, pipelines are chosen due to their particular linear nature and potential harm. Transmission pipelines carrying natural gas, oil, or any other petroleum by-product are especially susceptible to the lack of integrated action between relevant actors and

[5] Brazil was chosen because its regulatory framework represents a typical risk-based approach to regulate risks; the need to improve Brazil's framework; and due to previous experiences of the researcher with the Brazilian framework.

inefficiency in the regulation of risks. As compared to non-continuous facilities, linear systems, such as pipelines, have a much larger interface with human systems. Regulating the risks of transmission pipelines is often demanding and requires continuous engagement since a pipeline's route can be completely uninhabited at the time of the decision about the project but people may migrate towards it over time and modify the identified risk profiles.

1.3 Research goal and objectives

As described above, theory and practice have important roles in the regulation of technological hazards. This research explores these two components in order to achieve the following goal:

> *Research goal: to contribute to the current understanding and practices that regulatory processes apply to manage exposure to risk due to technological hazards.*

This goal is supported by seven specific objectives that, combined, will lead to the development of a broader perspective to understand and decide about such hazards. The first three objectives relate to theory. They seek to review, organize, and assess aspects in the literature on risks and related concepts, as well as practices in diverse countries, that assist with the research goal. Following that, another set addresses the Brazilian case. Three objectives seek to understand, assess, and improve Brazilian regulation of technological risks. Finally, a last objective compiles the findings and improvements in Brazil to feed back into theory. These objectives are detailed below:

Objectives – Theory

Objective 1: To review the literature on risk assessment and management in order to both identify current practices and trends, and develop an inventory of possibilities to be considered in future stages of research.

a. What are the models, approaches, and methods applied to address technological risks?
b. What is risk-based decision making (practices, strengths, and limitations)?
c. What is risk-informed decision making (practices, strengths, and limitations)?

Objective 2: To identify elements in the literature and in diverse countries that support the need for changes in risk regulation.

a. What are the current trends and recommendations to address technological risks?
b. What are the current practices regarding technological risks that are applied in diverse countries?

Objective 3: To design a conceptual framework to improve decision making for technological hazards.

a. What are the useful concepts and thinking across the literature from various disciplines that can support this decision making (i.e., literature on governance, social and environmental justice, complex systems, resilience, etc.)?

b. How can these concepts and thinking be organized into a new way of thinking about regulation of technological systems?

<u>Objectives – Brazilian Case</u>

Objective 4: To understand and assess the performance of Brazilian regulation of gas and oil transmission pipelines.

a. How does it work, how effective is the regulation of technological risks, and who is involved?
b. What are the strengths and limitations?

Objective 5: To test the conceptualization that emerges from Objective 3 in the Brazilian context.

a. How does the proposed conceptual framework fit the BELP (Brazilian environmental licensing process)?

Objective 6: To design a more comprehensive decision-making process for Brazil.

b. How can the previous objectives help Brazil better manage risk exposure?

<u>Objectives – Theory</u>

Objective 7: To reflect the Brazilian findings and the proposed conceptual framework back to theory.

a. How can the findings and improvements in the Brazilian case contribute to theory?

1.4 Research design

This study is designed to integrate concepts, grounded empirically in a case study, to achieve the objectives described above. The methodological approach applied in this research is qualitative. As described by Denzin and Lincoln (2000:385), “qualitative design is holistic. It looks at the large picture, the whole picture, and begins with a search for understanding of the whole”. As pointed out by Berg, qualitative research is an appropriate methodological approach to address the “meanings, concepts, definitions, characteristics, methods, symbols, and descriptions of things” (2008:4). Notwithstanding the broad literature covering qualitative research (Creswell 1998; Stake 1999; Babbie and Benaquisto 2002; Creswell 2003; Denzin and Lincoln 2005; Berg 2008; Yin 2008), two specific reasons support the use of such an approach in this work:

(a) The first one relates to the scale of the problem under study. In other words, some information or data cannot or should not be quantified and they are better addressed in a qualitative way (e.g., complex processes, such as resource and environmental management, land-use planning, risk regulations, and environmental licensing activities);

(b) The second point deals with the limitations associated with the use of quantitative tools in complex contexts. One supposed advantage of quantitative research is that numbers are usually better understood than subjective information. However, this assumption often fails due to the limitations and uncertainties inherently present in the quantification of a real event (e.g., many indexes are built upon an intricate chain of subjective assumptions, model-based confidence intervals, and personal expertise that jeopardize the reliability of such numbers in the end).

An overview of the research design is presented in Figure 1.1. Each step addresses a specific research objective (i.e., step 1 relates to objective 1, step 2 to objective 2, and so forth). The research starts with a broad review of the literature on risk assessment, evaluation, and management. This first review organizes the disciplines in order to understand the current status of the regulation of technological risks. Next, step 1 aims at the identification of the limitations of risk-based decision making and QRAs. Another comprehensive literature review is carried out in the sequence. Theories, thinking, and concepts in various fields are investigated in a search for concepts, measures, and actions that can improve the regulation of technological hazards. Risk assessment and management policies from other countries are also benchmarked at this stage in order to gather practices that can serve the same purpose. Searching back and forth between these two sources (literature and practice), step 2 compiles the identified elements in a rational way, into a research methodology. Building upon step 1 and step 2, step 3 structures those elements into a conceptual framework[6] to improve the regulation of technological risks. After this, a third and last literature review is conducted in order to approach the case study. Papers, reports, and dissertations addressing the Brazilian case are investigated to describe and evaluate performance. Step 4 takes the information gathered in the three previous steps to compile an initial position on issues. Questions for a semi-structured interview with key stakeholders in Brazil are designed based on the conceptual framework (step 3) and the information about the Brazilian regulatory system. After a detailed analysis of the interview's content, step 5 provides assessment of the conceptual framework in the Brazilian case. Questions are designed to test the relevance of the points brought up by this new framework in a short questionnaire. This survey is conducted with the same key stakeholders that participated in the interviews. Step 6 analyzes all data gathered and proposes improvements to the current Brazilian regulatory framework. Finally, step 7 assesses how the improvements observed in the Brazilian case and the particularities of the conceptual framework contribute to theory.

Case study:

The case study applied in the research consists of three components (addressed later in Section 3.2.2, Chapter 5, Chapter 6, and Chapter 7): (1) a description and criticism of the Brazilian environmental licensing processes[7]; (2) a qualitative evaluation of the processes regulating technological hazards; and (3) a proposition of a more comprehensive framework to regulate gas and oil transmission pipelines. Firstly, interviews with key stakeholders, complemented by literature review, describe the current routines and

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[6] Throughout this research, the term conceptual framework refers to the organization of concepts and thinking in a structured way in order to cover gaps in the current regulatory processes for technological hazards.

[7] The Brazilian environmental licensing process is the regulatory process addressing technological risks in Brazil.

identify opportunities for improvement. Secondly, based on the conceptual framework of the research and specific literature, a qualitative evaluation of the current regulatory process is carried out. Finally, considering the insights from the two previous components and a survey with the same thirty-two key stakeholders, the research proposes a more comprehensive framework for the Brazilian environmental licensing processes of technological hazards.

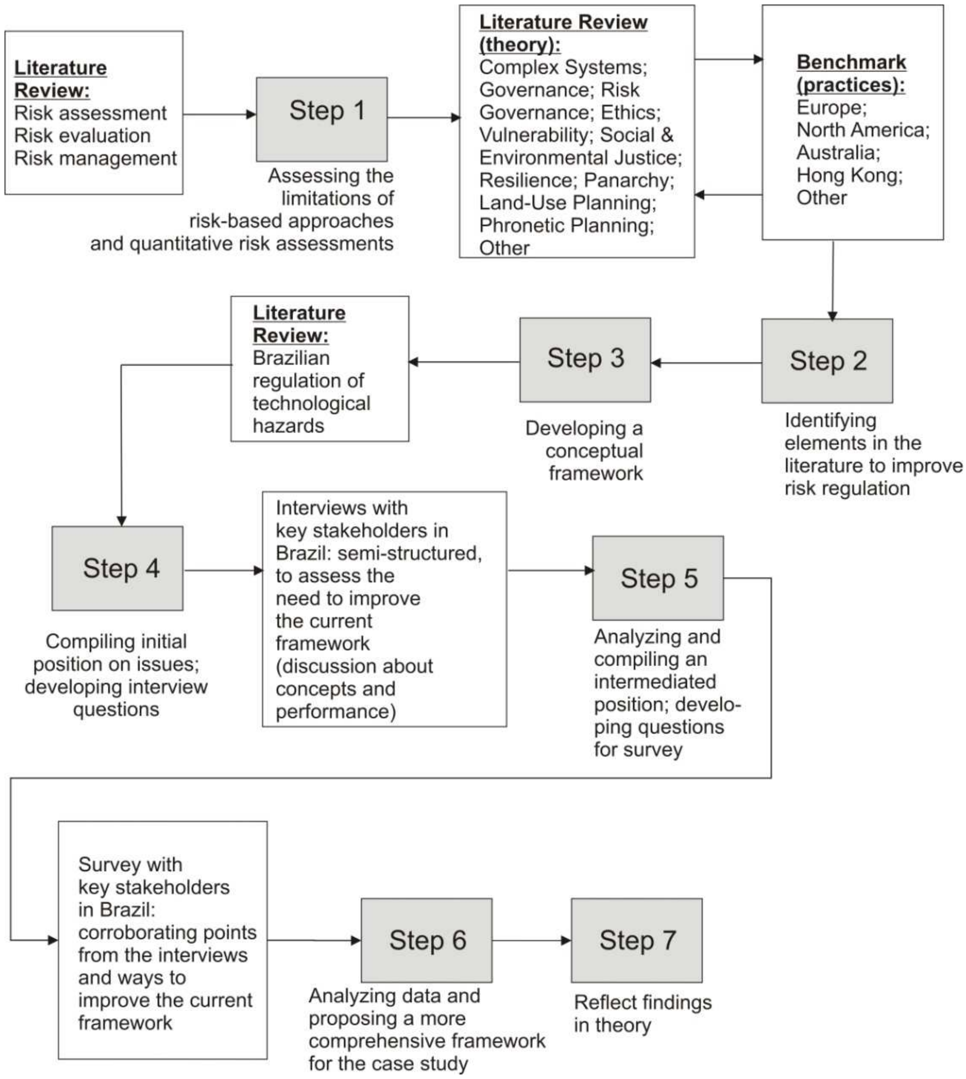

Figure 1.1 – Research Design.

1.5 Considerations about ethics

This research follows the formal requirements present in the FORM 101/101A of the “Office of Research Ethics” of the University of Waterloo. The extract below summarizes the ethical foundations enforced by the University of Waterloo:

> “Consistent with University of Waterloo's Guidelines for Research Involving Human Participants (as presented throughout this website), UW’s Statement on Human Research, and the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans , all faculty (i.e., with a regular faculty appointment or a research faculty appointment; see policy 76), staff, undergraduate and graduate students conducting research with humans on or off campus must ensure that their projects undergo prior ethics review and clearance through the Office of Research Ethics (ORE). This requirement applies to all grant-funded and unfunded research regardless of whether the procedures used are invasive or non-invasive in nature. It applies to research conducted by undergraduate or graduate students for thesis or course purposes”.

Source: The Office of Research Ethics, University of Waterloo

1.6 Outline of the dissertation

The dissertation is organized around the objectives of this research. **Chapter 2** reviews the literature on relevant topics for the research. Firstly, the literature on technological risk is reviewed and organized around models, approaches and methods for risk regulation, aimed at the description of current practices discussed in the literature and applied by diverse countries (main characteristics, strengths, and limitations). The second section of this chapter reviews the literature and practices integrating land-use planning with risk regulations, identifying current discussions and trends that can inform the development of new ways to regulate technological hazards. Finally, the last section briefly addresses two relevant concepts in geography that provide background to the importance of a contextual approach in this research: place and vulnerability to natural hazards.

Chapter 3 presents the methods applied in approaching the research, data collection, data analysis and validation. The research applies a literature review and a case study as the main methods supporting the research rationale. A literature review is conducted to identify opportunities to address the research question and elaborate a conceptual framework. An introduction to the case study is presented, where the phenomenon and the context of analysis are introduced, and the boundaries and unit of analysis are established. Data are collected using semi-structured interviews, a structured online questionnaire, document review, and observations from the field made by the researcher. Data analysis encompasses the identification of phenomena, description of contexts, understanding of intentions, observation of processes, classification of information, and establishment of connections between data. Finally, validation is approached applying information from the field to minimize misinterpretations, triangulation to ensure multiple perspectives, clarification of the bias from the researcher, the development of detailed (*rich and thick*) descriptions, and the use of pattern matching.

Chapter 4 explores the literature on social sciences to propose a conceptual framework. First, it investigates disciplines outside the quantitative risk literature that can inform the regulation of technological hazards: governance, environmental and social justice, vulnerability, resilience, complex systems, ethics, and the precautionary principle. In a second moment, this chapter develops a conceptual framework based on the preliminary investigation. From this framework, twelve types of actions are identified to improve the risk-based decision-making processes of technological hazards.

Chapter 5 discusses the Brazilian case study. It begins with a brief introduction to Brazil and the Brazilian regulatory processes for technological hazards, followed by a report on semi-structured interviews with thirty-two key stakeholders. The study focuses on policies at Brazil's federal level only, which is in charge of the regulation of the largest projects in the country. The report is organized around ten themes, identified according to the proposed methodology and with the aid of software entitled NVIVO: the importance of the regulatory process; limitations in the regulatory process; influences from the economic and development agenda; the need for legitimization as opposed to socio-environmental concern; an identification of what is missing in the current approach; technical information; sense of justice and inclusiveness; application of quantitative risk assessments in the regulatory process; encroachment of the pipeline's right-of-way; and follow-up. The main topics identified in the interviews are summarized at the end of the chapter.

Chapter 6 follows up the previous chapter carrying out an evaluation of performance of the current Brazilian regulatory process. The twelve types of actions suggested by the conceptual framework are proposed as qualitative indicators to carry out this assessment. The purpose of this evaluation is to assess Brazil's case against each of these identified actions for improvement of risk-based decision-making processes of technological hazards. The performance evaluation is based on the inputs from the interviewees and surveys, literature in the area, and the researcher's observations in the field as an insider.

Chapter 7 discusses a more comprehensive regulatory process for the Brazilian case, suggesting a redesign of the current framework that attempts to bring important perspectives from the social sciences and land-use planning to the regulation of technological risks in Brazil. This suggested design proposes new routines (pre-assessment of risk, vulnerability assessment, and resilience plan) and relocates others (such as moving the quantitative risk analysis and risk management program to the Installation License cycle). Finally, the chapter presents the main contributions of the research to the Brazilian case study.

Chapter 8 discusses how the research results and findings influence some theoretical perspectives on the technological risks regulation of hazardous linear installations. Firstly, the chapter discusses five topics: the importance of the human system in the regulatory processes; the importance of a solid transition from analysis and evaluation to management; the relevance of specific routines for risk management; the need to shift focus from management of risks to management of exposure; and a resilience plan for hazardous linear installations. Considering these five topics, the research proposes an adaptation of the Risk Governance model for hazardous linear installations. Secondly, drawing on the case study findings, the chapter presents inputs for some of the current debates in risk regulation literature.

Chapter 2 – Literature Review

This chapter is composed by three sections that aim to describe relevant background information and potential research gaps. Firstly, Section 2.1 describes the main characteristics of current models and approaches to regulate technological risks and the quantitative risk assessment method, which is the technical study commonly enforced by the models and approaches to assess hazard consequences and risk levels. As the control of the use of land is often indicated as an important component in the regulation of technological hazards, Section 2.2 identifies current trends and practices applied to integrate risk policies with land-use planning within governmental regulatory processes. Finally, Section 2.3 briefly reviews the concepts of vulnerability to hazards and place, as they reinforce the need for a contextual and comprehensive approach when addressing technological hazards and their regulatory processes.

2.1 Risk assessment and decision making

The industrialization of nations and the proliferation of new technologies have contributed to the rise of new types of risks. In particular, risks attributed to the proximity of populations to industrial and infrastructure facilities have caused great damage and considerable losses. Over the years, several major accidents[8] have brought concern all over the world about the danger that hazardous activities could represent to people living near such installations. The events of *Flisborough*, United Kingdom 1974 (Hriset et al. 2000), *Seveso*, Italy 1976 (Bertazzi et al. 1989), *Three Mile Island*, United State 1979 (Cutter and Barnes 1982), *Mexico City*, 1984 (Arturson 1987), *Bhopal*, India 1984 (Bogard 1989), and *Chernobyl*, Ukraine 1986 (Marples 1988) are examples of the most serious consequences that such technological risks can cause.

Often the lessons learned and the knowledge gathered from major accidents have pushed science and governments towards increased safety and better practices regarding risks. As such, these events are milestones raising consciousness for the need to take actions to avoid, or at least diminish, the undesirable consequences of hazardous installations for people and the environment. In the 1980s, some measures were put in place to address technological risks. The "Seveso Directive" in Europe (EEC 1982); the "Guidelines for Identifying, Analyzing, and Controlling Major Hazard Installation in Developing Countries" and the

[8] According to the Seveso Directive (1982), a major accident is "an occurrence such as a major emission, fire or explosion resulting from uncontrolled developments in the course of an industrial activity, leading to a serious danger to man, immediate or delayed, inside or outside the establishment, and/or to the environment, and involving one or more dangerous substances".

"Manual of Industrial Hazard Assessment Techniques" from the World Bank (Bank 1985); and the "Risk Assessment and Risk Management for Accidents Connected with Industrial Activities" from the Organization for Economic Cooperation and Development (1987) are reactions from governments and organizations to those major accidents (Carpenter 1995). In addition, corroborating a trend that risk policies needed to be integrated into decision-making processes, in 1992 the United Nations and diverse commercial banks signed a statement recommending risk assessments as a requisite for national and international credit lending (Carpenter 1995; UNEP retrieved 2008). These actions, and many others that were developed over the past twenty years (NRC 1994; IAEA 1995; SEVESO II 1996; Le Guen 1999; OECD 2002; IRGC 2008), have contributed to the development of new ways to integrate risk concerns into governmental decision making in many nations. The following subsection will briefly introduce some of them.

2.1.1 Models, approaches, and methods to account for technological risks

Amendola (2002:17) argues that the early deliberations on technological risk were structured into three steps: "establish the probability and magnitude of the hazards respecting the inherent scientific uncertainties (a technical process), evaluate the benefits and costs (a social process), and set priorities in such a way that the greatest social benefits are achieved at the lowest cost". This last step, setting priorities in a trade-off analysis, is usually a governmental process. The decision making is based upon a rather simplistic (though still strong) perspective: harms and hazards are balanced out by the benefits that hazardous activities would bring to the people and economy, either at the local or national level.

Over the years, diverse models, approaches and methods to consider technological risks have evolved from this initial view[9]. At this point, it is important to clarify the meanings of these three concepts in this review. Models refer to the different ways governments and societies account for risks, being closely related to the ways decisions are made. Approaches refer to the rationale behind the identification and estimation of the interactions of technological hazards with people and the environment; in other words, the methodological assumptions guiding the trade-off analysis that accounts for hazardous activities. Finally, methods are the tools used to calculate and evaluate risks. They are the instruments depicting the levels of risks one is subjected to by technological hazards. The list below presents common models, approaches, and methods:

- Millstone and colleagues (2004) identify three recurrent patterns of models: the 'technocratic' model, the 'decisionistic' model, and the 'transparent' model. Built upon the transparent model, the 'risk governance' model has also gained attention in the literature in recent years.
- The most common approaches discussed in the literature are the 'consequence-based', the 'risk-based', the 'risk-informed', the 'hybrid', the 'legalistic', and the 'precaution-based'.

[9] The research suggests the organization of the literature around these three topics because they offer a hierarchical view of the field: a regulatory process follows a model; which in turn adopts an approach to account for risks; and these risks are estimated by methods.

- Several methods are applied to estimate technological risks – please refer to Molak (1997), AIECHE (2000), Cox (2002), and Smith (2005). This study directs attention to the QRAs only since they are the most common applied method in regulatory processes, including the Brazilian case that is explored in considerable detail in the dissertation.

The next two subsections elaborate on the models and approaches applied in the regulation of technological hazards. After that, the QRA method is reviewed.

2.1.2 Models to account for technological risks

2.1.2.1 Technocratic model

The 'technocratic model' of risk is a centralized model that addresses risks in an often simplistic and unidirectional way. In this model, risk assessment is carried out based on scientific considerations. Science alone feeds governmental policy and decision-making processes, and scientists have the 'ultimate power' to judge the risks and their tolerability, providing decision makers with choices and directions (Renn 2008). It assumes that "science operates in complete independence of social, political, cultural, and economic conditions, and that science provides not just a necessary, but a sufficient, basis for policy decision-making" (Millstone et al. 2004:16). The outcome of the decisions is risk communication, which in turn becomes often the only opportunity civil society has to participate in the process. Figure 2.1 depicts the technocratic model, as presented by Millstone and colleagues.

Figure 2.1 – The 'technocratic model'. Reproduced from Millstone *et al.* (2004:16) and Renn (2008:10).

However, science when dealing with risks is often complex, uncertain, and inconclusive (Dubreuil 2001; Amendola 2002; Dubreuil *et al.* 2002; Redmill 2002; De Marchi 2003; Millstone *et al.* 2004; TRB 2004; van Asselt and Vos 2006). These limitations constitute an obstacle to the use of sound scientific information only in decision-making processes. As advocated by Millstone *et al.* (2004), "risk policy involves making judgments about the acceptability of risks, and of the uncertainties too, in exchange for some presumed or anticipated benefits. Judgments of that kind, which are concerned essentially with trade-offs, are understood to be value judgments which no amount of scientific information, theories and data could decide" (p.20). Science cannot provide all the answers. Moreover, even the answers provided can be oversimplified or unrealistic – further challenging the efficacy of the technocratic model.

2.1.2.2 Decisionistic model

The 'decisionistic model' is established upon three steps: risk assessment, risk evaluation, and risk management. Compared to the 'technocratic model', this model incorporates some other perspectives into the 'risk equation'. It assumes that science is important but that it is not the only mechanism feeding the decision-making process. Public participation becomes important and the socioeconomic background of affected groups plays an important role in the definition and implementation of governmental policies and regulations regarding risks. The model also presents a detachment of risk management from the risk assessment stage (Renn 2008). While scientific considerations drive the calculation of risks, the technical, economic, and social information now are important factors providing the shape of the risk management. The decisions are no longer taken based upon the outputs provided by science alone. Figure 2.2 depicts the 'decisionistic model', as viewed by Millstone and colleagues.

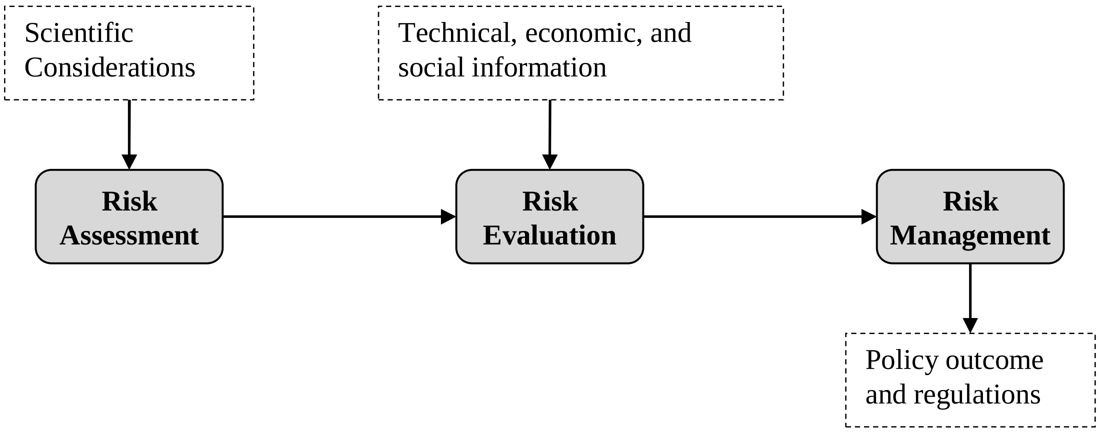

Figure 2.2 – The 'decisionistic' model. Reproduced from Millstone *et al.* (2004:16) and Renn (2008:10).

Decisionistic models still frame much of the relationship between government, science, and civil society in many countries. The list below presents some countries that apply elements of the 'decisionistic model':

- The Brazilian environmental licensing process (BELP), for instance, clearly applies those three steps to decide about the siting, installation, and operation of new hazardous activities and projects (IBAMA 2005). Risk is assessed by quantitative risk studies, evaluated according to standards of acceptability (individual risks), and managed with the knowledge gathered by the information raised in the two prior steps and other boundary conditions.

- The British Health and Safety Executive (HSE) also enforces this 'decisionistic' approach for transmission pipelines (Chatfield retrieved 2008:1). In the United Kingdom, risks are assessed applying quantitative methods and evaluated against acceptability standards (individual and societal risks). There is an intense focus on the reduction of risks, using both the "As Low as Reasonably Practicable - ALARP" and safe "So Far As Is Reasonably Practicable – SFAIRP" principles. These principles assure that cost- and time-effective measures will be implemented to diminish risks and mitigate their consequences. Decision making not only takes into consideration the numbers presented by the risk evaluation, but also some other qualitative factors that help with the limitations and uncertainties of quantitative approaches, such as the precautionary principle and good engineering practices (Ale et al. 2006). Broader public participation is granted during the assessment, evaluation, and management of the risks, and reinforced by good risk communication strategies. To some extent, this approach is similar to those applied in the Netherlands, Hong Kong, and Australia, with the main differences mostly related to the criteria of acceptability of the risks (Beroggi *et al.* 1997; Trbojevic 2004; Ale 2005; Ale *et al.* 2006; Kirchhoff and Doberstein 2006).

- Rather than comparing standards and levels of risks in a consensual approach, the United States Pipeline and Hazardous Materials Safety Administration (PHMSA) applies a 'decisionistic' approach that focuses on the enforcement of laws and codes and on the implementation of sound policies and practices to assure that risks are controlled and mitigated (McColl et al. 2000:1-6; e-CFR retrieved 2008). In 2006, the United States issued PUBLIC LAW 109–468—DEC. 29, 2006, aimed at enhancing the reliability and safety of pipeline transportation. Based on technical guidelines, pipelines and their systems and components must be inspected on a regular basis to assess safety standards and assure minimum failure rates (GAO 2006).

- In Canada, the *Environmental Health Risk Management – A Primer for Canadians* states that "the use of risk frameworks by Health Canada, Environment Canada, and other Canadian regulators is usually cited by foreign observers as representing a reasonable middle ground less cumbersome than the U.S. [United State] EPA's legalistic risk framework, and more consistent than the consensus-based decision-making processes employed by many European organizations" (McColl et al. 2000:1-6). The 'decisionistic' model applied, relies on the 'precautionary principle' and on sound scientific information and practices (McColl et al. 2000; CSChE 2004).

Although these countries still apply elements of the 'decisionistic model', it is important to mention that there has been a progressive and valuable move in practices towards the transparent model, discussed next.

2.1.2.3 Transparent model

The 'transparent model' builds upon the two prior models. According to Millstone *et al.* (2004), this model "differs from both of the antecedent models by assuming that risk assessments are framed in some important ways by their social and political contexts. From this perspective, it is misleading to represent policy-making as divided into a purely scientific up-stream assessment phase followed by a down-stream risk management phase" (p. 24). In the 'transparent model', socioeconomic and political considerations frame the scientific choices of the assessments, bringing science closer to the specific social, political, cultural and economic contexts where the risks are being assessed (Millstone et al. 2004). Another important difference from the two previous models rests on the interrelationship between assessment and management. According to Renn (2008:11), in the 'transparent model' "the interface between assessment and management has been stressed and (…) science, politics, economic actors and representatives of civil society are invited to play a role in both assessment and management". This model, with its holistic framework, seeks inclusivity by promoting participation and mutual learning. Figure 2.3 shows the 'transparent model', as viewed by Millstone and colleagues.

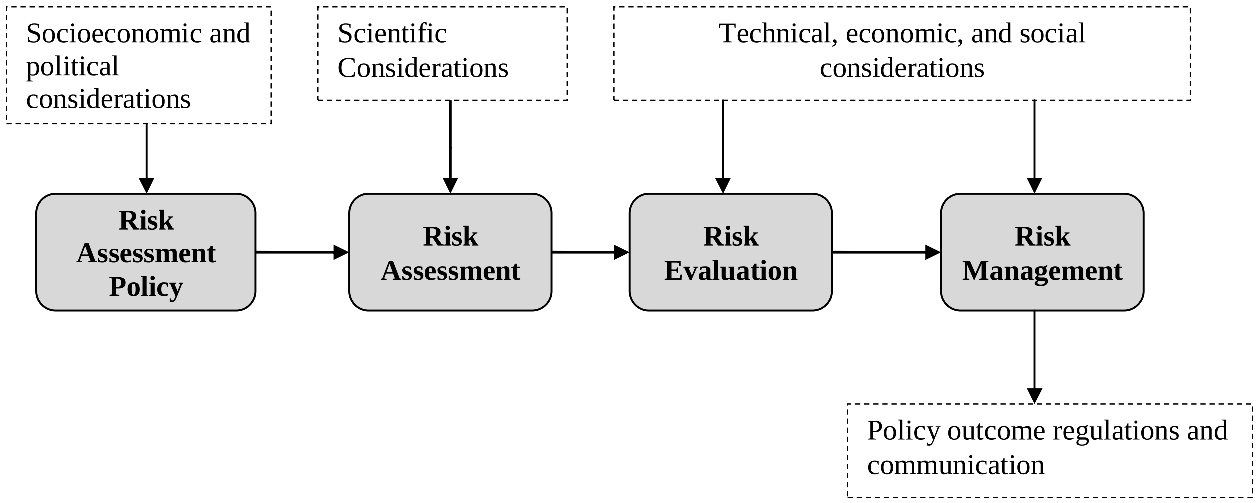

Figure 2.3 – The 'transparent' model. Reproduced from Millstone *et al.* (2004:16) and Renn (2008:10).

The 'transparent model' can be seen as a reaction to the new demands that 'risk' has been facing in recent years. According to Amendola (2002:17), "recent paradigms call for a participatory procedure, in which the different stakeholders are involved early in the risk analysis process to 'characterize' risks, even before they are given a formal assessment". Science is still indispensable in modeling and quantifying risks; however, it no longer provides the only directions that need to be taken. In a 'transparent model', non-scientific information is integrated into the decision-making process as support to overcome the uncertainties and limitations of methods to assess risks (Balzano and Sheppard 2002; Wilson 2003; Millstone *et al.* 2004). Local socioeconomic and cultural factors play an important role in the determination of the approaches used in the risk assessment, encompassing the multiple dimensions in which risks are understood and perceived.

2.1.2.4 Risk Governance model

Derived from the 'transparent model', the risk governance model is a prominent trend in the risk regulation field that attempts to address some recurrent criticisms and discussions in the literature that are not comprehensively addressed by the 'transparent model', such as:

(a) the "constant and insistent call for public participation" in governmental matters (Pellizzoni and Ungaro 2000; De Marchi 2003:173; Petts 2004; Gurabardhi et al. 2005; Renn 2006a; Ball and Boehmer-Christiansen 2007; Palenchar and Heath 2007; Coelho and Favareto 2008);

(b) the differing governmental attitudes towards different communities when dealing with risks (Dubreuil et al. 2002; Basolo et al. 2008);

(c) the methodological limitations assessing and managing risk and the "inadequate consideration of risk trade-offs" (Dubreuil 2001; Abrahamsson 2002; Dubreuil *et al.* 2002; Kozine *et al.* 2002; Kirchhoff and Doberstein 2006; Klinke *et al.* 2006; Fabbri and Contini 2008; IRGC 2008:5); and

(d) the multitude of "actors, rules, conventions, processes and mechanisms" dealing with risks (Papadakis *et al.* 1999; Amendola 2002; Millstone *et al.* 2004; Cutter 2006; van Asselt and Vos 2006; Benn *et al.* 2008; Pollard *et al.* 2008; Renn 2008:9).

According to Renn (2008:9), "'risk governance' involves the 'translations' of the substance and principles of governance to the context of risk and risk-related decision-making". Risk governance seems to better fit the aspirations and particularities of modern societies. The risk governance model emphasizes the need for constant communication and discussion of risks prior to any assessment being made. Figure 2.4 depicts the framework of the model. In this figure the important role of communication and the introduction of a pre-assessment of risks are evident.

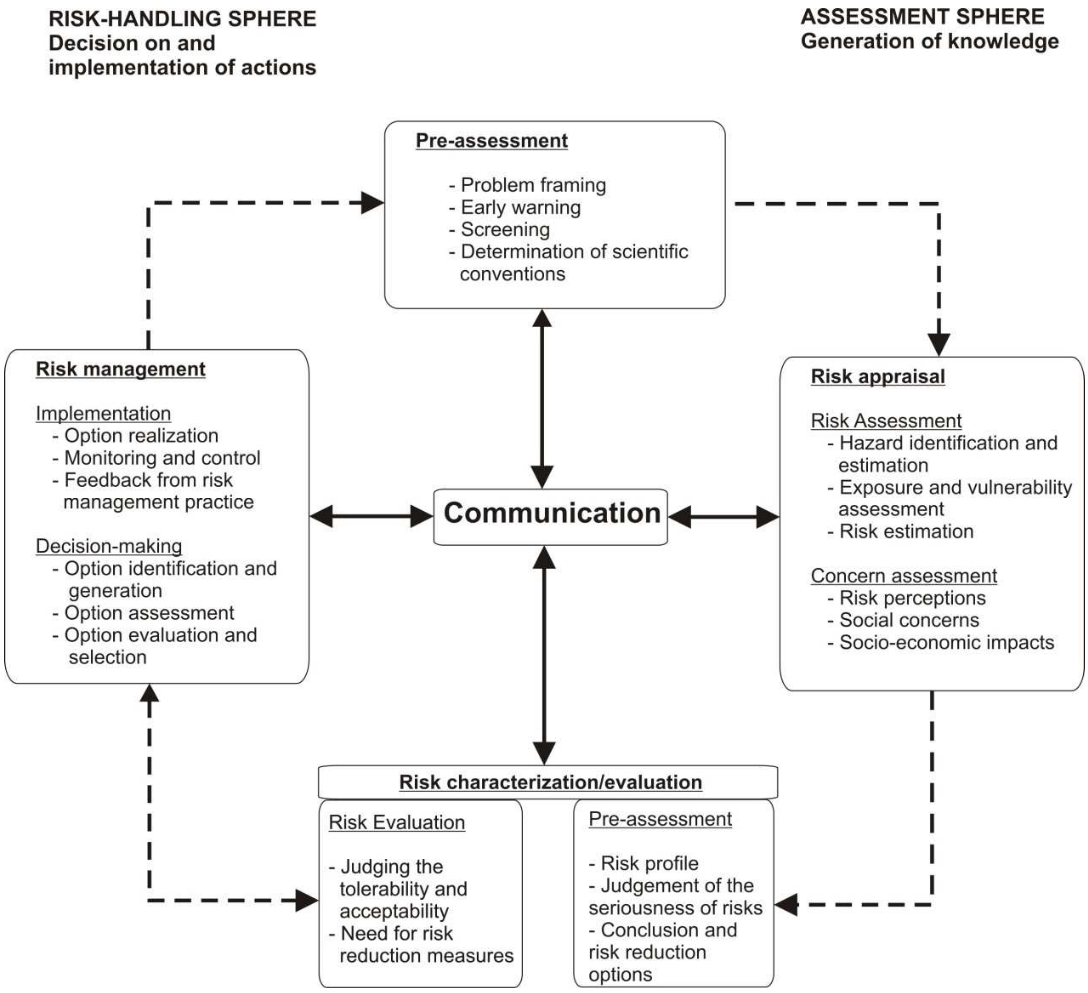

Figure 2.4 – Basic elements of the risk governance model. Reproduced from Renn (2008:365).

<u>Definition and purpose of the model:</u>

Renn defines the model:

> "**Risk governance**: includes the totality of actors, rules, conventions, processes, and mechanisms concerned with how relevant risk information is collected, analysed and communicated, and how management decisions are taken. Encompassing the combined risk-relevant decisions and actions of both governmental and private actors, risk governance is of particular importance in (but not restricted to) situations where there is no single authority to take a binding risk management decision, but where, instead, the nature of the risk requires cooperation and coordination between a range of different stakeholders. Risk governance, however, not only includes a multifaceted multi-actor risk process, but also calls for the consideration of contextual factors, such as institutional arrangements (e.g. the regulatory and legal framework that determines the relationship, roles and responsibilities of the actors, and coordination mechanisms such as markets, incentives or self-imposed norms) and political culture; including different perceptions of risk" (Renn 2008: 374).

According to the International Risk Governance Council (Renn and Walker 2008: xxiv-xxv), the Risk Governance model offers (1) a definition of risk governance, which implies collective decision making based on the particularities of “institutional design and role, organizational capacity, stakeholder involvement, collaborative decision making and political accountability on the part of public bodies and corporate responsibility on the part of private enterprises”; (2) a comprehensive framework to regulate risks, based on four routines (risk appraisal, risk characterization/evaluation, risk management, and risk communication); (3) a differentiation between “a management sphere (containing decision making and implementation) and an assessment sphere (containing risk appraisal)”; (4) an interdisciplinary approach, which pushes institutions regulating risks to pursue a “broader base of scientific knowledge” and comprehensive social concern assessments to inform their processes and support decisions; and (5) a more inclusive decision-making process, “based on the assumption that all stakeholders have something positive to contribute to the process of risk governance”.

Pre-Assessment:

The White Paper on Risk Governance (IRGC 2006; Renn 2008) describes the four steps of the model. The first step, pre-assessment, frames the problem before any effective assessment, to investigate “the different perspectives on how to conceptualize the issue” (IRGC 2006: 26). It comprises four actions: problem framing; early warning; screening; and determination of scientific conventions. Problem framing provides the background information that guide the beginning of the regulatory process, recommending that “a systematic review of risk-related actions needs to start with an analysis of what major societal actors such as … governments, companies, the scientific community and the general public select as risks and what types of problems they label as risk problems (rather than opportunities or innovation potentials, etc.)” (IRGC 2006: 24). After framing the risks and relevant issues, early warnings are carried out whenever needed (e.g., for tsunamis) and the process starts to monitor any manifestation of risks in the context being analyzed. The next component, screening, addresses ways to approach the identified risks, through the “selection of different routes for risk assessment, concern assessment and risk management” (IRGC 2006: 25). Screening investigates the risk profiles and suggests appropriate directions to perform the forthcoming assessment and management routines. Finally, the pre-assessment step develops conventions and procedural rules for comprehensive evaluation of risks, going as far as to “the selection rule determining which potentially negative effects should be considered in the risk governance process”; “the selection of valid and reliable methods for measuring perceptions and concerns”; and the elaboration of “assumptions about exposure or definition of target groups” (IRGC 2006: 25).

Risk Appraisal:

> “We envision risk appraisal as having two process stages: first, natural and technical scientists use their skills to produce the best estimate of the physical harm that a risk source may induce (…); secondly, social scientists

> and economists identify and analyse the issues that individuals or society as a whole link with a certain risk" (IRGC 2006: 34).

In the risk appraisal step, risks to human health and environment are estimated by natural and technical scientists, while any associated social and economic concerns and/or implications are assessed by social scientists and economists. According to the White Paper on Risk Governance, risk appraisal comprises two components: risk assessment and concern assessment. Firstly, risk assessment estimates risks, applying a "probability distribution of the modeled consequences" (IRGC 2006: 26). This estimation is carried out by three core components: (1) "identification and, if possible, estimation of hazard"; (2) "assessment of exposure and/or vulnerability"; and (3) "estimation of risk, combining the likelihood and the severity of the targeted consequences based on the identified hazardous characteristics and the exposure/vulnerability assessment". In this model, exposure "refers to the contact of the hazardous agent with the target (individuals, ecosystems, buildings, etc.)", while vulnerability "describes the various degrees of the target to experience harm or damage as a result of the exposure (for example: immune system of target population, vulnerable groups, structural deficiencies in buildings, etc.)" (IRGC 2006: 27). Acknowledging that the estimation of risks is often carried out by probability-based methods, the White Report points out to five challenges that risk regulators and the scientific community needs to address to improve risk assessment (IRGC 2006: 28):

- "widening the scope of effects for using risk assessment, including chronic diseases (rather than focusing only on fatal diseases such as cancer or heart attack); risks to ecosystem stability (rather than focusing on a single species); and the secondary and tertiary risk impacts that are associated with the primary physical risks";
- "addressing risk at a more aggregated and integrated level, such as studying synergistic effects of several toxins or constructing a risk profile over a geographic area that encompasses several risk causing facilities";
- "studying the variations among different populations, races, and individuals and getting a more adequate picture of the ranges of sensibilities with respect to environmental pollutants, lifestyle factors, stress levels, and impacts of noise";
- "integrating risk assessment in a comprehensive technology assessment or option appraisal so that the practical value of its information can be phased into the decision-making process at the needed time and that its inherent limitations can be compensated through additional methods of data collection and interpretation"; and
- "developing more forgiving technologies that tolerate a large range of human error and provide sufficient time for initiating counteractions".

The White Paper on Risk Governance argues that risk is a mental construct. Hence, the second component of the risk appraisal, concern assessment, plays an important role in the model. The White Paper discusses the need to consider the many perceptions human populations and individuals may have about a given technological hazard. The report enumerates five classes of risk perception, or “semantic risk patterns” (IRGC 2006: 32): (1) perception related to “risks posing an immediate threat such as nuclear energy or large dams”; (2) perception related to “risks dealt with as a blow of fate such as natural disasters”; (3) perception related to “risks presenting a challenge to one’s own strength such as sports activities”; (4) perception related to “risk as a gamble such as lotteries, stock exchange, insurances”; and (5) perception related to “risks as an early indication of insidious danger such as food additives, ionising radiation, viruses”. According to the White Paper, the regulatory processes have to properly address concerns arising from any of these perceptions.

Risk Characterization/Evaluation:

Risk characterization/evaluation, the third step in the Risk Governance model, is expected to “draw the line between ‘intolerable’ and ‘tolerable’ as well as ‘tolerable’ and ‘acceptable’” (IRGC 2006: 37). The White Paper on Risk Governance differentiates the terms tolerable and acceptable: tolerable risk refers to a activity or installation that is “seen as worth pursuing (for the benefit it carries) yet it requires additional efforts for risk reduction within reasonable limits”; while acceptable risk refers to “risks [that] are so low that additional efforts for risk reduction are not seen as necessary”. According to the White Paper, risk characterization “determines the evidence-based component for making the necessary judgement on the tolerability and/or acceptability of a risk” (IRGC 2006: 39), such as estimating risks and potential outcome scenarios. Complementarily, risk evaluation structures the decision making to “arrive at a judgement on tolerability and acceptability based on balancing pros and cons, testing potential impacts on quality of life, discussing different development options for the economy and society and weighing the competing arguments and evidence claims in a balanced manner” (IRGC 2006: 40).

Risk Management:

Finally, risk management integrates inputs from the previous steps to elaborate alternatives to monitor and control identified risks. According to the White Report on Risk Governance (IRGC 2006: 40), there are three potential outcomes for risk management:

- “Intolerable situation: this means that either the risk source (such as a technology or a chemical) needs to be abandoned or replaced or, in cases where that is not possible (for example natural hazards), vulnerabilities need to be reduced and exposure restricted”;
- “Tolerable situation: this means that the risks need to be reduced or handled in some other way within the limits of reasonable resource investments (…). This can be done by private actors (such as corporate risk managers) or public actors (such as regulatory agencies) or both (public-private partnerships)”; and

- "Acceptable situation: this means that the risks are so small – perhaps even regarded as negligible – that any risk reduction effort is unnecessary. However, risk sharing via insurance and/or further risk reduction on a voluntary basis presents options for action which can be worthwhile pursuing even in the case of an acceptable risk".

The White Paper advises regulators to pursue a systematic implementation of risk management for those risks that are tolerable and for those where their tolerability is disputed. Six steps are suggested for the elaboration of risk management procedures (IRGC 2006: 42-43): (1) "identification and generation of risk management options; (2) "assessment of risk management options with respect to predefined criteria"; (3) "evaluation of risk management options"; (4) "selection of risk management options"; (5) "implementation of risk management options"; and (6) "monitoring of option performance".

Strengths and criticism:

The Risk Governance model has received considerable attention in the past few years, being applied with often positive results in the regulation of some case-studies (Bonneck 2008; Knight et al. 2008; Kuenzi and McNeely 2008; North 2008; Okada et al. 2008; Roco et al. 2008; Tait 2008). Among the strengths of the model, Lofstedt and Asselt (2008: 79) point out that risk governance is a dynamic process "with many interactive loops and the emphasis on flexibility in applying the model in order to do justice to the particular societal context and contingencies". Lofstedt and Asselt also identify positive aspects in the design of the model, such as the relevance of communication protocols; the introduction of the pre-assessment routine; "the ambition to blend knowledge with perceptions in concern assessment and risk appraisal"; and the importance of "organizational capacity". According to North (2008: 96), the risk governance model integrates many concepts and ideas related to the regulation of risks into a single regulatory process; it emphasizes problem framing and dialogue among stakeholders; it applies a consistent rational for decision making; and it implements risk management policies in a sequential and structured way. Finally, Renn and Walker draw attention to the fact that the model "provides a structure within or around which particular risks may be investigated, discussed by stakeholders, communicated, and managed" (2008: 337) and acknowledges the importance of the context for the regulatory processes.

On the other hand, there has been some criticism as well. Loftsted and Asselt, North, and Renn and Jager compile some limitations of the model that are of relevance to this research:

- There is need for further simplification and translation of the model into a simpler language. Lofstedt and Asselt argue that the Risk Governance model is still complex and difficult to comprehend for non-risk policy specialists: "the IRGC framework did not adequately withstand the scholar's inclination to detail details and to differentiate differentiations" (2008: 81);

- The model needs a more adequate positioning. The Risk Governance framework attempts to address diverse types of risk. However, as pointed out by Lofstedt and Asselt (2008: 81), its coverage should be more restricted: "it would help, both in terms of practical and academic value, if the IRGC framework were to be portrayed and described as a 'risk governance framework for complex, uncertain and/or ambiguous risks'";
- The model stresses the need for "greater public and stakeholder involvement in risk management process" (Lofstedt and Asselt 2008: 81). However, this involvement does not necessarily imply better risk policies. According to Lofstedt and Asselt, public participation is still a controversial matter as: (1) "deliberation alone does not guarantee public trust in risk producers, risk managers and regulators"; (2) "deliberation is usually very expensive and time consuming"; (3) "it is difficult to assure representativeness of those participating in the deliberative process"; and (4) "it may be especially problematic to get relevant stakeholders and publics willing to participate … in cases of highly contested risks" (2008: 81-84);
- Although the management routines are well developed, it must still be acknowledged that risk management is a dynamic and continuous process. As pointed out by North (2008: 97), "[m]ost risk issues are ongoing, and risk management should be ongoing";
- The model does not elaborate on specific routines to implement its recommendations, or on likely specificities needed for the regulation of different types of risks. As pointed out by North, the Risk Governance model does not provide a 'to-do-list' for its implementation, "a check list, or a catalogue of what IRGC considers the 'approved' set of analytical tools and methodology" (North 2008: 93);
- According to North, the model still needs to pursue a more ideal balance between advances in the social sciences versus those in the natural sciences and engineering. North (2008: 96) argues that the White Paper on Risk Governance "should do more to indicate the importance of the scientific and engineering literature, the experience of the scientific and engineering community, and to centers of outstanding practice and scholarship".
- One last criticism addresses the White Paper on Risk Governance. Although the report stresses the burden and costs associated to the decisions related to risks, little is discussed or emphasized about the benefits the hazardous installations often bring to the local and regional context (Renn and Jager 2008).

Regardless of the criticisms above, the advances proposed by the risk governance model represent a milestone to the regulation of technological hazards. As the risk governance framework is relatively new, it is expected that scholarly works will continue to discuss the model and explore its potentialities. This research, specifically in Chapter 7 and Chapter 8, draws on the model's core elements to propose a more comprehensive way to regulate linear hazardous installations.

2.1.3 Approaches to account for technological risks

Hazard, vulnerability, risk, catastrophe, and disaster are some of the terms applied to describe elements of the complex and, many times, delicate interactions of public infrastructure or industrial facilities and human communities. Although there are diverse views and a lack of consensus on the definition of the concepts aforementioned, there are also some common points that can be used to group them, in a simplistic way, into three categories: a causal/triggering element (hazards), a boundary condition that leads to fragility (vulnerability), and the likelihood (risk) or outcomes (catastrophe and disaster) when hazards meet vulnerability.

These concepts facilitate the understanding of the approaches to address 'risk' in decision-making processes worldwide. The nuances behind them will guide the identification, measurement, and evaluation of the elements that provide the information needed to decide about technological risks.

2.1.3.1 Legalistic

'Legalistic' approaches tend to focus on the mitigation and control of *hazards*, by enforcing rigorous standards that projects, components, systems, installations, and operations must meet. It assumes that the risks can be managed by controlling and avoiding the possibility that any of such parameters will lead to a failure. For instance, the United States has a multitude of technical standards addressing industrial activities. In order to keep operating, pipelines must go through periodic maintenance programs to assure that each of their components and systems is still meeting established technical standards (GAO 2006; Chatfield retrieved 2008). If any of the components or systems do not meet the requirements, they must be replaced. However, this approach has been criticized because it may lead to severe catastrophes as it encourages people to live near hazard-prone areas since those 'safety' standards might induce a 'false' perception of security (Christou et al. 1999; TRB 2004).

2.1.3.2 Consequence-based

Consequence-based approaches prioritize the assessment and mitigation of *vulnerability*: if a hazard can lead to undesirable consequences, these consequences must be avoided. Usually, the most effective way of accomplishing this is to detach the hazards from the exposure. In other words, people should not be encouraged to live near sources of technological hazards, a completely different perspective compared to the legalistic approach. Such approaches tend to integrate urban land-use planning into hazardous activities management. For instance, France applies a consequence-based approach to assess safety distances based on the worst-case scenarios (Kirchsteiger 1999). Operators need to provide the government with a technical report stating the range of consequences to the population according to two pre-determined 'effects thresholds' (lethality and irreversible damage to human beings). The state, which is in charge of the evaluation, reports these ranges to the local communities. The decision making is then based upon a mostly decisionistic model. There is a negotiation between communities and the state in order to establish the 'safe distance' from households to the industrial or infrastructural facility. After an agreement between the parties, the local community, in charge of the land-use planning, adopts the new regulations. In case of disagreement, the government has the last word (Cahen 2006). Cahen argues that this policy has reduced vulnerability in the vicinity of hazardous industrial sites; however, it might not satisfactorily deal with places with pre-established industrial plants. Figure 2.5 depicts the French consequence-based approach, as viewed by Cahen.

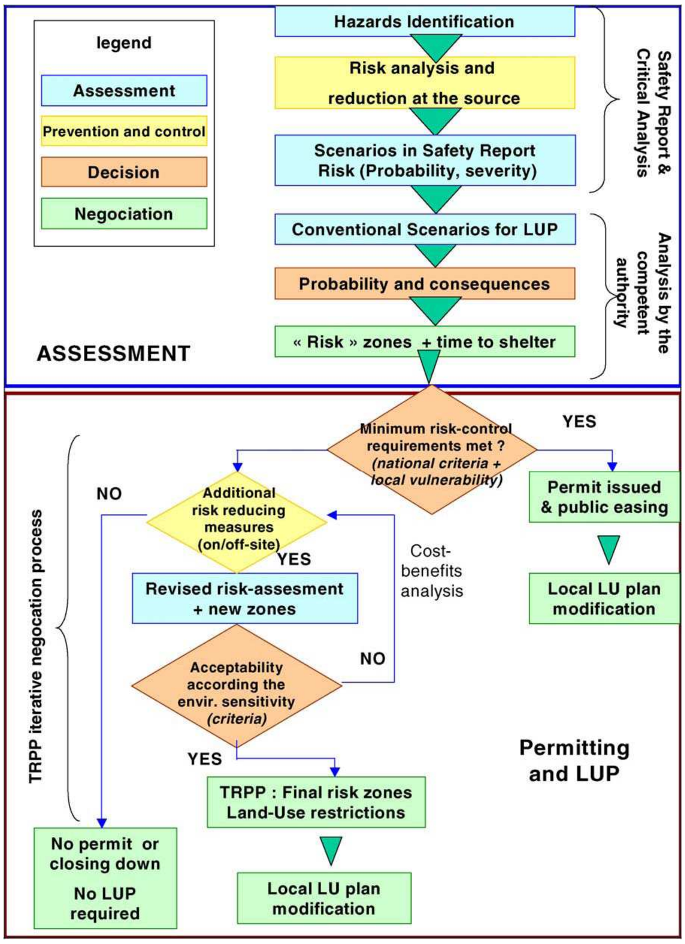

Figure 2.5 – French consequence-based approach for risk. Reproduced from Cahem (2006:296).

2.1.3.3 Risk-based and risk-informed

Risk-based and risk-informed approaches consider the *risks* as the most important component for the decision-making process. The assessment of risks is mainly composed of two elements: frequencies and consequences. In these approaches, the consequence scenarios are relativized by the expectation that these scenarios will likely occur. Decision making is often based upon graphical and numerical information, individual and societal risks rates, that are compared to thresholds of acceptability. If acceptable or tolerable, the industrial activities can operate. If not, measures should be put in place and the principle of 'As Low As Reasonably Practicable – ALARP" applied. For instance, the United Kingdom applies a risk-informed approach to assess technological risks. Individual risk is used in the elaboration of the land-use planning. Three risks zones are calculated, the inner zone (corresponding to the individual risk levels higher than $1x10^{-5}$ fatalities/year), the middle zone (individual risks higher than $1x10^{-6}$), and the outer zone (individual risks higher than $3x10^{-7}$). According to the United Kingdom's standards, no development is allowed in the inner zone. The middle and outer zone might include developments but the ALARP principle should be applied (Cozzani et al. 2006). Please refer to Figure 2.6 for an example of the British approach (applied to the Piombino port in Italy). Risk-based or risk-informed approaches have also been applied in Brazil (IBAMA 2005), Netherlands, Hong Kong, Australia (Kirchhoff and Doberstein 2006), and Canada (McColl et al. 2000).

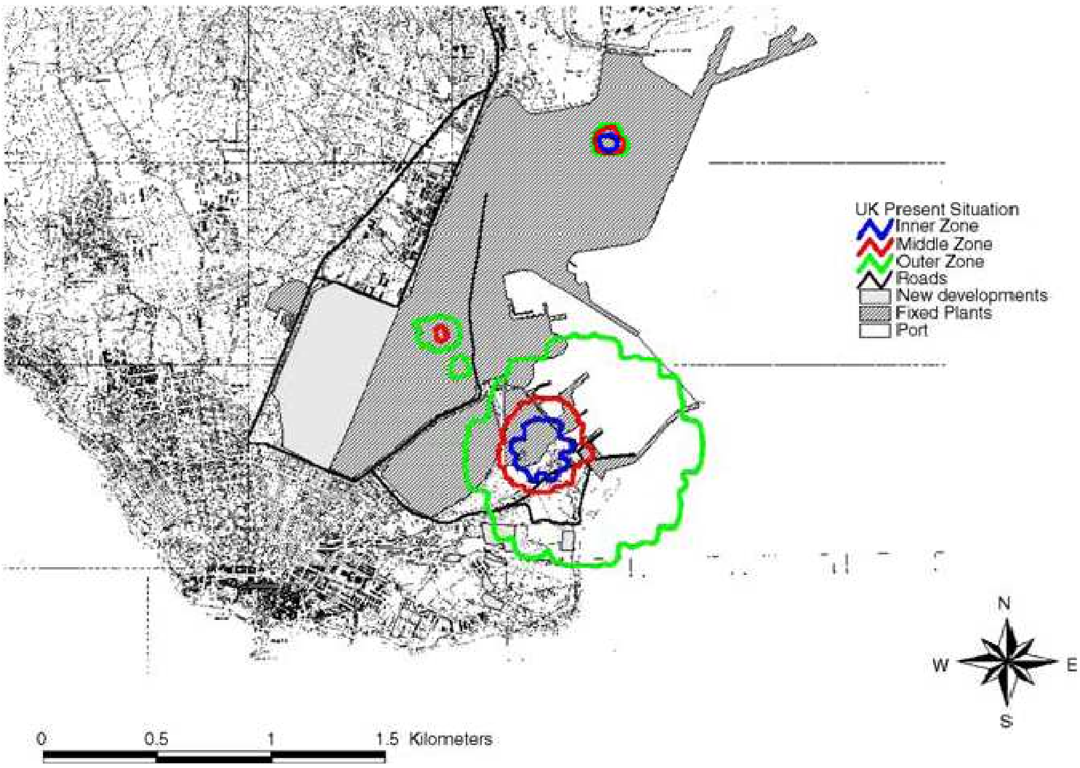

Figure 2.6 – The United Kingdom risk-based approach, represented by iso-risks curves. Reproduced from Cozzani et al. (2006:175)

2.1.3.4 Hybrid

In the hybrid approaches, *consequences* and *risks* are both important. This combination of the consequence-based with the risk-based/informed approaches has a presumed advantage of being more feasible than the often rigorous consequence-based and less 'scientific dependent' than the risk-based/informed approaches. It also facilitates the integration of land-use planning into management. For instance, in Italy the approach consists of the estimation of four consequence perimeters ('degrading damage zones'), where the inner perimeter represents areas of “high lethality” and the outer the “reversible damage” zone. Risk is visualized by the matrix of interactions of these four scenarios of consequences with four established levels of frequencies. The safety distances are estimated comparing these risks with pre-established thresholds values (Cozzani et al. 2006). Italy also provides a good example of the integration between land-use practices and risk management.

2.1.3.5 Precaution-based

The precaution-based approach tends to focus attention on the outcomes: *catastrophes* and *disasters*. This approach recognizes the complexity and uncertainty inherent in risk assessment and enforces measures that can limit the chances of doubts and errors when the scientific evidence is questionable. It is based on the assumption that precaution is a sound alternative to deal with risks when uncertainty is a considerable issue (Morris 2000; Klinke and Renn 2001; Wilson 2003; Klinke *et al.* 2006). The precautionary principle is addressed again later on in this literature review (Section 4.1.7).

Summary:

Among the five approaches described above, the risk-based/informed approach is especially relevant to this research as it is currently applied by the research’s case study (and diverse other jurisdictions). However, elements of the other four approaches eventually also contribute with insights that can be used to inform the research, such as: the enforcement of high reliability levels as a way to ensure safety, described in the legalistic approach; the focus on the assessment and mitigation of undesirable consequences to people due to the operation of technological hazards, as described in the consequence-based approach; the deliberations based on both consequence and risk levels, advocated by the hybrid approach; and the enforcement of precaution and conservative measures in face of uncertainties, as described in the precaution-based approach.

2.1.4 Methods: quantitative risk assessment

Cox describes quantitative risk assessment (QRA) as an instrument “providing a logical framework and a systematic procedure for organizing and applying scientific and engineering knowledge to improve ‘rational’ (consequence-driven) decision making when the consequences of alternative decisions are uncertain” (2007:27). A typical QRA consists of several steps with the purpose of characterizing and investigating hazards, the expected physical effects and the magnitude of consequences of extreme events, and the interaction of these events with the population nearby. The technical inputs to a typical QRA can be divided into four main sections; three steps involve ‘organizing’ information (contextual information, failure frequency estimation, and consequence prediction) and one final step involves ‘compiling’ all data (risk calculation) (McColl et al. 2000; CSChE 2004). In the first step, ‘contextual information’, the socioeconomic and environmental details of the proposed project (technological hazard) and its vicinity are gathered.

Populations likely to be affected by the project are identified and studied/characterized, expected hazards are recognized, and often a first qualitative risk estimation is carried out, usually applying a Preliminary Hazard Analysis (PHA) approach (IBAMA 2005).

Simplistically, risk can be calculated by multiplying the frequencies of occurrence of a given hazard by the predicted consequences this hazard may cause to the environment and population nearby, in a direct relation where risk = frequency * consequence (McColl et al. 2000). The other steps of a typical QRA address the three terms in this equation. 'Failure frequency estimation' deals with the prediction of the failure rates of the project. Two approaches are often applied: the use of historical information, based on background data gathered by information about accidents in the past; and the use of mechanistic models, which apply design and operational parameters to develop models to predict failures in technological systems (Kirchsteiger 1999). However, both approaches have important limitations:

- Disparities in the boundary conditions limit the use of 'historical data analysis' in systems other than those where the analysis was carried out. For instance, the failure frequency applied in the majority of the Brazilian transmission pipeline risk assessments is a number close to 10^{-4} failures/km*year, obtained from a European network (CETESB 2003; EGIG 2005; IBAMA 2005; EGIG 2008). In short, this average number is calculated by dividing the total number of failures of this European network by the total length and time of operation of the network. Although this European estimation is a reliable number from a large network, it does not represent accurately the Brazilian reality (for instance, due to the differences in the pipelines, products transported, surrounding environment, characteristics of the cities and populations, etc). Another limitation to the use of historical analysis is that, since it represents an average from the whole network, it may not precisely represent the failure rate of a given specific subsystem or single pipe. For instance, a specific region in a densely populated area or one constantly affected by erosion can have a higher failure rate than others, such as rural areas with a flat landscape. However, the use of an average number for the whole network does not consider this situation.
- Mechanistic models have important constraints as well. The estimation and use of parameters in these models are embedded with uncertainties and assumptions. Mechanistic approaches have another important limitation when calculating random events, related to third-party interference (external interference). In developed countries, third-party interference usually represents the most significant source of failures for transmission pipelines, accounting for near fifty percent according to EGIG (2005), around forty percent according to CONCAWE (2006), and twenty-five percent according to the PHSMA (2006). However, it is clear that such events cannot be appropriately addressed as a mechanistic process due to their random and inherently human nature.

The third step addresses the prediction of the consequences (e.g., type of the expected physical event such as fire or explosion) and vulnerable areas (e.g., the range for a certain level of radiation or over pressure for each physical event) in the vicinity of the transmission pipelines. Similar to the frequencies estimation, 'consequence prediction' is a complex and difficult task. It aims to predict the magnitude and the extent of the accidental events, given a set of pre-established assumptions. However, the parameters and models applied to assess the outcomes of such accidents can also bring undesirable levels of uncertainty and subjectivity that are ultimately added into the results of the QRA. In addition, often the physical, chemical, and effect models applied by the consulting companies to carry out the QRAs are truly 'black boxes'[10] to a great number of decision-makers evaluating such studies.

The last step of a typical QRA is the calculation of risk. At this point, the affected population and hazards have already been identified and the frequencies and consequences estimated. Then, 'risk calculation' consists of compiling all previous data into a mathematical/graphical fashion. The QRA's main outputs are usually presented in the form of rates or curves that indicate the expected number of individuals being fatally injured (Individual Risk) or group of people being fatally injured (Societal Risk) in a given period of time (Franks 2000; Cox 2002; Ale 2005; Purple 2005). Then decision making is based on evaluating the identified individual and societal risks levels in terms of standards and thresholds based on risk acceptability (CETESB 2003; Kirchhoff and Doberstein 2006; Chatfield retrieved 2008). For instance, Figure 2.7 presents the levels (criterion of acceptability) for Individual Risks in Brazil.

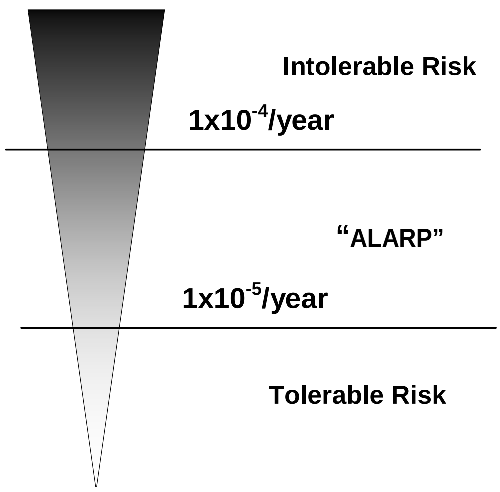

Figure 2.7 – Individual Risk Tolerability for pipelines in Brazil. Adapted from CETESB (2003). ALARP stands for "As Low as Reasonable Practicable".

[10] The estimation of the physical, chemical, and effect components of an accidental event are made by computational software not available to the environmental agencies.

Figure 2.8 shows the application of this interpretation of individual risk for transmission pipelines in the urban context. Safety distances (no-building zone) are estimated from the limits of the pipeline right-of-way and are enforced for risk higher than $1x10^{-5}$ fatalities/year.

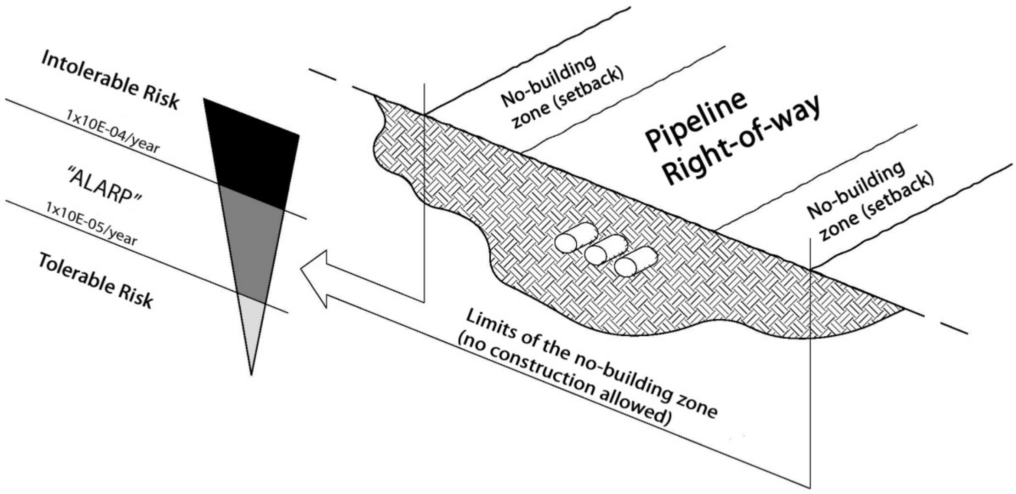

Figure 2.8 – Application of the Individual Risk into the decision making for transmission pipelines in urban context in Brazil. Reproduced from IBAMA (2005).

Box 2.1 – Risk assessments in complex systems

"Risk assessment in complex systems is strongly dependent on five crucial factors:

1. the inherent complexity of the system and the environment in which it exists and operates;
2. the models used to represent the system; i.e., how the system and its environment, and hence its complexity, are represented in the first place;
3. whether the models give equal weight to technical, individual human, organizational, and socio-political (e.g., legal) variables in determining the operation and the failure modes of the system; for instance, whether certain variables (e.g., engineering or technical) are emphasized or privileged over others, and whether the representation of the system is fundamentally biased or flawed to begin with;
4. as a direct result of factor 3., the number and kinds of terms included in determining the probability, or the probabilities, of failure of the system, and;
5. how the consequences of the failure of the system are also represented and determined."

(Bea et al. 2009:1-2)

"... no matter how much physical science and technology are involved in a complex system, no system is ever purely or solely physical or technical. Certainly no system of which we are aware is purely scientific or technical in its operation or management." (Bea et al. 2009:2)

2.1.4.1 Limitations in quantitative risk assessments

QRAs are widely applied supporting risk-based and risk-informed decision-making processes (McColl et al. 2000; Trbojevic 2004; Cahen 2006; Cozzani et al. 2006; Kirchhoff and Doberstein 2006). However, there are many criticisms of the technical aspects of QRAs (see also Box 2.1, Box 2.2, and Box 2.3) in the literature of both the engineering disciplines and social sciences due to their:

- inherent subjectivity (Amendola 2002; Redmill 2002; Cutter 2003; Murphy and Gardoni 2006; Bea et al. 2009). For instance, inputs feeding QRA's algorithms and routines are frequently based on the assumptions and experience of experts carrying out the study;
- uncertainties (Morgan and Henrion 1990; Amendola et al. 1992; Abrahamsson 2002; Amendola 2002; Kozine et al. 2002; Levin 2005; Fabbri and Contini 2008). For instance, the results from models to predict failure rates and physical effects are embedded with inherent uncertainties;
- ambiguities (Abrahamsson 2002; Kozine et al. 2002; Klinke et al. 2006; Fabbri and Contini 2008). For instance, when different QRAs result in different outcomes for the same installation and boundary conditions; and
- one-project focus (Assmuth et al. 2010). For instance, when QRAs calculate risks for a single installation, even though individuals are exposed to a group of independent hazardous facilities.

Moreover, not only do the quantitative studies have important limitations, but also the criteria judging the risks are built upon a great deal of subjectivity and ambiguity. Kirchhoff and Doberstein (2006:221) argue that "[r]isk evaluation is an important, albeit controversial, stage of risk assessment … since the establishment of what constitutes acceptable risk differs from place to place, and from people to people." They continue, "[t]he subjective value of what is considered to be acceptable risk is strongly influenced by societal norms and expectations about safety". For instance, the criteria to accept a pipeline's risks in Brazil is ten times more permissive than in other nations, leading to a scenario where 'approved' Brazilian transmission pipelines would fail in countries such as Australia, United Kingdom, and the Netherlands (Kirchhoff and Doberstein 2006:231). In fact, all this shows the inconsistencies of evaluating risks based only on the results of such a method.

2.1.4.2 Limitations of a QRA from the 'social science point-of-view'

There are many criticisms coming from the social sciences to the application of QRAs in regulatory processes as well. According to Klinke and Renn (2002:1078), "the discussion of social criteria into the formal risk evaluation process is still in its infancy and needs more refinement". Risk assessment is an important component of decision making but it should not be the only one. Instead, decisions about technological hazards should be more holistic and comprehensive to accommodate diverse factors, rather than being merely a direct outcome of the traditional risk assessment. Several authors have pointed out the limitations that a typical QRA has when addressing socio-environmental demands. The following questions, related to the applicability of QRAs in decision-making processes, are found across the literature of risk, and clearly depict the dimension of such demands:

1. Is it possible to achieve fair and comprehensive risk analysis in a risk-based study (Healy 2001; Apostolakis 2004)? If so, how? Is cost-benefit (or risk-benefit) analysis the best decision-making approach (Ersdal and Aven 2008; Roeser and Asveld 2009)? What is the best balance between precaution and cost-benefit (Starr 2003)?
2. When approaching issues of intergenerational justice versus risk and uncertainty, is the QRA an appropriate approach (Davidson 2009)?
3. How do feelings and information influence the balance between values and reasons (act) versus preferences and willingness to pay (legitimization)? What are the meanings attributed to uncertainties according to the filters proposed by Adams and Thompson (2002): psychology, economics, ideology, biology, and culture?
4. What is the role of the public? Do collective decisions influence individual risks? Is this fair (the collective deciding for the individual, who often is not represented)? Should decisions be participatory (de Freitas and Gomez 1996; Webler 1999; Davies 2001; Bryson 2004; Roeser and Asveld 2009)?
5. Is it possible to assess incommensurable risks applying cost-benefit or risk-benefit analysis (Hansson 2009)?
6. Given the gap that often exists between risk specialists and civil society, has the communication of these risks been appropriate (de Freitas and Gomez 1996; Wester-Herber and Warg 2004; Boholm 2008; Lidskog 2008)?
7. Referring to the design of new technologies and projects, do the moral and ethical guidelines on the 'regulative frameworks' represent the perspectives of all actors? Have the social factors, for instance, been taken into consideration (Asveld and Roeser 2009)?
8. Referring to the ALARP (As Low as Reasonable Practicable), what is low, reasonable, and practicable? What is safe enough? Is tolerability to risk uniform across different people? How does tolerability become acceptability and approval (Adams and Thompson 2002)?
9. Referring to the 'FN' and 'Iso-risk' curves (risk rates presented by the quantitative risk analysis), do we need to develop new ways to judge technological risks (or is just ameliorating such curves – raising the bar – enough)?
10. Considering the point of Adams and Thompson (2002:27) that "attempts to reduce the various consequences of risk-taking to a single common denominator will inevitably exclude legitimate voices", which voices are considered legitimate and which are not?

11. Since risk management is a balancing act, how is it possible to accommodate different stakeholders in harmonious decision making[11]? Has the 'individualist' group of stakeholders been more important than the others? (Adams and Thompson 2002)

Based on the inputs from the research's case study presented in **Chapter 5** and **Chapter 6**, this research will offer some contextual answers for these questions in **Chapter 8**.

2.1.4.3 Summary

Often the decisions in regulatory processes for technological risks coincide with the outputs of a QRA (McColl et al. 2000; Trbojevic 2004; Cahen 2006; Cozzani et al. 2006). Although QRAs represent a substantial portion of the decision, it does not necessarily address the complete set of situations that arises from the interaction between technological hazards and communities during the whole life cycle of hazardous installations (Amendola 2002; TRB 2004; IRGC 2006; Cox 2007; Hermansson and Hansson 2007; Bea et al. 2009). Yet, there are still a considerable number of other issues that QRAs currently do not address, such as those described above. As pointed out by Amendola

> "Risk assessment needs to be contextualized in the socio-cultural environment, and therefore, the development of reliable risk assessment procedures and the formation of reliable risk assessment procedures and the formation of an accountable risk assessment community – capable of interacting with the social parties and stake-holders – needs to be formed within viable public participation processes". (Amendola 2002:28)

QRAs deliver an important function in decision making but they cannot be the decision themselves. Figure 2.9 illustrates this, indicating that an extensive area in the regulatory processes has not been currently covered by QRAs. As argued by Aven, "... the results generated by the risk analysis need to be seen in a broader context taking into account that the risk analysis depends on assumptions made, the analyst performing the analysis, etc." (2007:307). The next sections of this chapter draw on two bodies of literature that can offer insights to understand how urban land-use and people have been accounted for by regulatory processes. Section 2.2 explores the influence of urban land-use planning on risk management practices, and vice-versa, while Section 2.3 briefly reviews the concepts of place and vulnerability to hazards within the discipline of geography.

[11] Adams and Thompson (2002:9-10) identify four group of stakeholders: individualist (e.g., entrepreneurs and developers), hierarchist (e.g., governmental institutions and representatives), egalitarian (e.g., NGOs), and fatalist (e.g., the civil society in general)

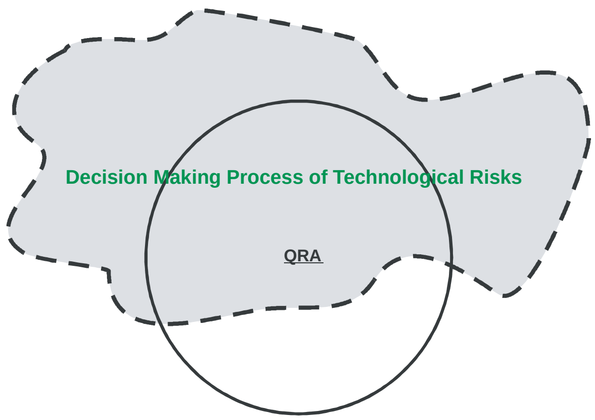

Figure 2.9 – Traditional Decision-Making Process of Technological Risks. The decision making is 'bigger' than the QRA.

Box 2.2 – Pipeline failure modes

There are many types of pipeline failures. For instance, the report (EGIG 2005) presents the most common causes of incidents in transmission pipeline systems: external interference (or third party action); corrosion; construction defect and/or material failure; incorrect operations; ground movement; other causes and unknown. These failure types can be grouped according to the time-dependence in the event cause. It is clear that some events are time-dependent and others are time-independent. While internal and external corrosion and material failure can be understood as time-dependent events, incorrect operations and external interference are events where time does not play a significant role.

The literature also presents several methods to estimate pipeline failure rates. They can be classified based on similarities: Historical Data Analysis (UKOPA 2005; EGIG 2008) and other Stochastic Approaches (Caleyo et al. 2006); Mechanistic Approaches, such as the Structural Reliability Analysis (SRA) (Zimmerman et al. 1996; McCallum et al. 2004; Nessin et al. 2004; Cosham et al. 2006); and the Finite Element Analysis (Hassanien and Adeeb 2006; Muhlbauer et al. 2006); and any combination of these previous models.

Very often governmental regulatory agencies make use of historical data analysis to calculate pipeline's failure rates. Industries and organizations worldwide have gathered pipelines' historical failure data, such as: the European Gas Pipeline Incident Data Group (EGIG 2005; EGIG 2008); the United Kingdom Onshore Pipeline Operator's Association (UKOPA 2005); the Health and Safety Executive (PARLOC 1998); the Conservation of Clean Air and Water in Europe (CONCAWE 2006); and the U. S. Department of Transportation's Research and Special Programs Administration (PHSMA 2006).

Box 2.3 – The example of the ASSURANCE project

The ASSURANCE project is a report conducted by the Risø National Laboratory in Denmark that assesses uncertainty in quantitative risk assessments (Lauridsen et al. 2002). The report discusses possible causes that led seven different technical teams to estimate discrepant results for the same chemical facility. A number of important sources of uncertainties are identified and their root causes were investigated. According to the study, deviations in frequency and consequence estimation are apparent when comparing the team's results. For instance, discrepancies in the "frequency assessments" reached up to four orders of magnitude, mainly due to differing technical interpretations of particular points of evaluation by the different technical staff, such as the failure causes and data sets considered (Lauridsen et al. 2002). Moreover, several sources of uncertainty in the "consequence assessment" are also identified. They are grouped into six categories (p. 30):

- "Scenario completeness and correctness", which deals with the correct and complete interpretation of the event, sequence of events, equipments, methods and so forth;
- "Uncertainty in the definition of scenarios", which relates to the interpretation of the events to be studied and is associated to ambiguity;
- "Modeling uncertainty, including description of physical phenomena and the detailed model characteristics, constants and parameters";
- "Input assumptions, boundary conditions, and interface between models";
- "Simplifications made throughout the analysis"; and
- "Overall level of 'conservatism' of the analyst".

Among the conclusions of the study, the implications of uncertainties in land-use planning in the vicinity of hazardous industrial establishments are stressed. The vulnerable area calculated by five technical teams are compared to each other and evaluated against threshold levels. The disparity observed in the results indicates the impacts that uncertainties might have in urban planning and risk management practices (Table A). For the individual risk curve of 10^{-5}/year, team 1 estimate a radius of 565 meters while team 3 predicts more than the double, 1310 meters. Similarly, the 10^{-6}/year individual risk curve reaches 820 meters according to team 4, while team 5 calculates a distance of 1150 meters.

TEAM	Average Radius (m) for 10^{-5}/year individual risk curve	Average Radius (m) for 10^{-6}/year individual risk curve
1	565	1325
2	125	925
3	1310	1676
4	545	820
5	530	1150
Average	**615**	**1179.2**

Table A – Comparison of predicted risk levels for the same chemical facility calculated by five different technical teams (adapted from Lauridsen *et al.* (2002)).

2.2 The integration of risk management practices with land-use planning

Another important component in the literature related to decision making for technological risks is land-use planning (SEVESO II 1996; TRB 2004; Kirchsteiger 2005). As argued by Wildavsky (2004:12), "planning is the attempt to control the consequences of our actions. The more consequences we control, the more we have succeeded in planning". In the context of land-use in urban areas, planning plays a fundamental role not only to regulate the cities' development or the 'increasing public demand to control over land' (Elliott 2008) but also in the organization of the use of land around hazardous facilities.

A good land-use plan must necessarily encompass information regarding risks. **In Europe,** the anticipation of the consequences due to the presence of hazardous facilities is a requirement in many nations. The SEVESO Directive II stresses the need to control the use and organization of land as an inherent part of risk management practices. Article 12 of the Directive demands that the Member States consider the implementation of safe distances between dangerous facilities and urban, natural and infrastructure developments (SEVESO II 1996). For instance, Christou et al. (1999) review different approaches to the control of major hazard accidents posed by fixed installations using land-use planning. The authors provide a discussion of different ways to incorporate considerations about hazards and risks while planning the use of land. They advocate that "establishments able to cause major accidents under certain circumstances with consequences extending outside their borders should be separated from residential and commercial areas by adequate distances" (p. 153). The authors also recognize limitations to the implementation of safety actions in the context of land-use planning due to the "desire to exploit in the best possible way the land, thus obtaining the maximum benefit from its exploitation" (p. 154).

The Directive also stresses the importance of risks for optimal land-use planning. For instance, Cozzani et al. (1999), studying an Italian industrial facility, correlate the application of quantitative risk assessments to land-use planning, demonstrating the feasibility of an integrated discussion about cities' growth and risk management. According to the authors, the QRAs techniques "proved to be a powerful decision-making tool in order to evaluate the impact on industrial risk of alternative land-use solutions" (p. 1). Corroborating this view, in a later study, Cozzani et al. (2006) studies differences of regulations to account for hazards and risk information in land-use planning in four European countries. The French, British, Italian, and Dutch approaches were applied to determine safe distances of an industrial area in Italy. Although "important differences are present in the extension of land-use limitations and in the priorities of hazard reduction actions identified by the different methods" (p.179), the results indicated that quantitative risk assessments are being used as important tools in the definition of the use of land in these nations.

Similarly, Basta et al. (2007) address the use of risk maps to inform land-use planning in the United Kingdom and the Netherlands. The authors argue that "'risk-maps' are a valuable tool for the visualization and exchange of risk-information" helping in the planning of the use of land. Atkins (2007) also explores the interaction between land-use planning and QRAs for large-scale petroleum storage sites in the United Kingdom. Calculating the results for different configurations, the authors showed how societal risk curves help in the estimation of safety zones.

The European trend also resounds in **North America**, where scholars have drawn attention to the need to address and incorporate hazard and risk mitigation in land-use planning (Burby 1998; TRB 2004). Addressing natural hazards, Burby (1998:1-2) argues that:

> "[by] planning for and managing land-use to enhance sustainability, we can reduce our vulnerability to disaster, if not eliminate them. Land-use plans enable local governments to gather and analyze information about the suitability of land for development, so that the limitations of hazard-prone areas are understood by policy-makers, potential investors, and community residents" and "… plans and land-use management programs enhance prospects for a sustainable future – one in which citizens and their elected officials make informed choices about using hazardous areas in ways that will not jeopardize the long-term viability of their communities." (Burby 1998:1-2)

Burby argues that "once people have exposed themselves to a hazard by locating in an area at risk, they will assume any hazards that might exist are trivial" (p. 5). Similarly, Godschalk et al. (1998:86) argue that "the general public and locally elected officials tend to minimize the importance of discouraging development in hazard areas".

These contestations have pushed authorities in North America to look for ways to address hazards and risks in urban areas. Burby (1998:18) argues that land-use planning for hazard mitigation needs to encompass several actions, such as (a) the disclosure of information related to hazards to the public; (b) the management of the land accordingly to the "type, assessed frequency, and potential damage of the hazard"; (c) the management of land in hazard-prone areas according to "social, economic, aesthetic, and ecological costs and benefits to individuals as well as the community, while taking into account the rights of private landowners"; (d) the enforcement that "all reasonable measures are taken to avoid hazards and potential damage to existing properties at risk"; and (e) the enforcement that "all reasonable measures are taken to alleviate the hazard and damage potential resulting from development in hazardous areas". However, Burby also recognizes important limitations to the implementation of these conjunct of actions. The "lack of local political will to manage land-use", the local "deficiency in management capacity", and the "regional fragmentation that limits opportunities for area wide management solutions" (p.16) are some of the obstacles pointed out.

Another approach is proposed by Berke (1998; 2000). He discusses the importance of managing the city's growth to reduce natural hazard-related risks in the United States. His approach focuses on the reduction of risk exposure based on the identification of hazardous areas; the control of the type, location, and density of development; the removal of existing developments or the prevention of future developments in hazardous areas; the implementation of practices to build up resilience; the direction of new development away from hazardous areas; and the encouragement of public participation and awareness. He also points out limitations to the implementation of such an approach: the low priority of integration of risk management practices to urban planning on public agendas and the reluctance of local leaders and communities to implement programs for risk reductions.

Similarly to Burby and Berk, Olshansky and Kartez (1998) also advocate that the management of land-use is a strong instrument to build community resilience to hazards, if effectively applied by regulators and embraced by the community. They argue that local governments hold a "wide variety of techniques to influence the location, type, intensity, design, quality, and timing of development" (p.170) that can help to control hazard and risk exposure, such as (p.170-171):

1. *Building standards*, which "regulate the details of building constructions";
2. *Development regulations,* the "traditional site development tools of current planning – the zoning and subdivision ordinances – which regulate the location, type, and intensity of new development";
3. *Critical and public facilities policies*, which allows government to have more control of some critical and pre-established facilities compared to private facilities (for instance, schools, fire stations, etc.);
4. *Land and property acquisition,* which means "purchasing properties in hazardous areas with public funds, and then using these properties in minimally vulnerable ways";
5. *Taxation and fiscal policies*, "used to more equitably distribute the public costs of private development of hazardous property, specifically, to shift more of the cost burden directly onto the owners of such properties"; and
6. *Information dissemination,* which is "intended to influence public behaviour, particularly, the behaviour of real estate consumer".

Often another approach to cope with risks in the urban context is the implementation of actions to build up community/local resilience. Burby et al. (2000:105) argue that "land-use planning for hazard mitigation is an essential ingredient in any recipe for building disaster resilient communities". The authors claim that the integration of risk mitigation actions into the land-use planning can help to increase community resilience. Stakeholder participation and public support decisions regarding land-use planning, the promotion of awareness, the discussion of mitigation and risk management goals, and the implementation of actions to prevent/control risk exposure are important steps of their model.

Similarly, Godschalk et al (1998:116) advocate for the use of land classification to determine the destination and use of the land. Developing a method to predict safe separation distances for natural gas transmission pipelines based on heat flux, Haklar (1997) also assesses the use of land classification and safety distances (setbacks) in the control of risk exposure.

Land-use planning for transmission pipelines:

Oil and gas transmission pipelines are also addressed in the literature on land-use planning. The report of the Committee for Pipelines and Public Safety draws attention to the need to integrate the planning of land with the risk-management practices in the United States (TRB 2004). This study recognizes that "just as transmission pipelines pose a risk to their surroundings, so does human activity in the vicinity of pipelines pose a risk to pipelines" (p. 6). Although the important role assigned to the control of the facilities (in particular carried out by the owner/administration of the facility), the control of the surroundings of such installations is also relevant. According to the report, "land-use decisions can affect the risks associated with increased human activity in the vicinity of transmission pipelines", regulators "have not directed significant attention to the manner in which land-use decisions can affect public safety and the environment", and "decision makers lack adequate tools and information to make effective land-use decisions concerning transmission pipelines" (p.6). The report elaborates on this problem to propose a model to account for pipeline risks considering as a fundamental core the regulation of the land-use near right-of-ways.

In Canada, the Major Industrial Accidents Council of Canada (MIACC) indicates the need for the enforcement of setbacks to control/diminish risk exposure (MIACC 1998) due to transmission pipelines. According to the report, there is great concern about the implementation of a pipeline's right-of-way in the urban context. However, the study recognizes that integrated action between urban development and safety is difficult due to the potential economic benefits from the use of the land, the costs imposed to the pipeline's operator to assure safety standards, and the lack of knowledge of local authorities.

Summary:

It emerges from the literature that the integration between land-use policies and risk regulation needs to be pursued as a way to avoid the repetition of catastrophic events from the past. Both in North America and Europe, scholarly works and technical reports/resolutions have drawn attention to the need for the development of effective ways to discuss and account for the urban land-use issue in the regulatory processes for technological hazards. This research draws on this trend and in the fact that limited attention has been directed on how to achieve this integration to offer some practical inputs to the subject, firstly addressing the case study (Chapter 7) and then regulatory processes (Chapter 8).

2.3 Context in Geography: place and vulnerability to hazards

This last section addresses two concepts broadly discussed in geography, which complements this review: place and vulnerability to hazards. As this research has a context-dependent component, the concept of place, as discussed in human geography, is briefly described to help understand the importance of the local characteristics in regulatory processes. As pointed out by Castree (2003: 182), "we must … acknowledge that place matters in a very profound and very worldly sense". Similarly, a brief review of the concept of vulnerability in the context of natural hazards is presented as a way to understand how the approaches to account for the dynamics and the implications of the interaction between human populations and hazards have evolved in the geography literature. Although, many of the insights presented in the review on vulnerability can provide directions to address the research question, it is important to mention that this section does not elaborate on opportunities to improve risk-based approaches. This discussion is left for Section 4.1.3, when the research develops its conceptual framework.

2.3.1 Place

Place is a central concept in human geography (Cresswell 2004; Gregory et al. 2009). According to Castree (2003: 167), human geographers attribute three principal meanings to the concept of place: (1) *place as location*, when place is seen as "a point on the earth's surface"; (2) *a sense of place*, when place is perceived as "the locus of individual and group identity" or the "subjective feelings people have about places, including the role of place in their individual and group identity"; and (3) *place as locale*, when place becomes "a setting and scale for people's daily action and interaction". According to the *Dictionary of Human Geography*, the current discussions on place are usually organized around three themes (Gregory et al. 2009):

- the association of place with human experiences, feelings, and emotions; "[t]he idea that place, to be a place, necessarily has meaning" (Gregory et al. 2009: 539);
- the transformation of places over time, which is a reflex of the transformations of human and non-human components; "[t]emporal change as a constituent feature of place has long been accepted, particularly in cultural-historical geographies" (Gregory et al. 2009: 540); and
- the new understandings of place in times of globalization, as a reflex of global interconnections and the modernity; "[t]here seems to be broad agreement that place does still matter, and that it would be wrong to see place and globalization as negating one another (Gregory et al. 2009: 540).

The *Dictionary of Human Geography* points out that place "is usually distinguished by the cultural or subjective meanings through which it is constructed and differentiated, and is understood by most human geographers to be in an incessant state of 'becoming'" (Gregory et al. 2009: 539). Hence, a broad understanding of the 'feelings' and 'arrangements' in a given 'location' and time are fundamental to pursue a comprehensive understanding of a place. As argued by Castree (2003: 182), “places are conceived of as being unique rather than singular”.

In the context of this research, this observation also stresses the need for a particularized view of regulatory processes, one that comprises the particularities of the human systems under analysis and the specificities of the decision-making processes of their jurisdictions. As pointed out by Amendola (2002:28), “[r]isk decision-making processes are depending on the cultural and regulatory context, which makes it difficult to transpose assessment and consultation procedures into a different socioeconomical context”.

2.3.2 Vulnerability to hazards: a brief review

In the early 1960’s, White, Burton, and Kates drew attention to the notion of vulnerability. Despite a traditional view at that time that natural hazards and catastrophes were acts of God, they pointed out the need to direct efforts to a more complete understanding of natural hazards and their associated triggering mechanisms. White (1961) presented insights on how to deal with floods in flood-prone areas, arguing that national agencies should manage “sensitivity points”. Burton and Kates (1963) proposed a definition to natural hazards, “those elements in the physical environment, harmful to man and caused by forces extraneous to him” (p. 413), pointing out to a new type of hazard “created by man … but transmitted through natural processes” (p. 414). Burton and Kates also advocated that natural hazards are often acts of “criminal negligence” in urban-industrial societies, since it was possible to estimate the location in “time, space, and size” of some of these hazards prior to any catastrophe.

Villagrán (2006) cited the United States Report to the Congress: Disaster Preparedness, from 1972, where the term “vulnerability is recognized as the predisposition of people, communities or larger jurisdictions, and of sectors such as economy, agriculture, and infrastructure to be affected by a natural disaster” (p. 11). According to this perspective, the effects of natural hazards on people could be diminished by the implementation of some proactive actions, such as the control of the urban development in flood-prone areas.

O’Keefe et al. (1976) elaborated on two variables that, when combined, lead to a disaster: “vulnerable human population” and “extreme physical phenomenon”. Both sides of this combination are of crucial importance: “without people there is no disaster” (p. 566). The authors advocated that the use of “precautionary planning”, focused on a “population’s vulnerability”, was a way to deal with the increasing number of disaster occurrences and number of lives lost. Since humans could control and modify vulnerability, it was also a human responsibility to put in place measures for better coping with vulnerable areas and natural hazards.

Burton, Kates and White (1978) connected the use of land resources to the increase of vulnerability. Human's search for "economic return" leads societies to tolerate higher "social risks". The expansion of cities and industrial parks in areas more susceptible to natural hazards contributes to the increase of life and economic losses worldwide. However, they also advocated that reasonable measures anticipating hazards could diminish considerably the "material damage, loss of life, and social dislocations" posed by any given catastrophe. Vulnerability needs to be controlled, even if by the application of the lessons just learned from a recent disaster. The prevention of repetition was a good first step in building up safer communities. According to them:

- The notion of vulnerability needs to be more complex. There is a close relation between vulnerability and social and economic conditions of nations and people: "to be poor as a nation or a person is to be particularly vulnerable" (p.12). Intricate relations in rural-urban migratory movements, concentration of wealth among countries and people, and industrial development bring more elements in the assessment of vulnerable areas. In the developing world, the lack of infrastructure and public facilities penalize the poor. In the developed world, the urban expansion frequently conflicts with hazard-prone areas.
- Human actions need to take a considerable share of the responsibility for catastrophic events: "it is *people* who transform the environment into resources and hazards, by using natural features for economic, social, and aesthetic purposes" (p.20). Although they did not address vulnerability in an explicit way, Burton, Kates, and White set a series of measures that communities could apply to address natural hazards, such as the "control of natural events and their effects", "comprehensive damage reduction", "combined multi-hazard management", and the collective action towards "adoption of adjustments".
- Four major modes of coping with natural hazards were presented in their work: absorption, acceptance, reduction, and change. The less traumatic mode, absorption, refers to the capacity of a society to absorb the effects of an external event in a relatively smooth way, remaining unaffected. When these external events are likely to affect society, there is also the possibility of accepting the risks posed by these events. However, if the risks are considerably high, societies still have two courses of action: the reduction of losses ("learning to prevent the risks"); and the ultimate change in location or use of the land.

If the foundation to the development of the 'vulnerability discipline' in the context of hazard management was already established in the 1980's, Beck (1992) brought another dimension for risks with his *Risk Society (*a short review of the book is presented in Appendix C). He argued that societies worldwide were being exposed to vulnerability from a great number of sources, from food to nuclear waste: "in advanced modernity the social production of wealth is systematically accompanied by the social production of risks" (p. 19).

According to Beck the distribution of risks are often not fair among social classes, with the lower strata usually overloaded: “poverty attracts an unfortunate abundance of risks” (p. 35). He argued that society became a laboratory, where risks were evaluated “live” (as they manifest). The idea of vulnerability should not be linked to a dimension encompassing hazards only. Seeking vulnerability and risk mitigation, the way societies and persons interact, organize, and prepare themselves in vulnerable areas is as crucial as the hazardous event itself.

Chambers (1989) elaborated on the vulnerability of individuals and households, identifying two main components: internal and external. The internal component relates to the lack of structure of individuals or households to cope with risks; while the external component refers to hazards themselves. Chambers also addressed the links between being poor and being vulnerable.

Arguing that “vulnerability is a multilayered and multidimensional social space defined by the determined political, economic and institutional capabilities of people in specific places and specific times”, Watts and Bohle (1993) claimed that vulnerability should be understood as a conjunct of factors that necessarily encompass the dimensions of time and place. Although addressing vulnerability to poverty, hunger and famine only, they advocated that vulnerability at that time was neither supported by a well-defined theory nor had appropriate tools to pursue a comprehensive assessment. Developing upon the contributions of Chamber, they expanded the ‘internal-external’ model, introducing three ways of being vulnerable: vulnerability by lack of potentiality (economic capability); vulnerability by exposure (property relation); and vulnerability by lack of capacity (class power).

While identifying that the biophysical and political economic perspectives are “two contrasting views of who may be vulnerable to global change” (p. 31), Liverman (1994) defended the need for a more comprehensive approach assessing vulnerability. According to her, the social, political, economic, and environmental information should be the core in the construction of a vulnerability profile.

The ‘Pressure and Release’ model of vulnerability was introduced in 1994 (Wisner et al. 2004), stressing root causes and the social relations (or dynamic processes) that lead to vulnerability. This model “shows the pressure from both hazard and unsafe conditions that leads to disaster, and then how changes in vulnerability can release people from being at risk” (p.35). Limited access to power is identified as examples of root causes in the vulnerability equation. On the other hand, lack of local institutions and investments, and rapid urbanization process are examples of the dynamism in societies that lead to vulnerability. Wisner et al. also corroborated the view that vulnerability is closely related to poverty and disadvantages in general. They proposed a model where the social, economic and political status of people and groups play a more realistic role to understand and estimate vulnerability, using an approach where processes account for a great part of the vulnerability, instead of the simplistic view that individuals are solely responsible for their own vulnerability.

Hewitt (1997) presented a comprehensive analysis of the concept, stressing the need for a broad social and cultural view when assessing vulnerability and risks. He pointed out that "[v]ulnerability is indicative of severe societal impairment, most often due to externally imposed constraints" (p.151). Power, or powerlessness, is usually the dominant root concept leading to vulnerability. According to him, there is a need to shift the view of the concept from a static, pre-determined viewpoint to a dynamic, action-centered one, where vulnerability is seen as 'a product of the circumstances'. He also discussed

- the need to develop a set of measures so that communities can better cope with natural and technological hazards;
- the impacts and implications that human actions and decisions have on vulnerability to hazards; and
- the importance that a comprehensive understanding of the socioeconomic profile of the likely affected population has in the assessment of vulnerability.

Hewitt also identified several broad concerns influencing vulnerability, mainly grouped as 'forms' and 'conditions'. Exposure to hazardous agents, weakness or susceptibility, lack of response capabilities, defenselessness, disadvantage, and powerlessness are the layers he names as 'forms' building up vulnerability. On the other hand, gender, social space, and economic and social status are some examples of what Hewitt called 'locus of vulnerability'.

Cutter (1996) described three different themes in vulnerability studies: vulnerability as risk/hazards exposure; vulnerability as social response; and vulnerability of places. She argued that this differentiation helps with the "theoretical and methodological orientations" of research in the area. Focusing on the vulnerability of places, she developers the 'Hazards of Place Model of Vulnerability', with "an explicit focus on locality". In this model, 'hazard potential', 'geographic context', 'social fabric', 'biophysical vulnerability', and 'social vulnerability' are dynamic elements that interact and lead to 'place vulnerability'. The core of the model is based upon the geographic context and the social fabric of a specific place. Biophysical vulnerability is a result of the exposure of a potential hazard in a given geographic location. Similarly, the social vulnerability is the result of the interaction of hazards with the social fabric.

Alexander (2000) described vulnerability as a result of a vicious circle, where politicians, electorate, planners and developers are the key actors pushing vulnerability increases. Corruption, excessive influence and negligence are factors that may trigger this circle. On the other hand, scientific research, the lessons learned from a previous disaster, and the sensitivity to risk can help slowing down the vulnerability process. Alexander also introduced some definitions for vulnerability: 'positive vulnerability' is related to the fact that ‘losses occur and are sustained’; ‘deprived vulnerability’ and ‘willful vulnerability’ are related to the way research results are (or are not) applied in the mitigation and prevention of undesired outcomes; ‘pristine vulnerability’ deals with the lack of experience with hazards in a given place; and ‘primary vulnerability’ and ‘second vulnerability’ are related to resilience and coping capacities.

Focusing on the vulnerability of the cities, Pelling (2003) presented some approaches and thoughts addressing how the development of cities, accompanied by urban sprawl, lead to vulnerability. He advocated that vulnerability is a threefold concept: ‘physical vulnerability’ relates to the built environment, the boundary conditions; ‘social vulnerability’ explains how social, economic, and political systems influence the vulnerability of people; and, ‘human vulnerability’ results from the combination of the previous two and is a process and not a status. Hence, Pelling claimed that human vulnerability is broken down into three components: exposure (location relative to hazard and environmental surroundings), resistance (livelihood and health), and resilience (adjustments and preparation).

Cardona (2004) argued that “vulnerability in social groups could (…) be understood as the reduced capacity to ‘adapt to’, or adjust to, a determined set of environmental circumstances” (p. 1). Vulnerability is seen mainly as an anthropocentric process. He pointed out that, when thinking of vulnerability, the first question that should come to one’s mind is: “vulnerable to what?” A given group of people can be vulnerable to a specific hazard, but not to another. Cardona also linked vulnerability to the ‘lack of development’ and identifies three ways in which it could be increased: physical fragility or exposure, related to the location of human settlements; socioeconomic fragility, that deals with social and economic factors; and the lack of resilience, linked to coping with and responding to impacts.

Cutter et al. (2003) argued that there are three main currents on vulnerability research: the first one focuses on the construction of exposure models, based on ‘the conditions that make people or places vulnerable to extreme natural events’ (p. 242); the second studies the frequent close relations between social conditions and vulnerability; and the third attempts to understand the vulnerability of particular places or regions by integrating the ‘potential exposure’ to the ‘societal resilience’. Cutter et al. proposed the Social Vulnerability Index (SoVI), considered by them as a step towards a more comprehensive use of the ‘Hazard-of-Place Model’ (proposed by Cutter (1996)). Cutter et al. carried out a factor analysis to identify the important factors that need to be applied for the development of a vulnerability model for the United States (focusing only on the social vulnerability component). Although admitting that the SoVI needed more refinements due to lack of consistence with the results, the authors claimed that the model provides a reasonable outlook of the general scenario of vulnerability, helping local decision-makers in the implementation of measures when dealing with hazards.

According to Birkmann and Wisner (2006), when choosing methods to asses vulnerability, some key questions should clarify the approaches one takes: “who and what is vulnerable?”; “vulnerable to what?”; “who wants to know and why?”; “what circumstances and context shape the daily life of the affected?” (p. 7). Since vulnerability is a concept applied in diverse disciplines of research, with meaning often varying considerably, they propose the elaboration of a definition for vulnerability based on a widening sphere, where the inner circle constitutes “a shared minimum agreement concerning what vulnerability is” (p. 12), and the outer one encompasses a broader scope of variables providing the definition with a more global coverage. The vulnerability spheres are organized in a sequence of steps: the inner definition is ‘vulnerability as an internal risk factor’ (intrinsic vulnerability); then comes ‘vulnerability as the likelihood of experience harm’ (human centered); followed by ‘vulnerability as a dualistic approach of susceptibility and coping capacity’; followed by ‘vulnerability as a multiple structure: susceptibility, coping capacity, exposure, and adaptive capacity’, and finally, ‘multi-dimensional vulnerability encompassing physical, social, economic, environmental, and institutional features’.

2.4 Summary

This chapter reviews the main models, approaches, and the quantitative risk assessment method applied in the regulation of technological hazards, describing their main characteristics, providing examples of their application, and discussing some of their limitations. The risk governance model, proposed by the International Risk Governance Council, represents a great step towards the accommodation of many of the current debates in the literature on social sciences and risk regulation. However, the model still has some limitations to address hazardous linear installations that represent a research gap, such as the lack of integration between risk and land-use policies and the absence of mechanisms to monitor exposure to hazards and risks. Considering these limitations, this chapter also reviews the body of literature that integrates risk management practices with land-use planning, seeking to identify current practices in Europe and North America that can provide insights to this research; and the literature on vulnerability to hazards, as a way to identify how geographers and social scientists have addressed aspects of the relationship between hazards and human populations over the past decades.

Chapter 3 – Methods

This chapter describes the methods used in the thesis. Section 3.1 briefly introduces the research methodology. Section 3.2 describes the two core research methods of this study: literature review and case study. Section 3.3 describes the four methods applied for data collection: semi-structured interviews, surveys, participant-observation, and documents. Section 3.4 presents the approach for qualitative data analysis and research validation.

3.1 Introduction

This research is based on a qualitative approach (please see Table 3.1). The literature on qualitative research covers several methods addressing topics such as research design, research inquiry, data collection, data analysis, validation, and research reporting (Creswell 1998; Babbie and Benaquisto 2002; Denzin and Lincoln 2005). This chapter outlines the methods selected to structure the research described in Section 1.4. Section 3.2 of this chapter elaborates on the *literature review* and the *case study* methods, the two core building elements behind this qualitative approach. Together, a literature review and a case study comprise a rich combination that fits comprehensively the objectives of this study.

The literature review, as research method, serves two purposes in this dissertation: to gather knowledge and inform the development of a conceptual framework; and to support the findings as an important tool for validation. A literature review is also important to pursue the research goals related to the 'theory level' (research objectives 1, 2, 3, and 7).

A case study, on the other hand, is used to approach the contextual implications of this study ('practical level' – objectives 4, 5, and 6). The Brazilian case is explored in detail, following recommendations to approach case studies discussed in the literature (Creswell 1998; Stake 1999; Yin 2008). Section 3.3 outlines the methods applied for data collection: interviews, surveys, participant-observation, and documentation. The interviews are semi-structured, as required by the conceptual framework. The surveys consist of 'objective' questions and are used to confirm information gathered in the interviews, as well as to test the conceptual framework. The last method in data collection is the observations from inside the case. The researcher was actively involved in Brazil's case as an analyst and coordinator for IBAMA for about five years and his experience is used for data collection purposes as well. Finally, Section 0 covers the methods used for data analysis and validation. A few strategies are used, including interpretive analysis, triangulation, and pattern matching.

Table 3.1 – Summary of the research's methodology

Research Methods	Case study and literature review
Data Collection Methods	Semi-structured interviews, surveys, participant-observation, and document analysis
Qualitative Data Analysis Methods	Dey's (1993) approach: indentifying phenomenon and context, understanding the intentions and processes, classifying the information (coding and grouping themes), interpreting themes, and making connections
Methods for Validation	Triangulation, pattern matching, clarification of bias, development of detailed descriptions (rich and thick descriptions, as in the literature on methods), and field observation.

3.2 Research methods

3.2.1 Literature review

A literature review comprises the identification of broad and specific information about a topic under analysis. Hart (1998:13) defines it as

> "the selection of available documents (both published and unpublished) on the topic, which contain information, ideas, data, and evidence written from a particular standpoint to fulfill certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed." (Hart 1998:13)

Hart (1998:30-31) also discusses steps that help the researcher to structure a good literature review on a given topic. The first step is to understand the structure of the knowledge on the chosen topic, as well as to identify the key scholars and works on the area. Next, the research needs to assess what methodological and moral assumptions are needed or have been used in the study of the topic. These first two steps help researchers grasp a basic sense of the field and organize a concrete starting point for the reviews. Moving on, as the researcher explores the literature, it is important to think about how the individual pieces of the information gathered interact with each other. Finally, the researcher assesses how these single pieces and their interaction contribute to the topic.

The literature review as research method serves two purposes in this dissertation: (1) to identify and organize concepts and thinking that may contribute to the improvement of risk regulatory processes (Chapter 4); and (2) to describe and support findings about the Brazilian case (Chapter 5, Chapter 6, and Chapter 7). Firstly, the literature review reconciles current trends and knowledge in the academic field with actual practices in countries and governmental institutions, exploring two particular segments: discussions in the academic community and arrangements in place in diverse jurisdiction to account for technological risks. Several areas of literature that offer critique and resolution to traditional problems in risk assessment and evaluation are identified. Further, concepts, measures, and actions from outside the traditional risk literature that can broaden the scope of information evaluated in governmental decisions about hazardous facilities are gathered for evaluation. However, only bodies of literature that can potentially contribute to this study are reviewed, as the justification for their applicability in the context of technological risks is stressed. A conceptual framework is outlined with the objective to identify and organize opportunities to improve the governmental regulation of technological hazards and risks. The research framework is developed based on the relevance of the topics being analyzed, the inputs provided by different scholars on each topic, and the researcher's assessment as to how this information helps to answer the research question.

Secondly, in order to contextualize Brazilian practices, an extensive review of the literature covering the governmental regulation processes of large projects is carried out to support the discussions in Chapter 5, Chapter 6, and Chapter 7. This review identifies the routines applied by Brazil's environmental agencies in the states and at the federal level. Special attention is given to the regulation of hazardous facilities by IBAMA (Brazilian Institute of the Environment and Renewable Natural Resources – Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis), the country's federal environmental agency. IBAMA's practices are described alongside inputs brought from scholars evaluating their strengths and limitations. Whenever observed, this review also stresses consensus and discordance among writers about any issue related to IBAMA's performance.

3.2.2 Case study

The case study as a method is discussed with a great deal of detail in the literature, being described as a common approach in qualitative research (Creswell 1998; Stake 1999; Creswell 2003; Denzin and Lincoln 2005; Gerring 2007; Yin 2008). Creswell defines it as

> "… a qualitative approach in which the investigator explores a bounded system (a *case*) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving *multiple sources of information* (e.g., observations, interviews, audiovisual material, and documents and reports), and reports a case *description* and case-based themes". (Creswell 2007:73)

As noted by Creswell, case-study research can be either a "strategy of inquiry, a methodology, or a comprehensive research strategy" (2007:73). As a relatively flexible method of research, it is expected that there will be differences in its use from one research to another. Regardless the various approaches taken to explore a case, the use of the case-study method needs to converge to a common element that is the case itself. Stake elaborates on this arguing that "[w]e could study it analytically or holistically, entirely or by repeated measures or hermeneutically, organically or culturally, and by mixed methods – but we concentrate at least for the time being, on the case" (Stake 2005: 443). Hence, when applying case-study methods, researchers need to carefully choose a case that best fulfills a research project's goal(s). It is important to have in mind what the case can offer to the study and how the research can best benefit from it.

3.2.2.1 Structuring a case study

Creswell (2007), Yin (2008), and Stake (2005) offer some inputs on ways to structure a research case study. The first important action researchers need to pursue is to carefully choose the case(s) so as to fulfill the research's goal(s). As pointed out by Yin, case studies are often used to explain, describe, illustrate, explore, or evaluate (Yin 2008:15). For any of these purposes, it is important to anticipate the contributions brought from the case in order to best benefit from the method.

Next, efforts are directed to framing the study. Creswell argues that the focus of a case study should be "developing an in-depth description and analysis of a case". To achieve this goal, researchers need first to assess the significance of the case being studied, as well as its context and boundaries. After this preliminary step, the development of the case moves on to the definition of a unit for analysis, such as an event, an activity, or a process. Next, there is the collection and analysis of data. Data collection can be done in multiple forms, such as interviews, observations, and documents. Data analysis strategies include "analyzing data through description of the case and themes of the case as well as cross-case themes". Finally, the researcher proceeds to the elaboration of a report describing the case and its findings (Creswell 2007:78-79).

Yin's *Case Study Research: Design and Methods* (2008) does not provide a particularly different view on the matter. On the contrary, he shares a considerably close perspective on how to carry out case-study research. He claims that case studies have certain central elements that encompass (a) answering a 'research question'; (b) the elaboration of theoretical propositions to address the case study; (c) the definition of the unit(s) of analysis; the development of the logic linking data to the propositions; and (d) the criteria applied for interpreting and validating findings (summary Yin 2008: 1).

According to Stake, the "major conceptual responsibilities of the qualitative case researcher include: a) bounding the case, conceptualizing the object of study; b) selecting phenomena themes, or issues (i.e., the research questions to emphasize); c) seeking patterns of data to develop issues; d) triangulating key observations and bases for interpretation; e) selecting alternative interpretations to pursue; and f) developing assertions and generations about the case" (Stake 2005: 459).

This research's case study benefits from the recommendations offered by these three scholars. In the next sections, the Brazilian case is structured and organized around six steps that help in the development of the case's framework: (1) the description of the *phenomenon* under analysis; (2) the identification of the case's *context (or natural setting)*; (3) the delineation of the case's *boundaries and unit of analysis*; (4) the identification procedures for *data collection*; (5) the identification of methods for *data analysis*; and (6) the definition of strategies for the case study's *validation*. The choice for this sequence of steps is based on the understanding that it leads to a case study's framework that better fits the purposes of this study and that the framework's rationale is in agreement with the literature in the area. The first three steps are presented below, as an introduction to the Brazilian case. The last three will be addressed in Section 3.3 (Methods for data collection) and Section 0 (

Qualitative data analysis and validation). However, before addressing the case study, some facts are presented to provide background information on Brazil.

3.2.2.2 Background information on Brazil

Brazil is a large country in South America, famous for its enormous tropical rain forest (the Amazon Forest) located on Brazil's north, soccer players, and the Carnival parades celebrated in its most famous city, Rio de Janeiro. Recently the country has also gained international attention for its increasing participation in international politics and economics. Brazil has been maturing as a democracy since 1986, gradually reshaping the country. The CIA's *The World Factbook* offers a brief introduction to the country (retrieved in April 2010):

> "Following more than three centuries under Portuguese rule, Brazil gained its independence in 1822, maintaining a monarchical system of government until the abolition of slavery in 1888 and the subsequent proclamation of a republic by the military in 1889. Brazilian coffee exporters politically dominated the country until populist leader Getulio Vargas rose to power in 1930. By far the largest and most populous country in South America, Brazil underwent more than half a century of populist and military government until 1985, when the military regime peacefully ceded power to civilian rulers. Brazil continues to pursue industrial and agricultural growth and development of its interior. Exploiting vast natural resources and a large labor pool, it is today South America's leading economic power and a regional leader. Highly unequal income distribution and crime remain pressing problems." CIA the World Factbook.

The CIA's *The World Factbook* also indicates some relevant geographical aspects of the country:

- Brazil borders Argentina (1,261 km), Bolivia (3,423 km), Colombia (1,644 km), French Guiana (730 km), Guyana (1,606 km), Paraguay (1,365 km), Peru (2,995 km), Suriname (593 km), Uruguay (1,068 km), and Venezuela (2,200 km); the only countries not bordered by Brazil in South America are Ecuador and Chile. The country also has an extensive coastline along the Atlantic Ocean (7,491 km);
- The climate is mostly tropical, with regions of temperate climate in the south;
- The country is mostly flat, with a highest point of 2,994 m (Pico da Neblina);
- Brazil has extensive natural resources, such as “bauxite, gold, iron ore, manganese, nickel, phosphates, platinum, tin, uranium, petroleum, hydropower, and timber”;
- Brazil lays in a geographical region with few natural hazards, aside from recurring droughts in the northeast, floods in the rain season, and occasional frost in the south;
- The country struggles with complex environmental issues, such as the deforestation in the Amazon Basin that “destroys the habitat and endangers a multitude of plant and animal species indigenous to the area”; a “lucrative illegal wildlife trade”; air and water pollution in Rio de Janeiro, Sao Paulo, and several other large cities; land degradation and water pollution caused by improper mining activities; wetland degradation; [and] severe oil spills”;

As for the Brazilian population (estimated by IBGE (2010) as 200 million people), it is concentrated along the coast, especially in the states of São Paulo (41 million people, comparable to the population of Argentina according to the *World Factbook*), Rio de Janeiro (comparable to Chile), Bahia (comparable to Ecuador), Rio Grande do Sul (comparable to Greece), and Paraná (comparable to Portugal). Minas Gerais, with population comparable to Australia, is the preeminent state away from the coastline. The 2000 Brazilian census indicate that 53.7% of Brazil’s population is considered white, 38.5% mulatto (mix of white and black), 6.2% black, and 0.9% other (includes Japanese, Arab, Amerindian). Unspecified ethnic group accounts for 0.7% of the population. The population is in its majority Christian: according to the 2000 census, 73.6% of the population follows the Roman Catholic Church, 15.4% protestant doctrines, 1.3% is spiritualist, and 0.3% Bantu/voodoo; while 7.4% follows no religion. According to the CIA World Factbook, Portuguese is the official and most widely spoken language; although less common languages such as Spanish, German, Italian, Japanese, English, and a few Amerindian languages are also spoken by some minority groups.

Finally, the CIA’s *The World Factbook* also offers a good synthesis of the Brazilian economy:

> “Characterized by large and well-developed agricultural, mining, manufacturing, and service sectors, Brazil's economy outweighs that of all other South American countries and Brazil is expanding its presence in world markets. Since 2003, Brazil has steadily improved macroeconomic stability, building up foreign reserves, reducing its debt profile by shifting its debt burden toward real denominated and domestically held instruments,

> adhering to an inflation target, and committing to fiscal responsibility. In 2008, Brazil became a net external creditor, Brazil's external debt totaled less than its foreign reserve holdings, and two ratings agencies awarded investment grade status to its debt. After record growth in 2007 and 2008, the onset of the global financial crisis hit Brazil in September 2008. Brazil's currency and its stock market - Bovespa - saw large swings as foreign investors pulled resources out of Brazil. Brazil experienced two quarters of recession, as global demand for Brazil's commodity-based exports dwindled and external credit dried up. However, Brazil was one of the first emerging markets to begin a recovery. Consumer and investor confidence revived and GDP growth returned to positive in the second quarter, 2009. The Central Bank expects growth of 5% for 2010." CIA's The World Factbook.

Since a comprehensive description of Brazil is not an objective of this thesis (Box 3.1 also presents relevant quotes and facts about the country), the research suggests some resources for further information: *From Inside Brazil – Development in a Land of Contrasts* (Thomas 2006); *Brazil: Equitable, Competitive, Sustainable – Contributions for Debate* (World Bank 2004); *BRICs and Beyond* (Sachs 2007); *Social exclusion and mobility in Brazil* (Gacitúa-Marió and Woolcock 2008); *Inside Brazil - A New Future* (The Guardian 2008); and *Brazil Takes Off - A 14-Page Report on Latin America's Big Success Story* (Economist 2009).

Box 3.1 – Selected facts and quotes about Brazil

- Brazil is a developing nation, according to the CIA's *World Factbook* (CIA 2009) with "large and well-developed agricultural, mining, manufacturing, and service sectors" (Sachs 2007; The Guardian 2008; Economist 2009). In 2001, the country was named by *Goldman Sachs* one the BRICs, alongside with Russia, India, and China, as the likely leading economies of the future (O'Neill 2001). Brazil's estimated nominal GDP of US$ 1.6 trillion makes the country the 8th economy of the world (World Bank 2008; CIA 2009).

  > "in some ways, Brazil outclasses the other BRICs. Unlike China, it is a democracy. Unlike India, it has no insurgents, no ethnic and religious conflicts nor hostile neighbours. Unlike Russia, it exports more than oil and arms, and treats foreign investors with respect." (Economist 2009: 15)

- The country has experienced a consistent period of economic growth in the past fifteen years, motivated by a "process of implementing a stabilisation programme, with a view to achieving macroeconomic stability" (Sachs 2007: 75). However, the continuity of sustained economic growth depends on investments in infrastructure (Sachs 2007), such as transmission pipelines, which many times have direct social and environmental implications. Although Brazil has comprehensive environmental legislation regulating large projects and hazardous facilities, the country is deemed to lack compliance and enforcement of the laws (McAllister 2005).

  > "In Brazil, the environmental licensing has been the subject of intense controversy, involving even the highest authorities of the country. On the one hand, there are those who say the excessive demands and slowness of the licensing process are responsible for delaying important infrastructure works, mainly in the energy area. On the other hand, there are complaints that the licenses are granted because of economic and political pressures and also to the detriment of relevant environmental issues" (Lima and Magrini 2009: 110).

- Brazil is a federal democracy with strong political institutions and free and independent press (Economist 2009), though, according to the *Economist*, struggles with an "obstructive government" or "strong government presence"

  > "The Brazilian state's problem is not so much that is overbearing and incompetent, a common complaint, but that it is weak where it ought to be strong and strong where it should be weak. It can withhold environmental permits for new hydroelectric dams and ports, preventing them from being built, but it cannot stop raw sewage

from being pumped into the river that runs through the country's largest city, or keep illegal loggers from despoiling it forests" (Economist 2009: 14)

- Brazil's population is estimated at 200 million people (IBGE 2010), with 86% living in urban areas (CIA 2009) and 7.6% living on an incoming of less than US$ 1 (PPP) per day (The Guardian 2008: 19).

  "Economic growth and macroeconomic reforms have significantly contributed to the stabilization of the economy and the alleviation of poverty. Nevertheless, there is an increasing consensus among Brazilian policy makers, scholars, legislators, and civil society organizations that growth and successful macroeconomic policies have not resolved the problems of inequality and social exclusion that generate and sustain poverty. Inequality and social exclusion persist as the main challenges facing Brazilian society today" (Gacitúa-Marió and Woolcock 2008: 97).

- Brazil is a continent-sized country, with total area of 8,514,877 sq km that makes it the 5th largest in the world (CIA 2009).

  "Geographical distances in Brazil are very large; the distance between the northern and southern extremities is about 4200 km and between the eastern and western extremities is about 4400 km. The country is divided into five geographical regions, comprising in total 26 states and the federal district. There are more than 5500 municipalities" (Glasson and Salvador 2000: 193).

- According to the CIA's *The World Factbook*, the country produces 2.422 million bbl/day of oil (13th in the world) and 12.62 billion cu m of natural gas (39th in the world). Consumption levels spin around 2.52 million bbl/day of oil (8th in the world) and 23.65 billion cu m of natural gas (32th in the world). These numbers do not consider the new discoveries of offshore oil made in pre-salt layers that can boost the country as an exporter in the global market (Economist 2009) and expand the country's pipeline network. The current pipeline network of the country (2009) comprises 62 km of condensate/gas; 9,989 km of natural gas; 353 km of liquid petroleum gas; 4,517 km of oil; and 4,465 km refined products.

  "With major new oil finds and the rise of ethanol, this sector, more than any other, is fuelling the Brazilian boom" (The Guardian 2008: 5).

  The offshore field is "a massive oil discovery by the state-owned Petróleo Brasileiro (Petrobras); a find that will not only transform the fortunes of the Brazilian energy company but also the country's economy" (The Guardian 2008: 5).

Figure 3.1 shows the most economic developed and populated region in the country (southeast Brazil), as well as the major transmission pipelines serving this region, operated by TRANSPETRO (a subsidiary of the Brazilian multinational energy company Petrobrás).

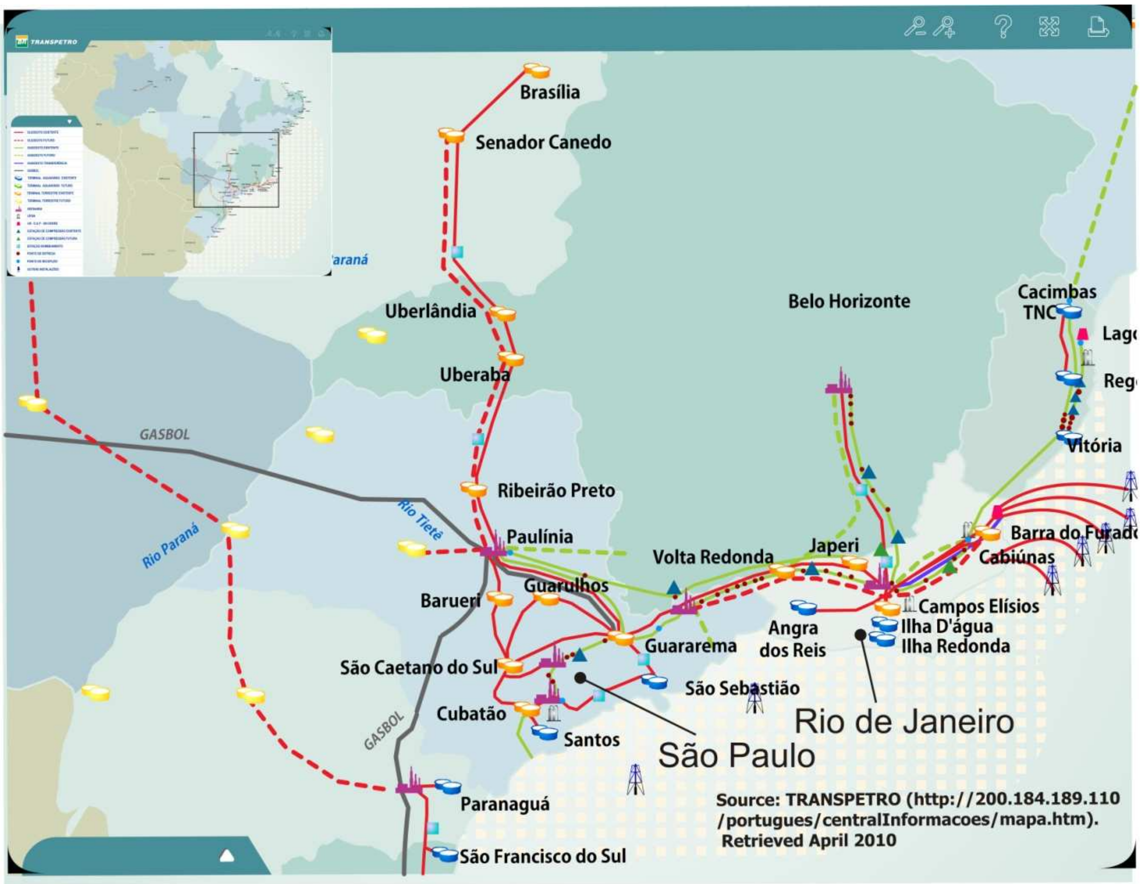

Figure 3.1 – Southeast Brazil and TRANSPETRO's pipeline network. Reproduced from TRANSPETRO's website.

3.2.2.3 Framing the Brazilian case

Phenomenon: *Risk exposure due to gas and oil transmission pipelines in Brazil.*

The population in Brazil is exposed to technological risks due to problems likely associated with land-use planning and regulation of hazardous facilities (see also Box 3.2). This affects a considerably large number of people in Brazil living in areas very close to a transmission pipeline, as shown in Figure 3.2, Figure 3.3, Figure 3.4, and Figure 3.5, taken by the researcher between 2003 and 2004, and Figure 3.6 (Rennó retrieved April 2010). It is noteworthy that the majority of the households shown in those pictures were built after the beginning of the pipeline's operation. Until 2004, the Brazilian federal law 6,766 (Brasil 1979) enforced a mandatory 15-meters setback on each side of any pipeline's right-of-way (ROW) intended to protect people from pipelines and vice-versa. Since this legal demand was not being met in nearly all large transmission pipelines in Brazil, the federal law 10,932 modified the 15-meter setback requirement attempting to regulate the urban expansion around the pipeline's ROWs (Brasil 2004). Nowadays, the new law attributes to the environmental agencies the responsibility to enforce, if needed, setbacks in urban areas. The estimation of this safety area is supported by risk curves presented on QRAs: if the calculated risk rates are above a threshold, the setback is enforced; if the risk rates are ‘acceptable’, there is no need to implement any setback.

Figure 3.2 – Encroachment around the pipeline right-of-way.

Figure 3.3 – Encroachment around the pipeline right-of-way.

Figure 3.4 – Encroachment around the pipeline right-of-way.

Figure 3.5 – Encroachment around the pipeline right-of-way.

Source:Petrobras/TRANSPETRO (http://www.braziltexas.org/attachments/contentmanagers/767/Capturing-Pipeline-Opps-in-Brazil.pdf)

Figure 3.6 - Encroachment around the pipeline right-of-way. Reproduced from Petrobras/TRANSPETRO (Rennó retrieved April 2010)

Context (or natural settings): *Brazilian urban patterns and the governmental institutions regulating the land-use and hazardous facilities.*

The phenomenon’s context encompasses two main factors: (1) the urban patterns and institutions controlling the use of the land in Brazilian cities; and (2) the peculiarities of gas and oil transmission pipelines. In Brazil, the cities’ growth often does not follow the common patterns observed in North American or European cities (Hardoy and Satterthwaite 1989; Pinto 2003). Although Brazil has a considerable number of formal instruments for land-use planning, such as the “Statute of the Cities” (Brazilian Federal Law 10,252/2001), the reality shows that a large part of the urbanization in the country happens in illegality and disorganization: new streets, lots, and residences are built in discordance or noncompliance with the civil and environmental legislation and the city plan policies and codes (Pinto 2003). For instance, consider the Brazilian cities of Rio de Janeiro and Brasília. Rio is the second largest metropolitan area in Brazil (IBGE 2006). The city and its metropolitan area have a high number of slums and suburbs lacking basic urban infrastructure. Other common characteristics of these neighborhoods are disorganization in the use of land and low socioeconomic indexes of their population (Gay 1994; Szwarcwald et al. 2002). On the other hand, Brasília is the planned capital city of the Republic. Resembling the shape of an airplane, the “pilot plan”, the city’s core area accommodates harmoniously governmental, commercial, and residential areas (or zones). However, the increasing demand for dwelling and the rigor of its city’s master plan have also pushed a considerable part of the population to look for new developments in Brasília’s suburbs, many of them in illegal areas (Serra et al. 2004; Paviani 2007).

Notwithstanding the differences in the socioeconomic profiles between Rio and Brasília, the lack of proper urban infrastructure can be observed in both municipalities. At different scales, disorganized urbanization processes in Rio, Brasília, and in practically all large cities in Brazil, lead to a multitude of undesired results, such as those observed by Pinto (2003):

- The inadequacy of the road systems, making it difficult for the transit of buses, ambulances, police vehicles, and garbage trucks;
- The development of neighborhoods susceptible to erosions and floods;
- The absence of public space for the implementation of health, recreational, and educational urban equipment;
- The pollution and degradation of water bodies (it is also important to mention that usually in these developments water supply comes from wells instead of the city’s water system, and sewer system are nonexistent) ; and
- The illegal connections to the electrical power systems, resulting in risk of accidents and fire.

<u>The regulation of transmission pipelines:</u>

Among the types of projects licensed by IBAMA, the regulation of oil and gas transmission pipelines (OGTP) in Brazil has peculiarities that are the object of closer attention in this case study. OGTPs are important infrastructure systems of industrialized countries. Usually connecting production fields to great urban centers, they also represent a considerable source of risks to populations in metropolitan areas in Brazil due to their linear characteristic. An OGTP can be very extensive and cross many cities with demand for gas. Unlike a fixed industrial activity, where the boundaries between communities and the industry are relatively restricted, an OGTP may interact with a considerably higher number of individuals and communities. Although this does not necessarily represent a particular challenge for risk calculation, the same cannot be said for risk management. Managing risks is closely related to boundary conditions, which can vary significantly from place to place and/or with time. For instance, Figure 3.7 and Figure 3.9 (taken in 2001) and Figure 3.8 and Figure 3.10 (taken in 2007) show changes in the boundary conditions for a pipeline right-of-way in the Brazilian city of Macaé (state of Rio de Janeiro – near to Cabiúnas in Figure 3.1). Within six years, an inhabited area is transformed in a new urban development – even though the presence of a pipeline’s right-of-way shown by the yellow line in the aerial photos. The orange line in Figure 3.8 and Figure 3.10 is a proposed path to avoid this new development.

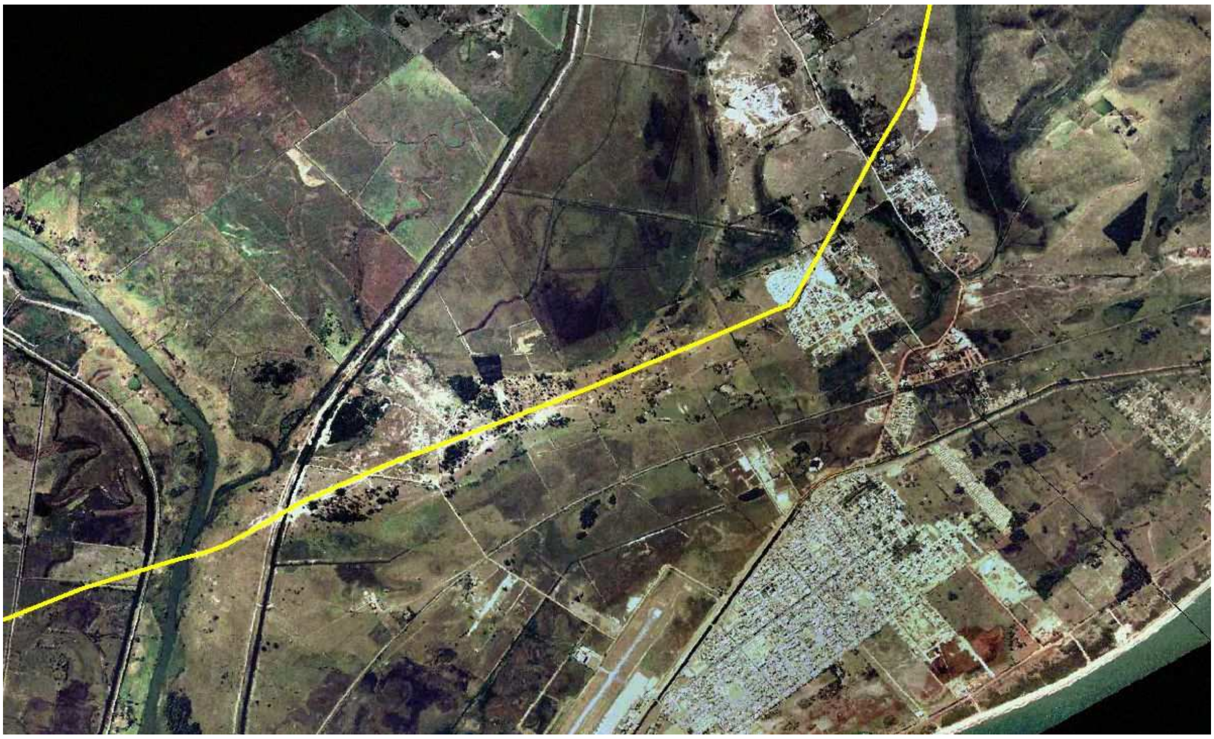

Figure 3.7 – City of Macaé, aerial photo taken in 2001 (scale 1:20,000). The yellow line is the pipeline right-of-way. Source: PETROBRAS/ENGENHARIA/IETEG/ETEG/EAMB - Engenharia de Avaliação Ambiental.

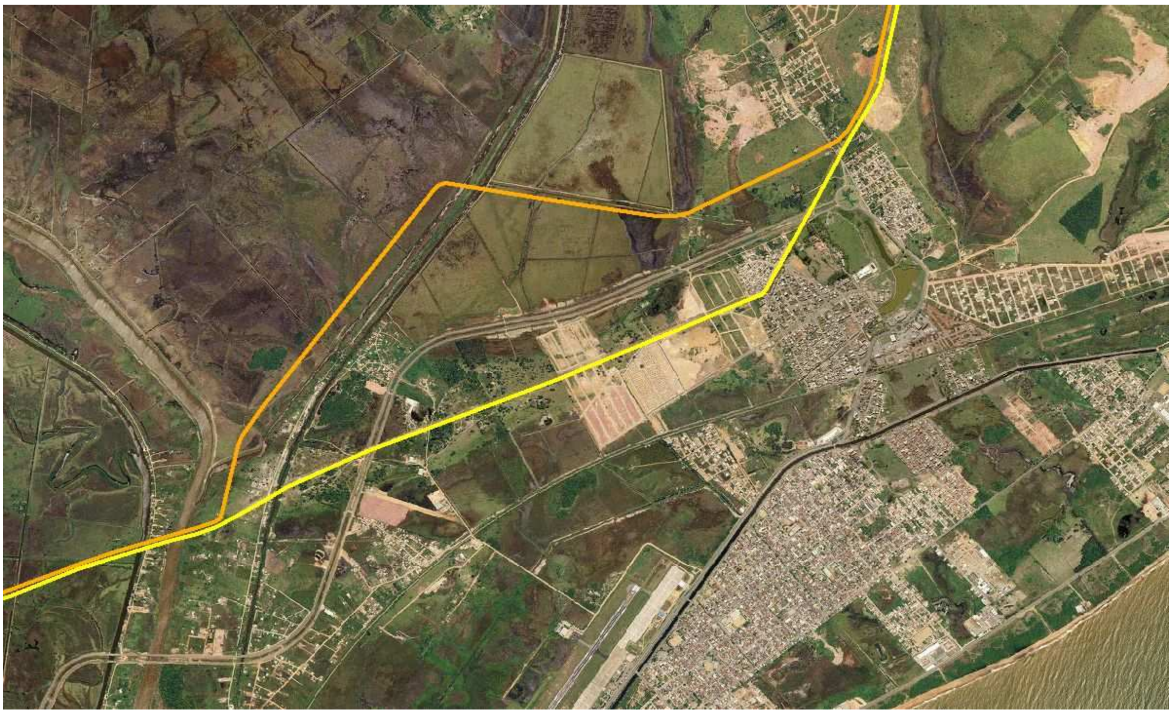

Figure 3.8 – City of Macaé, aerial photo taken in 2007 (scale 1:20,000). The yellow line is the pipeline right-of-way. The orange line is a proposed path to avoid the new urban development. Source: PETROBRAS/ENGENHARIA/IETEG/ETEG/EAMB - Engenharia de Avaliação Ambiental.

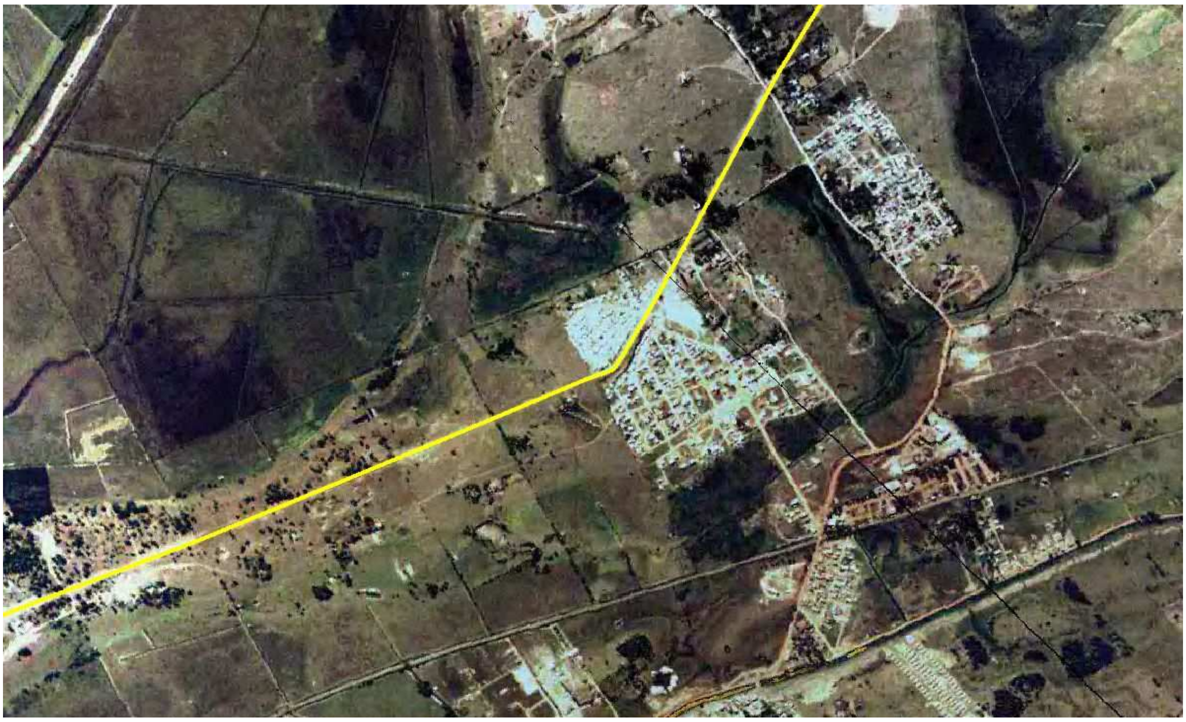

Figure 3.9 – City of Macaé, aerial photo taken in 2001 (scale 1:10,000). The yellow line is the pipeline right-of-way. Source: PETROBRAS/ENGENHARIA/IETEG/ETEG/EAMB - Engenharia de Avaliação Ambiental.

Figure 3.10 – City of Macaé, aerial photo taken in 2007 (scale 1:10,000). The yellow line is the pipeline right-of-way. The orange line is a proposed path to avoid the new urban development. Source: PETROBRAS/ENGENHARIA/IETEG/ETEG/EAMB - Engenharia de Avaliação Ambiental.

Boundaries: *The case study is restricted to*

1. *the analysis of the environmental licensing conducted at the Brazilian federal level by IBAMA;*
2. *gas and oil pressurized transmission pipelines; and*
3. *pipeline sections in urban area.*

The case study is delimited in three aspects. Firstly, the BELP is a complex process and only part of it is analyzed. Brazil is a federal republic and each municipality, state, and the federal government has its own role in the implementation and performance of national policies (CONAMA 1997). This case study focuses on aspects of the environmental decision-making process at the federal level only, which is carried out by IBAMA and regulates the largest projects in Brazil. Second, pipelines are systems used to transport different products. Moreover, the pipeline's project and operation conditions can vary considerably from one pipe to another as well. The case study considers only large pressurized pipelines transmitting gas, oil, or any other petroleum by-product. Please note that by doing so the study excludes distribution pipelines, such as the lines supplying residences, business, and industries. Finally, since transmission pipelines are long linear systems, the case study is also limited to their segments in urban area, which excludes rural uninhabited areas.

Box 3.2 – Cubatão, Brazil, 25 February 1984

"A major spill of some 700,000 l of gasoline caused a catastrophic fire in Cubatão, in the state of São Paulo, Brazil. The leak occurred in an 18-in. diameter pipeline located near the shantytown of Vila Socó, where approximately 8,000 people lived. The fire, which lasted almost 10 [hours], started in the early morning, but the gasoline leak had been perceived by some of the residents at least two [hours] before the fire began. There are some reports that residents had begun to collect and stockpile the spilled gasoline in their homes. The fire resulted in the complete destruction of an area of 100,000 m^2, nearly 75% of the shantytown (see Fig. 4). The bodies of 67 persons— almost all burned beyond recognition—were recovered from the ruins of their homes. Among the more than 200 seriously injured, many were unable to survive the severity of their burns and died. In any event, the number of fatalities commonly attributed to the fire (508) exceeds the number of fatalities that results from the sum of the number of bodies recovered (67) and the number of seriously injured people that died (200), by a considerable margin" (de Souza Jr 2000: 492-493).

3.3 Methods for data collection

Several methods for data collection are discussed in the literature (Babbie and Benaquisto 2002; Creswell 2003; Denzin and Lincoln 2005; Hay 2005; Creswell 2007; Berg 2008). Often, scholars group data collection methods according to the approach taken – qualitative, quantitative, or mixed. For instance, Creswell argues that qualitative research usually incorporate some or all of four basic types of procedures: observations from the field, interviews with people and institutions relevant to the research, analysis of public and/or private documents, and the analysis of audio and visual material (2003:185-88). Other times, the data collecting methods are discussed within a specific research method. For example, Yin argues that the most common data collection methods for case study research are documentation, archival records (such as maps and charts, previous survey data, and personal records) interviews, direct observations from the site, participant-observation (when the research takes part on the studied case), and through physical or cultural artifacts (2008:85).

However, regardless of the different ways that data collection is approached in the literature, it is clear that the selection among these methods depends mostly on the research itself, design and purposes. Since the empirical information in this research is used to support its case study and to test the research's conceptual framework in the Brazilian context, data is gathered using four different sources: (1) semi-structured interviews, (2) surveys, (3) participant-observation, and (4) document analysis.

3.3.1 Interviews

Semi-structured interviews with key stakeholders aim to describe IBAMA's environmental licensing and to assess its performance in the regulation of risks. Questions for the interviews are based on the research's conceptual framework elaborated in Section 4.2 and the particularities of the BELP. Key stakeholders are defined as professionals or individuals of the civil society who have experience with the routines applied by IBAMA, especially those related to the environmental licensing of gas and oil transmission pipelines. The list of key stakeholders encompasses representatives from the governmental institutions (environmental and other sectors; federal, state, and local levels), developers and operators of transmission pipelines, consulting companies, NGOs and representatives of the civil society, academia, and public prosecution, for a total of thirty-two interviewees. The interviews are conducted in Portuguese and recorded using the software Skype, being translated into English by the researcher. Appendix B presents the interview questions.

3.3.2 Surveys

A six-question survey is performed with the same stakeholders from the interviews. The surveys questions serve two purposes. Firstly, they follow up the considerations from the interviews, clarifying points considered relevant to the research purpose. Second, they test the research's conceptual framework in the

Brazilian context. Questionnaires were posted online on the website *LimeService* (all questions were in Portuguese). Out of the thirty-two participants, thirty answered the full questionnaire and two did not reply. The survey questions are presented in Chapter 6 and Chapter 7.

3.3.3 Participant-observation

Participant-observation is at the same time an important input for data collection and a considerable source of bias. As described by Yin (2008:93-94), "[p]articipant-observation provides certain unusual opportunities for collecting case study data, but it also involves major problems". Yin points out that "[p]articipant-observation is a special mode of observation in which you [researcher] are not merely a passive observer. Instead, you may assume a variety of roles within a case study situation and may actually participate in the events being studied". That is an unusual positive opportunity to "gain access to events or groups that are otherwise inaccessible to scientific investigation". However, being so close to the object of study also implies bringing some concerns. Yin draws attention to three important points. Firstly, if the participant was once an 'internal', it could be difficult for him/her to take the role as an 'external' conducting the research. Second, there is a risk that professional or personal bonds could lead the researcher to take a position *pro* group or organization being studied. Third, the researcher could give more weight to his/her participation and inputs, compromising the analysis of other perspectives. Therefore, it is important that the research acknowledges and addresses the likely bias coming from participant-observation to properly apply the method.

The use of participant-observation in this research is justified since the researcher was involved in the BELP (which also justifies a Brazilian case study), initially as an environmental specialist evaluating the risks of hazardous facilities such as the Brazilian gas and oil transportation pipeline network (for four years) and later as coordinator of licensing for the Coordination of Energy, Nuclear, and Pipelines (for one year). His experience in the case is then exploited throughout the study as a complementary source of information. The interviews, surveys, literature review, and other documents help to control the bias. Moreover, Section 3.4.2 (Validation) also addresses this question when it talks about approaches to validate the research findings.

3.3.4 Document analysis

Finally, two main types of documents are examined for data gathering. The first type includes scholarly papers and academic theses describing the routines of the BELP (e.g., Glasson and Salvador 2000). These documents often pointed out limitations in the licensing processes (e.g., Glasson and Salvador 2000; MPF 2004; Nicolaidis 2005; Kirchhoff and Doberstein 2006; Montano and Souza 2008). The second type includes technical norms applied to regulate routines of the BELP (e.g., Brasil 1979; CONAMA 1997; ESTATUTO 2002; CETESB 2003; Brasil 2004; IBAMA 2005).

3.4 Qualitative data analysis and validation

3.4.1 Qualitative data analysis

Dey argues that qualitative data analysis is "a process of resolving data in its constituent components, to reveal its characteristics elements and structure. Without analysis, we [researchers] would have to rely entirely on impressions and intuitions about data as a whole" (1993:31). Such an analysis not only seeks to describe the data, but also "to interpret, to explain, to understand – perhaps even to predict" it. According to Dey, "[t]he core of qualitative analysis lies in these related processes of describing the phenomenon, classifying it, and seeing how our concepts interconnect" (1993:31). Dey presents six steps for qualitative data analysis (see also Table 3.2).

- Firstly, the research needs to "develop thorough and comprehensive descriptions of the phenomenon under study", providing a deep assessment of actors, actions, and interactions being analyzed (1993:32).
- Second, the context where the phenomenon takes place is scrutinized – "[c]ontexts are important as a means of situating action, and of grasping its wider social and historical import" (1993:33).
- Third, the research identifies the intentions behind the data. Dey points out that "[i]n qualitative analysis there is a strong emphasis on describing the world as it is perceived by different observers" (1993:37) so it is important to consider and explore different perspectives on the issue.
- Fourth, it is important to acknowledge that the phenomenon and context under analysis may change, or have already changed over time. It is also important to identify any possible process(es) leading to these changes.
- Fifth, data need to be classified for better analysis, usually by interpretation and explanation. According to Dey, " [t]o interpret is to make action meaningful to others, not just or even necessarily within the terms used by the actors themselves", while "[t]o explain is to account for action, not just or necessarily through reference to the actors' intentions" (1993:41).
- Finally, the sixth step puts the different segments and pieces of information gathered in the previous steps, all together again, to develop meaningful connections to the data.

Table 3.2 – Steps for qualitative data analysis

<u>Dey's steps for Qualitative Data Analysis (1993):</u>
1 – Identify the Phenomenon
2 – Describe the Context
3 – Understand the Intentions
4 – Observe the Processes
5 – Classify the Information
6 – Make Connections

This research applies Dey's approach to qualitative data analysis for both research methods: literature review and case study. For the literature review, *phenomenon and context* are addressed in previous sections of this Chapter, that is, risk regulations in the context of the engineering disciplines and social sciences. Relevant and applicable information from the literature helps the researcher to *understand the intentions* and trends across the disciplines covering risk regulations. The review also carries out an assessment of how such regulations have evolved and what are the *processes* driving the changes. Once the first steps are completed, the information is then *classified* into a group of elements that can improve the regulation of technological risks, such as measures for public participation and environmental justice. Finally, the researcher *connects* all these elements with the development of the thesis' framework.

As for the case study, *phenomenon and context* are also addressed in previous sections of this Chapter, that is, risk exposure to transmission pipelines in the context of the Brazilian environmental licensing process. Insights into the *intentions and processes* in the Brazilian case is gathered by interviews, surveys, participant-observation, and documents. The methodology to *classify* and make *connections* for each of these data sources is presented next.

3.4.1.1 Interviews

The semi-structured interviews are analyzed with the aid of software NVIVO, which provides a set of tools including text analysis. Firstly all the interviews are transcribed from the original audio record in Portuguese, translated into English, and then imported to an NVIVO file. Participants are coded so their identities are protected. Then, the researcher proceeds to carefully read all the interviews to identify themes from the data. This is a continuous process that often requires the researcher to read the same interview transcription a few times. Twenty-six themes (or nodes in NVIVO) are identified, ranging from positive and negative aspects of the BELP to possible causes for the pipeline's right-of-ways encroachment. NVIVO helps the researcher to categorize the interviewees' inputs into the themes, organizing the information for better understanding of the phenomenon, context, and individualized perspectives on issues. These themes are then interpreted by the researcher and reported in a manner that describes the Brazilian case in regards to the regulation of risks from transmission pipelines.

In a second step, the interviews are also analyzed to assess the Brazilian case against the research's conceptual framework. Building on the first NVIVO file described above, a new NVIVO file is developed to assess the performance of the BELP using twelve qualitative indicators. NVIVO helps the researcher identifying inputs from the participants that may indicate any assessment of value, such as the discontentment with the number of public hearings or criticism of the ways the technical studies are presented to the general public. Here again, information from the thirty-two transcriptions, and the subsequent organized themes, are scrutinized to feed the assessment of the BELP performance of each indicator. A report of the assessments is presented in Chapter 5.

3.4.1.2 Surveys

The surveys also serve to describe and to test the Brazilian case against the research's conceptual framework. Analysis of the surveys is carried out using Microsoft Excel and the software provided by the online server (LimeService). Due to the small sample size and the relatively high concordance in the responses, the surveys are not used to provide any statistical inference. Rather, they are used to corroborate information from the interviews. Hence, a simple count of the results is made for each of the six questions. Results are interpreted and applied by the researcher in the assessment of the performance carried out in Chapter 6 and the discussion of suggestions to improve the case study in Chapter 7 (the survey questions are also presented in these chapters). The surveys also opened up an opportunity for participants to provide written comments on the questions and the survey. Those comments are approached in a manner similar to the one described to the interviews.

3.4.1.3 Participant-observation

Observations of the researcher as an insider in the Brazilian case are analyzed based on reflections about his experiences. Occasionally, the researcher expresses his opinions during the description and evaluation of performance of the case study as a complement to the points raised by other sources.

3.4.1.4 Documents

Documents are consulted whenever information about a specific topic is required. For instance, terms of reference provide information about the scope of QRAs in Brazil, and normative guidelines and laws provide inputs about the framework of the BELP.

3.4.2 Validation

In qualitative research, data often comes in the form of subjective information. In addition, a researcher's interpretation throughout the study also plays a fundamental role. Hence, good qualitative research is only possible with consistent validation of the strategies for inquiry and the respective findings (Stake 1999; Creswell 2007; Yin 2008). Creswell considers "'validation' in qualitative research to be an attempt to assess the 'accuracy' of the findings, as best described by the researcher and the participants (and) a distinct strength of qualitative research in that the account made through extensive time spent in the field, the detailed thick description, and the closeness of the researcher to participants in the study all add to the value or accuracy of a study" (2007:207-08).

Creswell also argues that the strategies to validate a study are a choice of the researcher (2007:207). However, the choice of these strategies should not be arbitrary, but rather an option that needs to be based on the choice of features that best fit the research design. Although Creswell acknowledge that there are many approaches to validate qualitative research, he offers a review of eight main strategies (2007:207-). Considering the methodological approach described in this chapter, the **bolded** items below are used in this research (items 1, 2, 5, and 7):

1. **The use of the time spent in the field to diminish misinterpretations and bias introduced by the researcher or the informants.**
2. **The use of triangulation, an approach where "researchers make use of multiple and different sources, methods, investigators, and theories to provide corroborating evidence" (p. 208).** According to Stake, "[t]riangulation has been generally considered a process of using multiple options to clarify meanings, verifying the repeatability of an observation or interpretation. But acknowledging that no observations or interpretations are perfectly repeatable, triangulation serves also to clarify meanings by identifying different ways the case is being seen" (Denzin and Lincoln 2005:453-54).
3. The submission of the work or findings to a peer review providing "external check of the research process" (p. 208).
4. The use of negative case analysis, where the researcher confronts his hypothesis in light of negative or disconfirming negative elements until all cases fit.
5. **The clarification of researcher bias so the "reader understands the researcher's position and biases or assumptions that impact the inquiry" (p. 208).**
6. The use of 'member checking', where the researcher asks the participants to review the findings and interpretations.
7. **The development of rich and thick descriptions of issues, which "allows readers to make decisions regarding transferability … because the writer describes in detail the participants or settings under study" (p.209).**
8. The use of an external auditor to examine both the research processes and results.

Besides these eight strategies, Yin (2008) also discusses the '**pattern matching**', also applied by this research. In this strategy of validation the researcher uses the many pieces of information from the case being analyzed to identify if any are related to some of the research's theoretical predictions or propositions. A dissonant pattern can indicate problems in the data and interpretation, while coherent and concordant patterns, brought by different sources, help validating the findings.

3.5 Study limitations

Four aspects associated with the research design need to be addressed as they represent potential limitations in the development of the study.

1. As this research design utilizes a case study, the implications of this work may be restricted to Brazil only, or to countries with similar social systems. Since the empirical part of the study is carried out in Brazil, the contextual research findings need to be interpreted back to the theoretical level so these findings can offer inputs to other jurisdictions.
2. This research is mainly qualitative; and qualitative research often carries an inherent level of bias that needs to be recognized. Likely bias is addressed with the use of sound methods to design, collect data, analyze data, and report qualitative studies.
3. The third limitation follows up on the previous. The researcher participated actively in the Brazilian case as a civil servant working in the regulation of technological risks, and his likely bias needs to be approached in the same way.
4. The last limitation refers to the representativeness of participants in the case study. Participants in the interviews and surveys were selected based on their familiarity with the Brazilian case and the segment they represent, in order to ensure they could effectively contribute to the discussion. Sampling ensured balanced representation from governmental institutions, corporations, academia, non-governmental organizations (NGO), and civil society[12], but it is not possible to speak with certainty about the representativeness of the sample group.

3.6 Summary

This chapter addresses the two research methods applied by the research: literature review and case study. It also discusses the methods used for data collection, data analysis, and research validation. An introduction to the case study is presented, with a brief introduction of information about Brazil, followed by the description of the phenomenon under study (risk exposure due to gas and oil transmission pipelines in Brazil), its natural settings and context, and the boundaries and unit for analysis. The next chapter develops the research's conceptual framework, drawing on the literature of diverse disciplines to identify opportunities to improve the regulatory processes of technological hazards.

[12] Civil society is described by Foley and Edwards (1996:38) as "a 'dense network of civil associations' (…) to promote the stability and effectiveness of the democratic polity through both the effects of association on citizens' 'habits of the heart' and the ability of associations to mobilize citizens on behalf of public causes".

Chapter 4 – Conceptual Framework

This chapter develops the conceptual framework for this research: an organization of concepts and thinking from bodies of the literature outside the risk management field in a structured way in order to cover gaps in the current regulatory processes for technological hazards. Section 4.1 draws on diverse concepts and thinking in disciplines in the social sciences and risk management related to identifying opportunities to improve the decision-making processes of technological risks. Section 4.2 integrates these opportunities topics into a conceptual framework that aims to incorporate the social sciences' perspectives into risk-based decision making.

4.1 Opportunities to improve risk-based approaches

The limitations to the application of QRAs in risk-based decision-making processes, discussed in Chapter 1 and Chapter 2, impel managers, regulators, and the scientific community to develop new ways to regulate technological hazards. The concepts assessed in the next sections are collected from various literatures, in order to identify elements outside the specific literature on risk assessment and management that can help to design a more comprehensive framework for such regulatory processes. It is important to stress that, although many literatures overlap with this research (such as place-based vulnerability and resilience, natural accidents, ethics of risks, and coupled human-natural systems), the focus of this chapter is on developing a conceptualization to improve decision-making processes for technological risks in order to better transfer debates and advances in the scientific community to the daily routines of regulators, planners, risk specialists, and managers.

The research selected nine topics to contribute to the conceptual framework: governance; environmental and social justice; vulnerability; resilience; panarchy; complex systems; ethics; phronetic social science; and the precautionary principle. However, other concepts were also analyzed but not considered in this study since they do not offer any significant input, either because they overlap with one (or more) of the nine already select concepts or they are not appropriate for the context of this research. For instance, *Adaptive Management* is not considered due to overlap with other concepts and the criticism to its results and effectiveness in the literature (McLain and Lee 1996). The concept of *Organizational Learning* overlaps with adaptive management, so it is not considered for the same reason. *Environmental Impact Assessment* (EIA) overlaps with risk regulatory processes[13]. Moreover, a consistent QRA should also provide decision makers with the technical socioeconomic information needed for their decisions. *Anti-Science*, although proposing a new perspective on the role of the scientific information, is not considered because it does not provide concrete inputs to the specific research. *Participatory Decision-Making* overlaps with governance, social justice and ethics. *Complexity, natural accidents,* and *high reliability* are considered under complex systems thinking. *Place-Based Vulnerability* overlaps with vulnerability and resilience.

4.1.1 Governance

Governance supports new approaches to deal with technological risks, as discussed by Thompson and Rayner (1998; 1998), Dubreuil (2001; 2002), Renn and Roco (2006c), Klinke et al. (2006), Kristensen et al. (2006), the International Risk Governance Council (IRGC 2007), Renn (2008) and others. Public participation, institutional strengthening, and governmental integration are some aspects of governance that can improve the performance of risk assessment and management practices. For instance, public participation brings legitimization of decisions, and especially helps in the effective implementation of the agreed terms discussed in the regulatory processes; management of risks and exposure benefit from the presence of strong governmental institutions enforcing specific programs; and the harmonization of the demands for land-use and risk management is not possible without an integrated action of all relevant governmental regulatory bodies. On the other hand, the lack of good governance practices leads to many undesirable outcomes. One noteworthy point is the likely increase in vulnerability levels due to the presence of technological hazards in urban areas. In other words, when addressing risks, 'blind spots' can appear where overlapping responsibilities are expected, different actors are responsible for different roles in the regulatory process (present and future), an unequal share of power among actors is present, and conflicts of many sources are expected. In such a complex context, not only do hazards threaten people and communities, but the negligence, inefficiency, and unpreparedness of the governmental actors can be as important as the hazard itself.

[13] EIA is commonly addressed in the literature as a decision-making process and/or a technical input. As a decision-making process it overlaps with risk regulatory processes. As a technical input it overlaps with QRAs. In both cases, EIA is not considered (at least explicitly) in the development of the conceptual framework as the research understands that the chosen nine topics grasp much of the essence and required components for a good EIA process.

4.1.2 Environmental and social justice

There are many connections between the concepts of *environmental and social justice* and the limitations present in traditional risk-based approaches. Arnold defines environmental justice as the "pursuit of fairness in environmental and land-use policies" (2007:v). Goldman links environmental and social justice to the complexity and uncertainties inherent in QRAs arguing that "many uncertainties of risk analysis tend to give polluters the benefit of the doubt and the victims of pollution the burden of proof" (2000:542). Beck connects vulnerability to disadvantaged people when he says that "some people are more affected than others by the distribution and growth of risks" (1992:23) and "poverty attracts an unfortunate abundance of risks" (p. 35). Three opportunities to improve practices in risk management embrace the environmental and social justice cause: 'risk education', 'public participation', and 'siting fairness':

- Often individuals and communities have different perspectives on hazards and risks. Goldman (2000:543) argues that "people with lower incomes, less education, and poor mobility are at tremendous disadvantage" in understanding the products of risk analysis. Risk education is an opportunity to systematically educate and prepare affected communities (in present and future perspectives) to better cope with hazards and risks. A continuous and interactive exchange of knowledge and information between governmental regulators, developers, and local communities can also boost public participation, contribute to the 'scientific versus local knowledge' balance, and lead to more harmonious decision making.
- As argued by Beck (1992:35), "education and attentiveness to information open up new possibilities of dealing with and avoiding risks". Public participation should be pursued and included in 'risk management practices'. If communities become more involved with the discussion of new projects and activities in their neighborhoods, they will need formalized instruments to express their opinions and concerns. Moreover, it is also important to note that developers and governments should see public participation as an effective opportunity for the achievement of the best risk management.
- Finally, fairness when siting hazardous installations would be, then, facilitated/instigated by the combination of 'risk education' and 'public participation' during the regulatory processes. Local knowledge and awareness can be used to prevent the movement of people towards hazard-prone areas. Furthermore, consolidated and qualified public participation can diminish considerably the likelihood that developers will attempt to install pipelines in vulnerable urban areas and that governments will be willing to open up discussions of such projects.

4.1.3 Vulnerability

In the social sciences, *vulnerability* is frequently applied as an important component of the many ways to approach hazards and risks. As discussed in this thesis, risk-based approaches applying QRAs have limitations addressing human systems. A broader approach for the assessment of *vulnerability* can aggregate a considerable amount of information that complements the calculation of affected areas by technical risk analysis (e.g. estimation of the range of physical effects) and inform decision making. As pointed out by Renn (2008: 69), “[v]ulnerabilities can increase risk, either by influencing the likelihood of some event or the severity of the consequences, should it occur, or both”. In geography, vulnerability is currently seen as a multi-layered and holistic concept (Hewitt 1997; Alexander 2000; Cutter et al. 2003; Pelling 2003; Cardona 2004; Birkmann 2006). In the past twenty years, many scholarly works have addressed and contributed with important insights into the vulnerability research, such as, but not confined to:

- the close relationship between socio-disadvantage and vulnerability (Chambers 1989; Beck 1992; Watts and Bohle 1993; Cardona 2004; Wisner et al. 2004);
- the role of power in vulnerability (Beck 1992; Hewitt 1997; Alexander 2000; Wisner et al. 2004);
- the need for a broad socio-environmental view when assessing vulnerability (Liverman 1994; Cutter 1996; Hewitt 1997; Pelling 2003; Birkmann and Wisner 2006; Jones and Andrey 2007);
- the importance of hazard-specific and local ‘space’ focus when assessing vulnerability (Cutter et al. 2003; Cardona 2004; Birkmann 2007; Andrey and Jones 2008);
- the contributions of definitions and new forms of the concept of vulnerability (Hewitt 1997; Alexander 2000; Cutter et al. 2003; Pelling 2003; Cardona 2004; Hogan and Marandola 2005; Birkmann and Wisner 2006); and
- models attempting to measure and contextualize vulnerability, such as the ‘Internal and External’ model proposed by Chambers (1989) and expanded later by Watts and Bohle (1993); the ‘Pressure and Release’ model introduced by Wisner and Blaikie (2004); the ‘Hazard of Place’ model introduced by Cutter (1996); the ‘Social Vulnerability Index’ model proposed by Cutter, Boruff, and Shirley (2003); and the BBC conceptual framework (Birkmann 2006).

This increasing complexity and associated challenges have lead to a more focused understanding and estimation of the concept, where the source of the hazard and the profile of the likely affected population are of fundamental importance (Cardona 2004; Birkmann and Wisner 2006). Among the many challenges in the research on vulnerability, it is worth mentioning the importance it has in the management of technological risks. When dealing with technological hazards, regulators usually have a crucial role in risk control. Either when the hazard goes to the community or the community comes to the hazards, regulators have the duty to mediate any conflict that can endanger the integrity of both sides. A comprehensive vulnerability assessment provides a more holistic view of the affected population and facilitates the implementation of appropriate risk management programs. Moreover, vulnerability assessments must be local and hazard-specific so they become a fundamental component informing the risk management framework and programs.

It is important to mention that this research acknowledges the inherent nuances differentiating the regulation of natural from technological hazards. Technological hazards are human-made (designed, constructed, and operated by people), different from natural hazards that have causes originating in events of nature. Hence, regulators of hazardous facilities have a better opportunity to be more proactive addressing technological hazards than earthquakes and floods, for instance, because they can actually say no to the installation and operation of a hazardous facility whereas this is not possible for natural events (Perrow 2007). It is clear that in both cases there are plenty of opportunities to control the human systems and mitigate consequences. However, controlling the causes of natural hazards is considerably more complex and difficult than controlling aspects of a technological system. Often, regulators are only able to develop measures to cope with the effects of an earthquake, avoiding urban sprawl into hazard-prone areas or developing actions to increase resilience of the populations. On the other hand, a multitude of other actions can be put in place to address technological risks, from the discussion of the details of the project to the operation of the hazardous installation, which not only address the effects of the hazard but also its causes and triggering mechanisms.

4.1.4 Resilience

The concept of *resilience* was initially applied in physics and ecology, with slightly different interpretations in these two bodies of literature. In physics, resilience is the ability of a material to absorb energy and bounce back to its original/natural arrangement (Manyena 2006). In the study of ecology, Holling (1973:14) defines resilience as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables". Similarly, Gundersen and Holling (2002:28) defines resilience in ecosystems as " ... the magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior."

From the initial use in ecology and physics, the concept has now spread over different areas, particularly in the social sciences (Kaplan 2006). Resilience is seen by some researchers and safety engineers as a counterpart of vulnerability (Hollnagel et al. 2006; Kaplan 2006). While vulnerability depicts weaknesses, resilience builds up strengths and skills to cope with risks. In this approach, resilience becomes an important characteristic of a system under threat, a desirable ability to coexist with vulnerability and uncertainty (Buckle et al. 2000; Pelling 2003; Manyena 2006; United Nations 2008; World Bank 2008). However, resilience is inherently passive from the threat viewpoint. It focuses on the consequences rather than the causes. For natural disasters, this may be a reasonable approach due to the considerable unpredictability of such events. However, technological risks are mostly human-made, with narrower boundary conditions. It is expected that regulators and governmental institutions have more opportunities and instruments to enforce guarantees (or even to say no a new project) when facing technological hazards. It is important to mention that the most effective way to cope with such risks involves controlling the sources imposing the risks rather than the affected population or system.

Panarchy:

Panarchy is a term coined by Gunderson and Holling (2002:5), defining a theory attempting to understand and organize the "economic, ecological, and institutional systems" when addressing, for instance, natural resource management. It models resilience in complex systems, seeing uncertainty as an important actor. If resilience is the ability or strategy to cope with vulnerability, and complex systems depict the dynamic interrelations of any real system involving multiple agents and subsystems, panarchy provides, then, a flexible framework to accommodate this reality.

Panarchy provides several important insights. Pursuing proper management is a matter of addressing different expectations in a balanced way. Natural resources and risk management are analogs in many aspects. Both are social- and institution-dependent, both are complex, uncertain, and dynamic. Although in the literature there is still little overlap between panarchy theory and technological risk management, extrapolation is possible and can be helpful to the latter, at least to reassure the need to deal with risks in a broader way. For instance, Grenoble and Saint Martin d'Heres (2006:211) developed a model based on the panarchy theory to manage rockfall risks. This model helped the authors to optimize decisions, considering the interactions between protected forests, human organizations, and rockfalls, as well as the ideal balance between different managing strategies and their costs over the long term.

4.1.5 Complex systems

In the context of technological hazard regulation, complexity is an important and inherent component of technical risk studies and decision-making processes. Renn (2008) draws attention to this point, offering a definition for complexity that stresses the difficulty in properly and comprehensively estimating risks, and how this becomes a challenge for regulators

> "**Complexity** refers to the difficulty of identifying and quantifying causal links between a multitude of potential causal agents and specific observed effects. The nature of this difficulty may be traced back to interactive effects among these agents (synergism and antagonisms), long delay periods between cause and effect, inter-individual variation, intervening variables, and others. Risk assessors have to make judgments about the level of complexity that they are able to process and about how to treat intervening variables (such as lifestyle, other environmental factors, psychosomatic impacts, etc.)" (Renn 2008: 18).

Complex system thinking (or theory) helps, then, to understand problems once faced in a unilateral or restricted perspective. It acknowledges that the diverse parts of systems are, to some extent, interconnected and interdependent (Perrow 1984; Funtowicz and Ravetz 1994; Castree 2003); and so are interconnected and interdependent people and hazardous installations sharing a common space. As pointed out by Funtowicz and

Ravetz (1994:570), “since we are natural as well as social beings, the emergent aspects of our social and technical systems will always be, as it were, the tip of an iceberg of which the greater part is ordinarily complex”. Complex system thinking provides insights on ways to understand these interdependencies and how they compromise safety.

Complex system thinking also acknowledges that technical studies have limitations to describe real events. It serves as background to the need to assess, evaluate, and manage risks in a more comprehensive way. As mentioned before, this research draws on recurrent criticism that risk-based approaches cannot alone address all the questions posed by the presence of technological systems in urban areas (Healy 2001; Ball 2002; Klinke and Renn 2002; Starr 2003; Apostolakis 2004; Martuzzi 2005; Allio et al. 2006; Cox 2007). Risk rates are helpful at some point of the decision-making process but they do not grasp the complete reality of the environment where such technological facilities are placed (Renn 2008). As pointed out by Coze (2005: 623), technical risk assessments “concerns closed technical installations, which are not recursive, not reflexive, not evolving, not sensitive and not opened to their environment as self-organized complex systems”. Complex system thinking underscores that there must be room for other sources of inputs in the regulation of technological systems, aiming at to provide a more realistic picture of the scenario under study (Funtowicz and Ravetz 1994; Helton 1994; Winkler 1996; Bea et al. 2009).

Normal Accidents Theory:

Perrow’s *normal accidents theory* relies on many elements of complex system thinking. Although the theory does not specifically address the common types of accidents for transmission pipelines (these types are usually motivated by single component failure or external human action (CONCAWE 2006; EGIG 2008)), it stresses the importance of the interactions between components and systems in complex and dynamic context to avoid accidents and catastrophes: “it takes just the right combination of circumstances to produce a catastrophe, just as it takes the right combination of inevitable errors to produce an accident” (1999: 356). He explains this point arguing that, in some circumstances (tightly coupled systems with high interactive complexity), the complex nature of systems, associated with the development and interaction of unexpected two or more failures, can initiate accidents and ultimately result in catastrophes (1984; 1999).

> “Nothing is perfect, neither designs, equipment, procedures, operators, supplies, or the environment. Because we know this, we load our complex systems with safety devices in the form of buffers, redundancies, circuit breakers, alarms, bells, and whistles. Small failures go on continuously in the system since nothing is perfect, but the safety devices and the cunning of designers, and the wit and experience of operating personnel, cope with them. Occasionally, however, two or more failures, none of them devastating in themselves in isolation, come together in unexpected ways and defeat the safety devices” (Perrow 1999: 356).

According to Perrow (2004: 10), the normal accidents theory “sensitized us to features of organizational systems that would help us understand both normal accidents and the more prosaic component-failure accidents, such as Chernobyl, Bhopal, the Challenger, and several other large disasters since then". The theory reminds us that the technological facilities are fallible; but it also draws attention to the fact that the ways these facilities are regulated often overestimate the importance and comprehensiveness of the technical information supporting their decisions and the effectiveness of the safeguards put in place to control risks.

4.1.6 Ethics

Many scholars advocate that risk-based approaches do not provide decision-makers with complete information, especially regarding ethical aspects. Hansson (2003) criticizes the use of numbers and probabilities when assessing moral values. According to him, rights, equity, and intentions are some considerations that also need to be addressed in decision making. Another insight is given by Taylor-Gooby and Zinn (2006) with a discussion on how psychology and sociology can help in risk management. Aven presents a synthesis of the limitations to the use of risk acceptance criteria, claiming that

> "any tool being used for balancing pros and cons would have strong limitations and be based on a number of assumption … [hence] … we need some marginal review and judgment that opens up for a broader perspective, reflecting the limitations and assumptions of the tools, and all the ethical concerns that need to be taken into account when making decisions in the face of uncertainties" (Aven 2007:309).

Complementarily, Hermansson and Hansson (2007:130) argue that traditional quantitative analysis needs to address ethical aspects, such as voluntariness, consent, intent and justice, as well as the consideration of possible social conflicts. Ersdal and Aven (2008) draw attention to the fact that traditional approaches to risk, although having a reasonable basis in ethics, do not necessarily lead to good or right decisions, but rather provide relative information to be assessed by decision makers. Asveld and Roeser (2009:4) point out important questions that usually are not answered by traditional cost and risk-benefit analyses, such as "the morally legitimate considerations in judging acceptability of risks" and "the role of the public and emotions" when deciding about risks.

<u>Phronetic social science:</u>

Phronetic approaches have been applied in the social science and planning as an alternative to the traditional approaches based on both 'episteme' (epistemology and epistemic) and 'techne' (technology and technical). According to Flyvbjerg (2004:287), "[p]hronesis is a sense or a tacit skill for doing the ethically practical rather than a kind of science". It focuses on "values and, especially, evaluative judgments" (p.291). As an approach that encompasses local knowledge and values, as well as the profile of power in that specific context, it is closely related to ethics and the seeking of fairness. A methodological guideline for phronetic research also embraces the need to attend to details as opposed to generalizations and simplifications; and to the inclusion and understanding of a broad group of stakeholders (and their interrelationship) during planning and decision-making processes. Risk assessment and management is context-dependent, as is the phronetic approach, so phronesis can contribute to the 'relationship' between communities and technological hazards as a sound reference to the harmonization of the interaction of these two different systems in all stages of technological projects (discussion, implementation, operation, and decommissioning).

4.1.7 The precautionary principle:

In the context of decision making regarding risks, the *precautionary principle* is often applied "as a paradigm for response to potential risks to the environment or health when scientific data are uncertain" (Balzano and Sheppard 2002:351). Stirling (2007:312) recognizes that the principle "provides a general normative guide to the effect that policy-making under uncertainty, ambiguity and ignorance should give the benefit of the doubt to the protection of human health and the environment, rather than to competing organization or economic interests". The Rio Declaration on Environment and Development arguments, in its Article 15 (UN 1992), that "[i]n order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities". Precaution is also seen as a fundamental component in the ethics of risks (Hansson 2003; Aven 2007; Hermansson and Hansson 2007; Ersdal and Aven 2008; Asveld and Roeser 2009; Davidson 2009) and in the discussion of social and environmental justice (Munton 1996; Goldman 2000; Boholm and Löfstedt 2004; Fothergill and Peek 2004; Arnold 2007).

However, the application of 'precaution' in the context of technological risks is controversial (Sandin et al. 2002; Peterson 2006). Comparing the precautionary principle against scientific risk analysis, Starr (2003:1) argues that the principle is a "rhetorical statement" based on "hypothetical speculation" that "provides government a public welfare masquerade for an indefinite deferment of a long-term policy response, or allows the deferment of disclosure of near-term actions motivated by political pressures". He also sees the "use of the precautionary principle as a politically defensible umbrella" to governments and decision-makers. Similarly, Stirling (2007:309) criticizes the application of the precautionary principle alleging that the principle "is based on unfavorable comparisons with established 'sound scientific' methods in the governance of risk". Farrow (2004:727) also points out the fact that the precautionary principle is "vaguely framed", indicating the need for a framework that could lead to a "quantitative implementation" of the principle. Notwithstanding the criticism, the precautionary principle can always provide background for ideal measures and decisions, offering an opportunity for regulators to benchmark approaches for technological risks against a conservative and often idealistic perspective.

4.2 Conceptual framework: integrating the social sciences into decision making

This section draws on the reviews carried out in this chapter and Chapter 2 to elaborate a conceptual framework to provide theoretical guidelines to address the research questions: how can risk-based decision-making processes regulating technological installations be improved to better manage ongoing risk exposure?

These regulatory processes can benefit from the advances discussed in the bodies of the literature addressing the regulation of technological hazards and also concepts and thinking outside this literature to make decisions more comprehensive. The risk governance framework introduced by Renn and the International Risk Governance Council (IRGC 2006; Renn 2008; Renn and Walker 2008) is used as a template, a starting point to develop this framework. The conceptual framework aims at to identify opportunities that can complement Renn's model, integrating components from disciplines such as environmental and social justice, vulnerability, resilience, panarchy, complex systems, ethics, phronetic social science, and the precautionary principle into a more comprehensive way to manage human exposure to technological hazards during the life-cycle of a hazardous installation.

4.2.1 Project's life-cycle

In order to discuss ways to integrate elements of the social sciences into the assessment, evaluation, and management of technological risks, this section first introduces some background information about the phases a project (such as gas and oil transmission pipelines) undergo in a typical decisionistic and risk-based regulatory process (such as the Brazilian case). This is fundamental in the development of the research framework as the concepts described in the following sections need to be considered in light of current settings. The life cycle of a typical hazardous installation usually encompasses five main steps: discussion, decision, siting, operation, and decommissioning.

1. The *discussion* intends to present information (technical, socioeconomic, environmental, etc.) to those interested in the project (decision-makers, developers, civil society, etc.). In risk-based approaches, information about the risks of hazardous installations is frequently presented in QRAs.
2. The *decision* consists of the assessments and deliberations about the proposed project, the decision making itself (also referred as the *risk evaluation*). In this step, the calculated risks are compared to standards of acceptability for technological hazards.
3. An accepted project might then move to the next step, *siting*. It is expected that there will be risks during facility siting, such as those affecting employees during the installation, but often they are not calculated as they have a different and more limited profile.
4. QRAs normally address risks for the next step only, the *operation*, when effectively the installation becomes a technological hazard. Risk management is enforced at this step.
5. A project can operate for several years or decades until the last step, the *decommissioning*, when the installation shuts down.

In this sequence of events, as the project's timeline goes on, the importance of QRA decreases while Risk Management practices take a prominent role. QRAs help in understanding the risks and the environment near the hazard. They inform the discussion prior to deliberations, providing managers, regulators, and individuals and groups from civil society with valuable inputs before decisions are made. However, with the beginning of the operation, the management of the just agreed/imposed risks comes into play. While risk assessment depicts the background, Risk Management helps manage these boundary conditions and the risk levels. Risk is an outcome of the coexistence of hazards and human populations. As such, a good Risk Management program addresses both the industrial installations and human populations, and their transformation and interrelation over time. Figure 4.1 shows the approximate balance between QRA and Risk Management in a typical case throughout the life cycle of a given hazardous installation. Decommissioning is not considered and the proportions are not expected to be accurate.

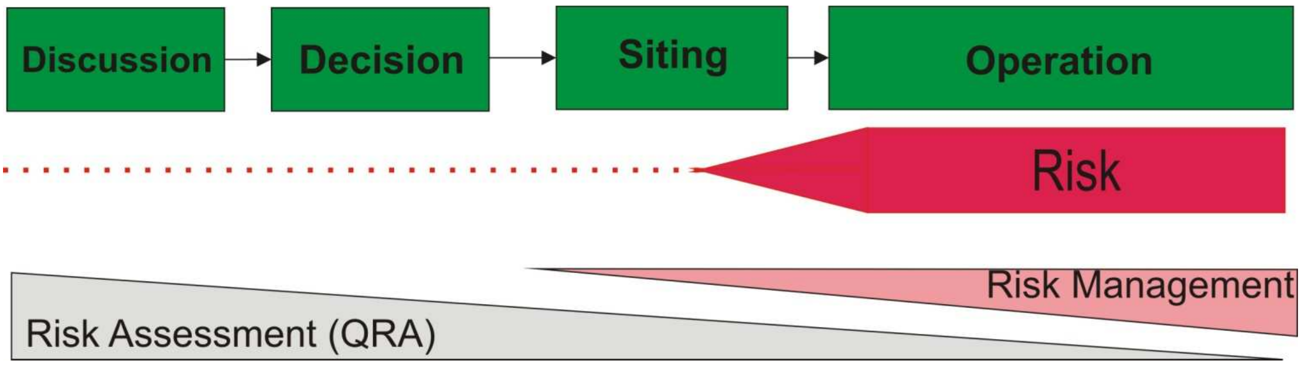

Figure 4.1 – Risk Assessment and risk management throughout the life-cycle in a typical decisionistic and risk-based regulatory process.

4.2.2 Deciding under complexity

Section 4.1 draws on a series of concepts and thinking to transform the risk-based decision making into a more holistic and comprehensive approach, often named in the literature as the risk-informed decision making. Simplistically, the risk-informed approach differs from the risk-based approach by the 'weight' that the calculated risks have on the whole decision making (TRB 2004). QRAs are important tools in both approaches but the decision making in a risk-informed approach is not confined to the numbers only. Complex systems, governance, ethics, social and environmental justice, and phroenetic social science, for instance, can provide some other arrangements and perspectives to also support the decisions in regulatory processes. These concepts help to qualify the 'discussion' and to improve the 'decision', as they bring a set of social aspects and demands into consideration.

As discussed in this research, the interaction between technological systems and people is complex and often transforms over time (de Freitas and Gomez 1996; Perrow 2007; Renn 2008). This relationship depends on a multitude of variables from the industrial installations, the communities, and the interface they share (Castree

2003; Gregory et al. 2009: 529). In the proposed framework, complex system thinking is the background motivating governance and ethics. Social and environmental justice and the phronetic planning act as both instigators and outcomes of more comprehensive decision making. Figure 4.2 presents an intuitive arrangement of the interrelationship of these concepts. Facing complexity, good governance practices consolidate ethical positions, while the pursuing of ethic demands sound instruments in governance. Governance and ethics also contribute to fairness. Social justice and the phronetic planning are not achievable without a solid basis in ethics and sound practices in governance.

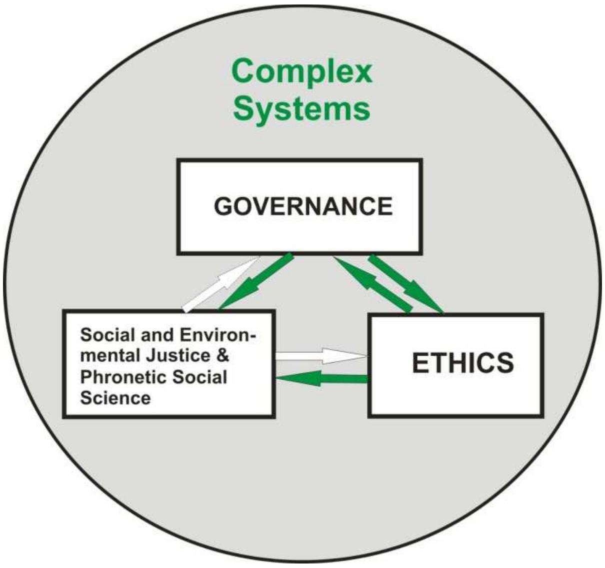

Figure 4.2 – Decision-making under complexity – alternative concepts to improve the risk-based approach.

The integration of these concepts into the decision-making process covers some of the QRA's limitations, as shown in Figure 4.3. Rather than being precise, this picture intends to illustrate the contribution these concepts may provide to decision making as they cover some 'empty' areas of the decision making that are currently not addressed by traditional quantitative risk assessments. Governance stresses the need for broad public participation, institutional strengthening, and governmental integration; ethics and environmental and social justice enforce protocols for communication and education, seeking fair processes; phronetic social science lays down principles for the ethically practical development; and the complex systems thinking serves as background for the decision making, interconnecting the many components involved in the regulatory process. As these concepts overlap in many aspects, this figure also attempts to represent this situation.

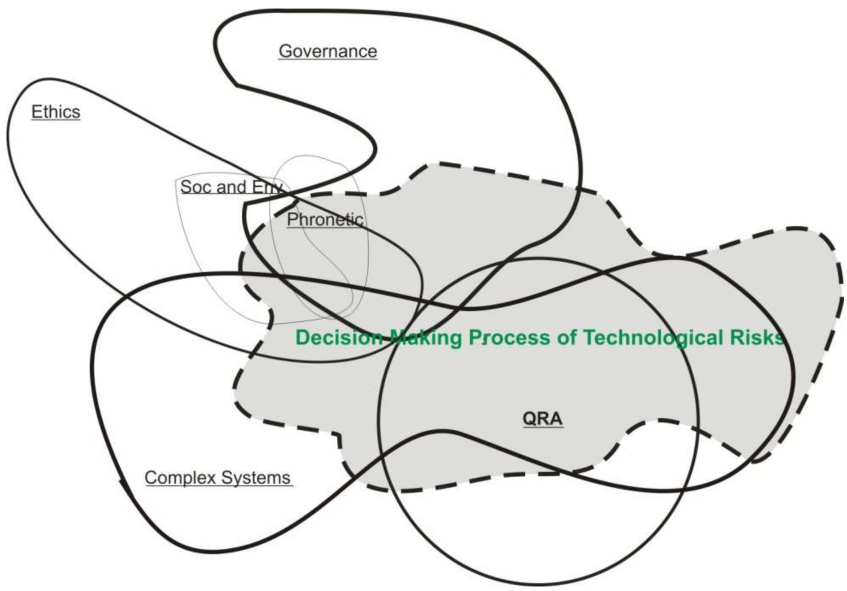

Figure 4.3 – A more comprehensive decision-making process, new concepts help in decisions about technological risks.

4.2.3 Managing under complexity, a conceptual framework

A QRA addresses some of the issues raised by technological risks, especially when time is not a constraint. However, when time needs to be considered (and often hazardous installations operate for a few decades), the QRA presents limitations that should be compensated by other measures. QRAs are fundamental during the discussion and decision about technological risks. However, with the beginning of operation, the QRA gives space to the enforcement of the risk management program. A good risk management program is expected to consider three of the concepts explored in Section 4.1: vulnerability, resilience, and panarchy. Vulnerability works on the understanding of the profile of the communities living near hazardous installations, which is crucial for effective management. Resilience and panarchy builds on the vulnerability assessment to propose practices to diminish the fragility imposed by the hazards. Figure 4.4 presents an intuitive relation between these concepts addressing technological risks.

Please note that the conceptual figure does not include the “precautionary principle”. The principle is not considered due to the criticism of its application (Section 4.1.7) and the frequently polarized debate it evokes in the literature of risk assessment and management (Starr 2003; Choi et al. 2005; Allio et al. 2006; Stirling 2007). However, the precautionary principle is addressed in the group of actions and measures, introduced in the next section, as it often offers an idealist perspective that can be used to push regulatory processes towards better practices to account for risks.

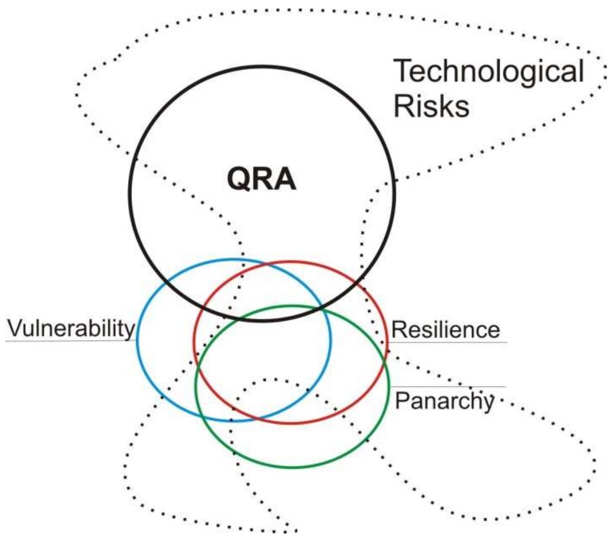

Figure 4.4 – Improving Risk Management, more than an extension of the QRA's results.

Finally, after strengthening the decision making, proposed in Figure 4.3, the last aspect of this conceptual framework refers to the management of risks in the future, when the project starts to operate. The inclusion of vulnerability, resilience, and panarchy into this framework facilitates the management of risks during the operation phase. The complete framework is presented, then, in Figure 4.5.

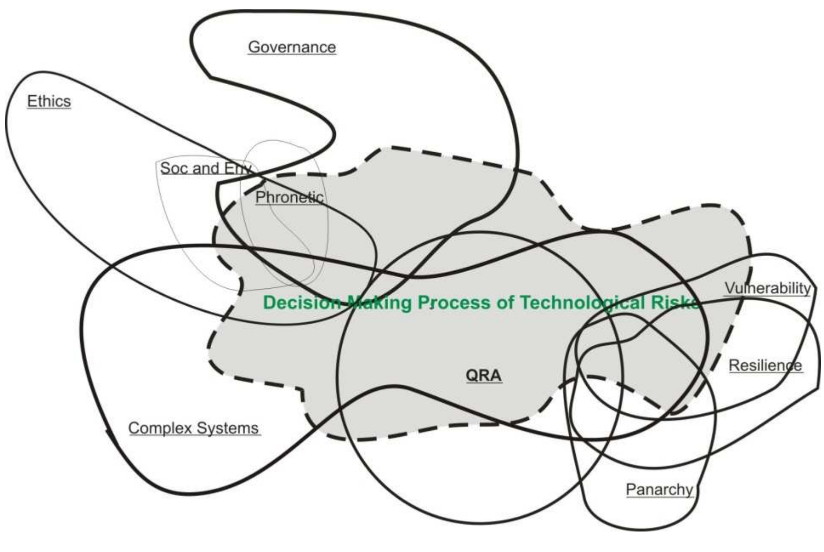

Figure 4.5 – Improving decision-making process, new concepts help cope with technological risks.

In summary, this conceptual framework ideally brings to the decision several actions and instruments to better address the installation of hazardous facilities in the urban context, such as public participation; strengthening and integrated action of governmental institutions; risk education and communication; siting fairness based on ethical standards; comprehensive vulnerability assessment; development of resilient communities; integration of the local land planning to the risk management program; and so forth. It aims to offer a broad view on how to ameliorate the performance of decision making and risk management, understanding that they are interrelated. Comprehensive and participatory decision making lays down practices that help the future management of risks. If decision making is confined to the analysis of numbers, there is a great chance that the risk management becomes associated only with the management of the industrial installations and its components. However, it is important to understand that risk management is context- and time-dependent; the context changes over time; and the context is not only the hazardous installation. Decision making needs to be aware of this peculiarity, embodying in its framework other social instruments so the management is also extended to the people and the environment in the vicinities of the installations.

4.2.4 Practical inputs from the conceptual framework

Drawing on the reviews conducted in this chapter and the conceptual framework outlined in Figure 4.5, twelve themes are proposed to effectively translate the ideas and assumptions from Sections 4.2.2 and 4.2.3 into concrete opportunities to improve risk-based decision-making processes of gas and oil transmission pipelines. They are presented in Table 4.1, as well as the conceptual foundation that they rely on (literature or practices in other countries), examples of their application (either conceptual or practical), and the relevance they have for the routines of the BELP.

Table 4.1 – Actions and measures to improve the decisionistic risk-based approaches for linear hazardous installations.

#	**Action/Measure**	**Conceptual foundation**	**Examples**	**Idea/Purpose**
1	*Pre-assessment of risks*	Risk Governance and Complex systems	Nanotechnology (Renn, 2006c)	1 - It helps in the elaboration of the scope for the QRA and risk management, bringing a more realistic perspective to the process.
2	*Concern Assessment*	Risk Governance, Risk Communication, Complex Systems, and Ethics	Risk Governance (Renn, 2008; Klinke et al, 2006)	1 – It accesses concern and perception of risk; 2 - This information is used then in the elaboration of the risk management program, in the communication and education of risks, in the assessment of vulnerability, and the implementation of resilience actions.
3	*Communication and Education*	Environmental & Social Justice, Governance, Complex systems, and Ethics	Risk Governance (Renn, 2008), The Ethics of Technological Risks (Asveld and Roeser, 2009), Risk Management in Post Trust Societies (Lofstedt 2009)	1 - Communication and education must be the instrument linking stakeholders, institutions, and affected population; 2 - Communication and education must be the bridge linking risk assessment; risk evaluation; and risk management; 3 - Communication and education is the shortcut to transit from the QRA to the risk management.

#	**Action/Measure**	**Conceptual foundation**	**Examples**	**Idea/Purpose**
4	*Precautionary Appraisal*	Precautionary Principle and Risk Governance	Precaution-based risk approaches (Morris, 2000; Klinke and Renn, 2001; Wilson, 2003; Klinke et al., 2006)	1 - The precautionary appraisal indicates an ideal situation that will be compared to the realistic input provided by the QRA; 2 - It presents assessment of the project without the engineering and budget constraints, as an idealistic perspective about the insertion of the project into the urban land. It serves, ultimately, as the benchmark for ideal decisions.
5	*Public Participation*	Environmental & Social Justice, Governance, Complex Systems, and Ethics	Diverse countries, such as Canada, France, and the United Kingdom. The Ethics of Technological Risk (Asveld & Roeser, 2009)	1 - Public participation is a right in many western democracies; 2 - Public participation is needed for the best risk management and to manage and/or diminish risk exposure;
6	*Integration of Governmental Actors*	Governance, Complex Systems, Resilience, and Panarchy		1 - Discussion and consensual deliberation involving stakeholders from different sectors during the licensing processes towards the integration of risk management and land-use plan.
7	*Risk Reduction at Source*	Vulnerability, Resilience, and QRA	QRA (HSE, 2006; Purple, 2005), France (Cahen, 2006)	1 - Whenever possible, reduction of risk at the source should be enforced.
8	*Land-use Control around ROW*	Phronetic, Complex Systems, Resilience, Env & Social Justice, Risk Governance	France (Cahen, 2006); Italy (Cozzani et al, 2006); the SEVESO II directive (1996)	1 – It checks existing by-law, land-use plans, and regulations, as well as existing pipelines; 2 – It instigates meetings with key stakeholders to discuss the integration of the risk management to the city's master plan; 3 – It negotiates land-use restrictions; 4 – It negotiates setbacks (differing approaches for different class location); 5 – It ultimately modifies the master plan.
9	*Specific routine for risk management*	Vulnerability, Resilience, Complex Systems, Governance, and Phronetic Planning	Canada (at least in part) (MIACC, 1998)	1 - Definition of system and scope; 2 - Identification of stakeholder needs and discussion with local people about the risk management program; 3 - Public hearing about the risk management program; 4 - Meeting with key stakeholders about the risk management program; 5 - Approval of the risk management program by key stakeholders; 6 - Continued monitoring and evaluation of the risk management program.

#	Action/Measure	Conceptual foundation	Examples	Idea/Purpose
10	*Follow-up*	Governance, Complex Systems, Resilience, and Panarchy		1 - Stakeholders discussion and technical report after selected steps of the approval process (before approval of installation; before approval of operation; and in a regular basis after the beginning of operation)
11	*Vulnerability Assessment*	Vulnerability and Complex Systems		1 - Socioeconomic vulnerability assessment that contributes to the risk assessment and management and follow-up;
12	*Resilience Plan*	Resilience, Vulnerability, Complex Systems, and Panarchy		1 - Development of a program to increase community resilience to the hazard; 2 - Discussion with key stakeholders and affected population; 3 - Implementation of program to increase resilience/diminish exposure of the population near the ROW

4.3 Summary

This chapter develops the research's conceptual framework, drawing on the literature on disciplines that can offer insights to improve the regulation for technological hazards. These disciplines are organized in conceptual figures: Figure 4.3 presents the organization of concepts/theories to improve the assessment and evaluation of risks; Figure 4.4 shows this organization now to the improvement of management practices; and, finally, Figure 4.5 integrates these two figures, showing how it is possible to address current regulatory gaps of traditional risk-based decision-making processes. Twelve groups of actions/measures are designed from Figure 4.5 and are used to assess the performance of the case study and to propose improvements in the regulatory processes of technological risks – discussed in Chapter 6, Chapter 7, and Chapter 8. However, firstly, Chapter 5presents the results from the interviews with key stakeholders about the Brazilian environmental licensing processes in order to describe the case study.

Chapter 5 – Case Study: IBAMA's Environmental Licensing

This chapter covers Brazil's environmental licensing and IBAMA's current framework. Section 5.1 provides background information on IBAMA's processes related to licensing activities. Section 5.2 reports the findings from interviews for the case study, organized as ten themes that represent the main inputs from the semi-structured interviews: positive aspects of the BELP, the limitations in the BELP, the economic and development agenda, the need for legitimization, missing aspects in the BELP, technical information, sense of justice and inclusiveness, the application of QRAs in the BELP, encroachment of pipeline's right-of-way, and issues related to the BELP follow-up activities. Section 5.3 presents a summary of these interview themes.

5.1 Approaching the case study: a brief introduction to IBAMA's environmental licensing process

5.1.1 The Brazilian environmental licensing process

The Brazilian environmental licensing process (BELP) is a comprehensive governmental approval process that applies environmental impact assessment (EIA) and quantitative risk assessment (QRA) to make decisions about the siting, installation, and operation of industrial and infrastructure projects in Brazil (CONAMA 1986; CONAMA 1997; Glasson and Salvador 2000; IBAMA 2005; Nicolaidis 2005; Castro 2006; Kirchhoff et al. 2007; IBAMA 2008; Lima and Magrini 2009). The BELP is especially important in the management of hazardous activities and projects in urban areas, often providing the only opportunity for the public and stakeholders in general to discuss with governments and developers the integration of these projects into their communities. As a federative republic, municipalities, states, and the federal government in Brazil have their own role in the implementation and performance of national policies. This case study focuses on the environmental decision-making process at the federal level only, which is carried out by IBAMA and regulates the largest projects in Brazil – including pressurized gas and oil transmission pipelines.

Serving as an introduction to a discussion on the insights collected from interviews with key informants involved in the environmental licensing processes in Brazil, this section contextualizes the case study and provides an initial bridge between the conceptual/theoretical review presented in Chapter 3 and the empirical findings from the case study. The Commission on Global Governance (1995) defines governance as "the sum of the many ways individuals and institutions, public and private, manage their common affairs". In decision-making processes, governance can be understood as a continuous process of accommodating conflicts and diverse interests in the public arena. However, the diversity of interests and ideologies involved in the processes (Alonso and Costa 2002; Nicolaidis 2005; Coelho and Favareto 2008), the political and economic influence and power of some groups over others (Little 2003; Marinho and Minayo-Gomez 2004; MPF 2004), and the often uneasy relationship between governmental institutions and other stakeholders representing different points (Glasson and Salvador 2000; Nicolaidis 2005; Souza et al. 2007) make the implementation of broad governance practices a difficult task in Brazil.

With respect to the BELP, three aspects concerning governance are worth noting: (1) participation; (2) institutional strengthening and independency; and (3) governmental integration. Public participation throughout the BELP is limited and in most of the cases confined to a few public hearings conducted by the environmental agency in the early stages of the process (Glasson and Salvador 2000; Alonso and Costa 2002; MPF 2004; Nicolaidis 2005; Assunção 2006; Souza et al. 2007). These public hearings are the only formal opportunity for civil society to manifest concerns and expectations about the siting, installation and operation of activities and facilities in their communities and regions (CONAMA 1997; Egler 1998; Cappelli 2002). However, these public hearings take place only in the early stages of the BELP and the tone of the discussion at this time is relatively conceptual and vague (Glasson and Salvador 2000; Filho 2002; Nicolaidis 2005). Furthermore, the affected population and civil society in general are often not sufficiently organized, nor do they have the ability to understand the implications and impacts that a new project will have in their lives (Oliveira 2000; Coelho and Favareto 2008). Hence, public participation can be compromised by bias and inefficiency due to the inability of the participants to contribute their experiences and expectations into the discussion. In the end, the hearings are very likely to become merely *pro forma* acts; as opposed to a continuing, interactive, and participative process that represents a better opportunity for both the government and civil society to learn and contribute for the best decision making possible.

The second element refers to the weakness of the Brazilian environmental agencies, which limits the performance of the state in the environmental area. This is observed in two ways. The first relates to the shortage of economic, human, and structural resources (Glasson and Salvador 2000; MPF 2004; Nicolaidis 2005; Borinelli 2007). The limited number of civil servants to conduct the processes and evaluate the environmental studies, the scanty financial support to perform their tasks, the deficiencies in the physical installations and logistics, and the lack of supplies and equipment are a reality most of the environmental agencies have to face. The second aspect refers to the political and institutional weakness of the environmental agencies (Nicolaidis 2005; Assunção 2006; Caribé 2009; Lima and Magrini 2009). Usually the environmental agencies have limited power of persuasion vis-à-vis other sectors and actors of the Brazilian government and society, especially those fostering the industrial and economic development of the country. In addition, the number of political appointments and the constant turnover of ‘crews’ and policies prevent these agencies from having an identity and an institutional and technical memory. There are often negative implications to the BELP either when the political support behind the decisions of the environmental agencies is limited or when these agencies continuously struggle with the absence of a sound background to rely on.

The last element is the usual lack of integration of the governmental actors in the BELP (Glasson and Salvador 2000; Filho 2002; Nicolaidis 2005; Lima and Magrini 2009). Often, differing governmental levels and agencies are in charge of different aspects in the assessment and evaluation of the impacts and risks posed by new activities and projects. Lack of integration, or even recurrent conflicts of interests and priorities, are important aspects that need to be taken into account by the BELP to assure not only reasonable decision making but also effective follow-up and management of these impacts and risks in the future.

5.1.2 IBAMA’s environmental licensing process

IBAMA works in conjunction with a multitude of stakeholders toward fair and consensual decisions regarding the development of industrial and infrastructure-related activities in urban areas. The Brazilian legislation prescribes that hazardous projects must undergo environmental licensing processes before operational status is granted. The framework of IBAMA’s environmental licensing (IEL) is based upon three environmental permits (CONAMA 1997; IBAMA 2008):

(1) the Prior License (PL), the first license of the process, granted after the evaluation and approval of an Environmental Impact Assessment (EIA) and a Quantitative Risk Assessment (QRA);
(2) the Installation License (IL), granted after the evaluation and approval of an Environmental Basic Project (EBP), which allows the siting/construction/installation to begin;
(3) the Operation License (OL), granted after the evaluation and approval of all necessary studies, including the Risk Management Program (RMP) and the Contingency Plan (CP) for hazardous activities.

This three-license process aims to assure that impacts and risks are identified and evaluated in different stages of the IBELP. In few words, (1) the impacts and risks are identified, estimated and evaluated as a prerequisite for the PL; (2) mitigation and compensatory plans, programs, and actions are proposed for the identified impacts and risks as a prerequisite for the Installation License; and (3) these plans, programs, and actions are implemented as a prerequisite for the Operation License. Follow-up of all the plans, programs, and actions is expected throughout the life cycle of the project and at any reissuing of the OL (a typical OL expires between four and ten years from the date of issue). Regarding hazardous activities, these steps are intended to ensure that risks are understood and discussed before any decision is made or operational status is granted. The main instruments applied for each one of the three environmental licenses are presented in Figure 5.1. Please also refer to Appendix A, Figure 7.7, and Glasson and Salvador (2000), Goldemberg and Barbosa (2004), Little (2003), Kirchhoff (2006b), Montaño and de Souza (2008), Ministério Público Federal (2004), Nicolaides (2005), Egler (1998), dos Reis (2007), and Lima and Magrini (2009) for more information on the BELP and IBAMA's framework for environmental licensing.

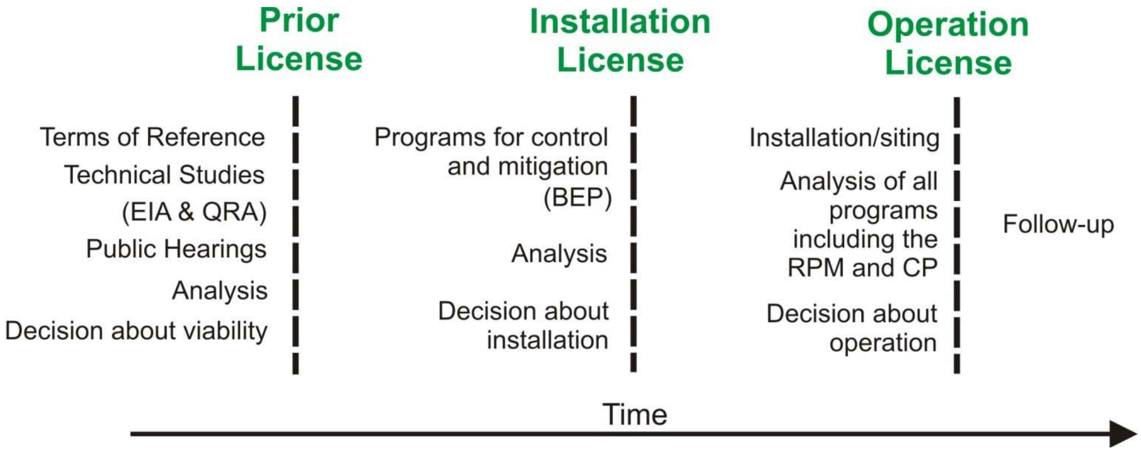

Figure 5.1 – Basic routines of the BELP. BEP stands for Basic Environmental Project, RPM stands for Risk Management Program and CP for Contingency Plan.

5.2 Themes emerging from case study interviews

This section describes the licensing processes from the viewpoint of thirty-two participants. The interviews, which serve the purpose of providing a comprehensive contextualization of aspects and any problems of a typical risk-based decision making, are analyzed and reported according to the methodology described in Section 0. Major themes are identified with the help of *NVIVO* software, and are related to the main points investigated by the semi-structured interviews (questions are presented in Appendix B).

The semi-structured interviews were conducted between September and October, 2009. In total, thirty-two participants were interviewed using the *Skype* software. A reasonable degree of familiarity and/or involvement with the BELP at either the state or federal level was a prerequisite for participation. Participants are grouped into three main categories of stakeholders: (a) governmental sector; (b) economic sector; and (c) civil society. The first group, governmental sector (GOV), encompasses representatives from the environmental agencies at the federal and state levels and Brazil's Ministry of Environment. The second group, economic sector (ES), encompasses representatives from petroleum corporations, gas and oil pipelines operators, and consulting companies[14]. The last group, civil society (CS), encompasses representatives from academia, Non-Governmental Organizations (NGOs), Federal Public Prosecution (MPF – Ministério Público Federal), Federal Policy, and citizens. Interviewees are not identified in this document. Table 5.1 presents simplified information about participants, with their codes and the segment each belongs to.

Table 5.1 – Group of Stakeholders.

Group of Stakeholders	Number of Participants	Interviewee Code
Governmental Sector	11	GOV1 to GOV11
Economic Sector	11	ES1 to ES11
Civil Society	10	CS1 to CS10

The objectives of the interviews are twofold: (1) to understand the environmental licensing processes in Brazil, focusing always on IBAMA's processes; and (2) to assess IBAMA's performance related to risk policies. To pursue these goals, the question for the interviews are divided into four main themes (please see Appendix B – Interview Questions). The first theme focuses on general aspects of the BELP, such as strengths, limitations, level of public participation, disclosure of technical information, and sense of justice. The second theme deals with the application of Quantitative Risk Assessments (QRA) by the BELP: how it is carried out; level of comprehensiveness and communication among stakeholders about risk results; and measures for precaution and prevention. The third theme entails the encroachment of pipelines' right-of-ways, its causes and actions to avoid it. The last theme discusses the activities of control and management in the BELP, how they are carried out, limitations, and opportunities for improvement.

The report of the interviews, presented in the next sections, follows the data analysis approach described in Section 0. It is organized around ten themes: the importance of the BELP; limitations in the BELP; economic and development agenda; need for legitimization; what is missing; technical information; sense of justice and inclusiveness; application of QRA in the BELP; encroachment of pipeline's right-of-way; and follow-up. The organization of the report around these topics reflects the sequence of questions of the semi-structured interviews. The main insights brought out by interviewees are underlined throughout the report for easy identification. The researcher also provides some examples of his experience at IBAMA to illustrate or complement the discussions.

[14] In the BELP, the consulting companies in charge of assessments are contracted by the proponent of the project. In this research they will be included in the economic sector.

5.2.1 Positives aspects of the BELP

Participants acknowledge the importance of the BELP. Several interviewees indicate that the BELP is a milestone in the implementation of a socio-environmental agenda in Brazil, although some of them also argue that the process is still under development. As pointed out by CS8, before the BELP there was nothing[15]. GOV11 advocates that the BELP has been contributing to the design of the environmental agenda in the country. GOV 10 and GOV6 elucidate that

> "The environmental licensing has been an important element in structuring the environmental issue. Nowadays, a company cannot get any funding if they do not have the green protocol. The issuing of the law of environmental crimes brought a very big focus on licensing as part of compliance." **GOV 10, interview 2009.**

> "The environmental licensing really brings new contributions to knowledge in the regulatory process, the risk analysis, the issues of concern with the social, physical, and biotic components of the environment. I think this is of profound significance in terms of changing the structure of the development paradigm in Brazil". **GOV6, interview 2009.**

Thus, a first noticeably positive interpretation of the BELP, as articulated by participants, is that it brings both the social and environmental perspectives to the agenda of governmental deliberations (CS6 2009; CS8 2009; ES1 2009; ES2 2009; ES3 2009; ES4 2009; ES5 2009; GOV3 2009; GOV5 2009; GOV7 2009; GOV11 2009). ES4 advocates that, without the BELP, developers[16] would have a limited performance in safety and environmental protection. ES5 understands that the BELP forces developers to think about the future social and environmental impacts of their projects and facilities, presuming that without the obligation imposed by the licensing processes many companies would refuse to do so. As described by CS2,

> "It helps; it assists the management of enterprises, if you think of enterprises of medium, large sizes, with monitoring programs. Not only formalizing, but also maintaining the environmental variable as part of the life of the project. Now, quality is something else..." **CS2, interview 2009**.

For some participants, a second positive aspect of the BELP observed is the enforcement of the law in diverse stages of a project, from the discussion of ideas to the control and management of the industrial and infrastructure installations (CS7 2009; ES5 2009; GOV6 2009; GOV7 2009; GOV10 2009). Some interviewees explain that the routines regulating the licensing activities are foreseen by legal and normative guidelines enshrined in the Brazilian legislation, such as the CONAMA resolutions 001/86 and 237/97 and the Federal Law of Environmental Crimes. CS6 and CS7 draw attention to the fact that article 225 of the Brazilian constitution supports both the environmental legislation and the environmental licensing:

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[15] Two regulatory milestones structured the environmental licensing in Brazil, the CONAMA Resolution 001 from 1986 and the CONAMA Resolution 237 from 1997.

[16] Developers are the proponents/owners of a project undergoing environmental licensing.

> "Art. 225. Everyone has the right to an ecologically balanced environment (…), imposing upon the government and the collectivity the duty to defend it and preserve it for present and future generations". **Brazilian Constitution from 1988.**

As described by Glasson and Salvador (2000), the discussion of environmental impacts and risks is taken during the routines of the BELP. In this context, and fulfilling the constitutional article above, the BELP represents and acts on behalf of the state. And doing so, it inherently has to accommodate divergent interests that reflect the diversity of the nation itself. Thus, participants point out that the BELP is expected to mediate and resolve conflicts arising from the proposal, discussion, installation, and operation of new technological and infrastructural projects (CS8 2009; ES3 2009; ES5 2009; ES8 2009; GOV5 2009; GOV6 2009; GOV11 2009). In fact, as described by representatives of the environmental agencies, the mediation of conflicts among stakeholders is a daily routine for staff and managers at environmental agencies across the country since political, economic, and individual interests need to be constantly balanced out while seeking a 'common welfare' (local, regional, or national).

As for the routines of environmental licensing, participants point out that the technical studies are another important aspect of the BELP. As defended by some interviewees, the environmental agencies not only compel developers to present technical information about the impacts and risks to support decisions (CS5 2009; ES1 2009; ES4 2009; GOV2 2009; GOV11 2009), but they also are expected to watch for the quality of the information presented (ES3 2009; GOV2 2009). Associated with the need to feed the decisions with accurate and broadly scoped data, a few participants also indicate that the information gathered represents a great opportunity to accumulate knowledge about the social and environmental aspects of the nation (GOV1 2009). Each study presented to environmental agencies has the potential to aggregate information to the 'puzzle' that may be creating a complete dataset contemplating the country's diversity in geographic and ecological terms.

Another important aspect of the BELP that was identified by participants relates to the possibility of anticipating and mitigating/preventing impacts and risks (CS1 2009; CS2 2009; CS4 2009; CS8 2009; ES1 2009; ES3 2009; ES8 2009; GOV5 2009; GOV11 2009). CS8 argues that the BELP enables the understanding and discussion of a project before it is installed/sited. ES3, ES8 and GOV1 point out that this permits the development of actions to mitigate pre-identified impacts and risks. As indicated by GOV5, the BELP provides the state with an instrument to judge appropriated actions and choices during decision-making processes. CS5 elaborates on this point:

> "It makes possible that in the end there is a conclusion. If this conclusion encourages the development you are proposing, or if the enterprise is inadequate, if it needs to undergo modifications to suit the environment (…) in my opinion it is perfect, almost mathematical logic, one plus one makes two. I think that is fundamental." **CS5, interview 2009.**

The anticipation of risks and impacts combined with the enforcement of technical studies and the incorporation of the social and environmental perspective in the governmental agenda are identified by interviewees as facilitators in the elaboration of follow-up (or monitoring) strategies (CS2 2009; CS5 2009; CS6 2009; ES2 2009; GOV1 2009; GOV5 2009; GOV7 2009; GOV11 2009). The three-license system that constitutes the BELP divides the implementation of a project into three fundamental steps. Ideally, at the end of each step the environmental agency has the opportunity to audit the licensing process. Furthermore, these processes also organize the implementation of a new project in such a way that, by the beginning of operation, the identified risks and impacts are accommodated into programs of control and management. GOV11 exemplifies this point claiming that, once the developer is granted a permit, it needs to continuously show consistent environmental performance. GOV5 agrees, remembering that this environmental performance is set upon indicators of safety and socio-environmental quality.

Finally, the BELP is considered by participants to be one of the few opportunities (if not the only one, as described by some interviwees) for public input and participation in governmental decision-making processes in Brazil (CS5 2009; GOV5 2009). Although still limited, this channel for participation is considered a relevant aspect of the licensing activities for many participants (CS1 2009; CS5 2009; CS7 2009; CS8 2009; ES3 2009; ES5 2009; ES8 2009; GOV3 2009; GOV4 2009; GOV5 2009; GOV6 2009). ES3 and ES5 point out that the BELP includes actors of civil society in the discussion of the nation's agenda. GOV4 argues that, though imperfect, the BELP is a systematic and democratic process facilitating the exchange of information. CS8 advocates that even the opposition to a given project is made possible through environmental licensing and other instruments of democratic participation.

Participant-observation: The researcher recalls the importance of the environmental licensing processes for small communities and sensitive species and environments across Brazil. For instance, once a community affected by a dam relied only on the licensing process to reform their houses affected by a destabilization on the ground caused by the dam; another time a city appealed to IBAMA to request a company/developer to reform its streets damaged by heavy trucks transporting components for a new project; one more example is given often by governmental and non-governmental organizations that often use the licensing processes to protect endangered species, sensitive environments, and traditional populations.

5.2.2 Limitations of the BELP

The diverse elaborations on the positive aspects of the BELP suggest that in theory the environmental licensing seems to be a solid decision-making process. However, the interviewees also indicate that the practical and contextual implications permeating the routines of the licensing processes compromise its performance (CS5 2009; CS8 2009; ES2 2009; ES3 2009; ES4 2009; ES7 2009; ES11 2009; GOV1 2009; GOV9 2009; GOV10 2009). The distance to reality, the gap between what is proposed and what is achieved in the processes, is stated by many interviewees as a serious limitation, with direct implication in the technical studies and the pursuing of safety and environmental quality. GOV11 argues that there is a considerable distance between the questions asked by the BELP and the answers given throughout the licensing processes. This gap arises from what CS8 and ES11 argue to be a lack of practical sense in the licensing routines, probably motivated by what ES3 discusses as an aspect of the precautionary principle; due to the lack of knowledge about the project and region of installation and the lack of qualification of the staff in the environmental agencies, the terms of reference for the technical studies often require excessive and unnecessary information. As pointed out by ES2 and GOV1, often the term of references are partly detached from the context of a new project due to the great level of uncertainty involved. ES3 elaborates that

> "The environmental agency tends to require programs for control that often are broadly scoped and are not necessarily going to generate solid conclusions on an issue. In the activity of oil and gas, in which I have involved a lot lately, that is well known, there is much misinformation about what happens in the marine environment, the impact, and it happens that we have to structure some projects for environmental control that are too large; and often we know that this activity has no potential to cause such effects, these supposed impacts, but we end up having to prove that doesn't happen in fact. This is complicating the process; we end up seeing it as natural, we need to go on that way." **ES3, interview 2009.**

According to the interviewees, this negative aspect of the BELP is closely related to the lack of resources (CS1 2009; CS2 2009; CS7 2009; ES2 2009; ES3 2009; ES8 2009; GOV1 2009; GOV6 2009; GOV8 2009) and the technical staff in the environmental agencies (ES1 2009; ES2 2009; ES4 2009; ES8 2009; ES11 2009; GOV1 2009; GOV8 2009). ES3 argues that the lack of resources is a notorious limitation of the environmental agencies. CS2 stresses that the structure of the environmental agencies in Brazil is 'horrible' and CS1 points out that the environmental agencies lack financial resources to perform their duties. CS7 illuminates the situation by commenting on how the environmental agencies do not have an appropriate library to store the technical studies, or even a data set ready to use. ES2 supports this point drawing attention to the fact that those agencies lack all sort of equipment, such as computers, cameras, and GPSs (global positioning systems). GOV6 makes the same point, succinctly stating that the environmental agencies do not have the minimum structure necessary to perform their activities.

The lack of qualification of the technical staff, or even the scanty number of personnel carrying out the licensing activities in the environmental agencies is another structural constraint of the BELP that was pointed out in the interviews. ES4 and ES11 ponder that the environmental agencies usually do not have a qualified, experienced, and permanent team of specialists; and GOV1 and GOV8 agree alleging that the number of specialists in such agencies is relatively small. CS7 claims that the environmental agencies are just now implementing policies for staff qualification. However, participants indicate that there still is a gap to be closed. ES1 advocates that the specialists at the environmental agencies need to be better qualified. ES11 comments that those specialists often are not prepared to understand and communicate technical questions with representatives of the developers and the consulting companies. Thus, GOV1 and ES3 hypothesize that the lack of qualification and the limited number of specialists has a direct implication on the detachment of the BELP as it might be compared to current reality. According to them, it is likely that an unqualified and inexperienced specialist will request unnecessary or excessive information about a given licensing process in order to feel comfortable to emit a report or recommendation.

According to participants, the lack of resources and qualification/number of staff often leads to another limitation, a lack of professionalism in the environmental agencies (ES1 2009; ES5 2009; ES9 2009; ES11 2009; GOV5 2009). ES1 complains that the environmental agencies need to perform with a minimum level of professionalism, but that this is absent in some situations. ES11 illustrates this point with examples where developers need to conduct several meetings with the environmental agency about the same topic; that happens because of the excessive rates of turnover in the environmental agencies. Interviewees indicate that it is a common situation where the environmental agencies need to make use of a developer’s logistics and infrastructure to even perform necessary field trips.

On the other hand, the quality of the studies in the BELP is also an object of criticism. Interviewees indicate that developers and consulting companies experience, to some extent, the same lack of qualification and number of specialists to carry out consistent technical studies (such as the EIA and the QRA). ES1 points out that the studies are often standardized, with evidence of the ‘copy and paste practices’; according to he/she it is common to find information about thermal power plants in a study about gas and oil transmission pipelines. GOV1 also talks about that type of scenario, describing a situation where the environmental study was discussing the Amazon rainforest in a project proposed for Brazil’s Atlantic Forest. GOV7 reinforces the point, claiming that the programs for control and management of risks and impacts are often too general; ‘made in series like pizza’.

Participant-observation: The researcher recalls several limitations in the organization of IBAMA that compromised his activities. There is also lack of administrative support in the environmental licensing units. For example, environmental specialists often have to arrange for logistics and book their hotels when they go for field trips, as IBAMA does not have enough staff (secretaries or other support personnel) to do that. The turn-over of environmental specialist is also very high, affected by a somewhat consensual lack of importance of the environmental agenda in Brazil. A new specialist starts to work motivated by the environmental cause and the perspective of doing a good job, but with time he/she often faces extreme political, economic, and moral pressure that undermine the initial impetus and lead them to look for other professional opportunities with better remuneration and work conditions.

5.2.3 The economic and development agenda

Although the supposed theoretical benefits of the BELP accommodating the social and environmental perspectives into the Brazilian governmental agenda, interviewees understand that the reality depicts a different picture. GOV3 and CS6 argue that the environmental agenda is still seen by many stakeholders as merely an obstacle to the development of the nation. CS2 contextualizes the situations, saying that the environmental agenda is not a glamorous portfolio in the Brazilian government. On the contrary, it is commonly seen as an unimportant component in the governmental structure. Thus, some participants claim that the lack of interest in the social and environmental perspectives during the discussion and development of the nation's goals and projects is still evident. CS5 illustrates this alleging that frequently the discussion of a new project in the BELP becomes a formality only, since before the discussion in the public arena the project was already discussed and approved in the governmental offices in charge of the economic development of the country.

In fact, the interviews noticed that the country's pursuit of economic development is leading to a series of other limitations. The first is political influence in the environmental agencies (CS3 2009; CS4 2009; CS10 2009; ES2 2009; ES9 2009; ES11 2009; GOV2 2009; GOV5 2009; GOV6 2009; GOV8 2009). As pointed out by CS4, the BELP often becomes a political instrument to implement the agenda of the economic development, disregarding many of the technical aspects of the licensing processes. ES2 and CS11 comment that environmental agencies have many political appointments in their structure, positions assigned based on political affiliations and interests. It is common for there to be discordance between staff (technical) and managers (political) regarding the recommendation of a new project (CS6 2009; CS10 2009); while the specialists ponder the technical implications, managers are driven by political reasons.

The economic influence in the BELP plays a role similar to the political influence (CS1 2009; CS4 2009; CS8 2009; CS10 2009; ES11 2009; GOV6 2009). CS1 argues that the need to develop the country leads to the weakness of the environmental agencies. CS4 draws attention to the fact that the economy is always ahead in the game, outweighing the environment. Thus, the decisions of environmental agencies are compromised by an ostensible watch and interference of economic perspectives. For instance, a few interviewees draw attention to the fact that substantial parts of the technical studies presented by the developers to the environmental agencies are carried out by consulting companies hired by the developer. CS10 argues that this arrangement implies that the studies only show the benefits and the importance of the projects. In a related way, CS8 and CS10 ask for a complete reformulation in the relationship between consulting companies and developers.

According to several interviewees, one of the possible causes for the political and economic influence in the BELP comes from the detachment of the environmental licensing from strategic planning (CS1 2009; CS2 2009; ES11 2009; GOV8 2009; GOV10 2009). GOV3 claims that Brazil misses an environmental presence inside governmental planning. CS2 brings more details saying that the BELP is detached from the strategic matters related to the nation’s goals. GOV10 hypothesizes that the BELP has serious limitations due to its inability to predict and accommodate sectorial planning in its routines (electricity, roads, pipeline network, railways, etc.). For instance, talking about risks, CS1 argues that the BELP focuses on individual projects rather than pursuing a global view of a group of new projects and existing facilities in a given area.

The interviewees also indicate that the BELP lacks integration with other governmental agencies. CS2 argues that the notion of environment encompasses a broad, holistic dimension; consequently, environmental licensing deals with diverse themes and demands. Explaining this point, assuming that environment comprises the social, physical, and biotic spheres interacting in geographic space, the discussions in the BELP need to democratically accommodate the different views on what is best for each sphere. CS2 explains that in a democratic nation there must be multiple organized actors representing the nation’s complex social and economic dynamic; and the use of the physical and bio-resources. The environmental agencies need to articulate with other governmental actors in order to deliver optimized assessment and decision. Thus, CS5 understands that the lack of integration compromises the integration of the cumulative and synergic risks and impacts. Yet, GOV7 observes that often governmental agencies have an attitude of confrontation and dispute instead of harmonization and representation of a common ideal.

Participant-observation: The researcher recalls many examples of the disproportional power of the economic sector compared to the social and environmental sectors in Brazil. For instance, as reported in the Brazilian media, Mr. Lula, the Brazilian President, once mentioned that the country could not stop because of catfishes and toads – an allusion to the environmental impacts that supposedly were slowing down the licensing process of two large projects in Brazil.

5.2.4 The need for legitimization

> "The way the environmental licensing is done nowadays is only a means of legitimizing the development. Since its construction, or even in the licensing processes, what is legally prescribed for public participation is very little. I believe that the environmental licensing in its very core should be rethought, starting with the hiring of the consulting companies, which should not be hired by the entrepreneur. The entrepreneur could pay the licensing agency to conduct the hiring. I recognize that from the standpoint of the entrepreneur much of that license now is only an obstruction used to amass resources, because it has, in many cases, little practical meaning." **CS8, interview 2009.**

The BELP is criticized due to the poor quality of and few opportunities for public participation (CS1 2009; CS3 2009; CS5 2009; CS8 2009; CS10 2009; GOV6 2009; GOV7 2009; GOV9 2009). Interviewees representing society-at-large often argue that the channels in the BELP for public participation are scanty and inadequate. CS1 sees societal participation as limited and weak. For instance, CS3 argues that the civil society does not have a say in the licensing process. CS5 complements this perspective by pointing out that, in theory, the participation in the BELP is perfect but in practical terms it does not happen; the decisions are taken in the offices of the environmental agencies prior to any hearing with the public. One more input is given by CS8, who says that even what is laid down by the legislation is insufficient to assure effective public participation.

However, when GOV9 claims that public participation is often used to legitimize the projects only, this criticism is deepened. Not only is public participation viewed in this way, but the BELP itself is often seen as a process applied to legitimize the decisions already made by other actors in the government and economic sector (CS5 2009; CS7 2009; CS8 2009; CS9 2009; CS10 2009; GOV10 2009). For instance, CS5, CS8, and CS10 argue that the public hearings take place at a stage where there is little room for significant changes in the proposed project. ES2 points out that in some situations the BELP resembles 'pork-barrel politics'[17], where the discussion and decision spins around the developer, the consulting company, and the environmental agency only. It is important to mention, once more, that the environmental licensing is considered by participants to be the only opportunity that civil society in Brazil has to manifest its concerns about the governmental agenda. GOV6 reflects this comment, noting that the BELP is probably the only governmental decision-making process in Brazil that calls for public participation.

Due to the lack of opportunity for public involvement in the Brazilian governmental structure in general, interviewees claim that the purpose of the environmental licensing is often misread, with the BELP becoming

[17] 'Ação entre amigos' - deciding among friends in a free translation from Portuguese.

an assembly for bargains and diverse compensation (CS2 2009; CS8 2009; ES2 2009; ES8 2009; ES10 2009; ES11 2009; GOV10 2009). As described by CS2,

> "In practice, the environmental licensing is no longer a process that helps in taking the best decision about a project; it turned into an instrument of mitigation. Then, seeking for alternatives, or even the option of not taking the development forward, very rarely happen. The environmental licensing is less an instrument of decision making on environmental sustainability, and more a tool for mitigating environmental and social impacts." **CS2, interview 2009.**

In concordance with what CS2 says, CS8 points out that in large part licensing appears to be an obstacle, a 'toll station' to collect resources from the developer. The discussion of the impacts and risks becomes secondary to the discussion of the "crumbs from the mitigation processes". CS8 summarizes the situation by arguing that in the public hearings "some [people] question technical matters, a great part of them tries to understand the project, and another chunk is trying to take some advantage [from the project]". ES10 thinks that the BELP is a good process; that there is meaning in it. However, ES10 continues that, stating that, sometimes it has been used to get resources from the developer, and giving examples where municipalities ask for hospitals and recreational centers as compensation for the implementation of gas and oil transmission pipelines in their lands. ES8 understands that the environmental agencies should mediate this situation in order to avoid these 'distortions', although recognizing that this situation is brought to the BELP due to lack of opportunities given to civil society to discuss their needs in other forums.

Participant-observation: The researcher recalls many occasions in public hearings carried out to discuss a new project with the affected/interested public when individuals and organizations complained that the environmental licensing was not being fair to the local population; that the local concerns were not being taken into consideration during IBAMA's deliberations; or that the public perceived IBAMA as a representative of the economic sector and/or developer defending the new project.

5.2.5 What is missing?

> "The environmental licensing lacks qualification; lacks technical and financial resources to implement licensing the way it has to be done. I think it is still a process very deficient from a technical point-of-view; it is a process very vulnerable to economic issues, the economic pressure on environmental institutions in general." **CS1, interview 2009.**

> "Structurally, the environmental agencies have difficulties, this is notorious. The time for analysis of these studies and processes is still very long. The environmental agencies in the states and the federal one, in general, are crowded with processes so we don't have a speed more suitable for the analyses." **ES3, interview 2009**.

When asked about what is missing in the current BELP's framework, interviewees have the opportunity to spontaneously elaborate about the limitations of the licensing processes. For participants from the group *civil society*, it is not unexpected that they commented at length about how there is room in the BELP to improve public participation (CS1 2009; CS6 2009; CS8 2009; CS10 2009; ES3 2009; ES4 2009). Some of them give some suggestions. CS1 advocates that the municipality and local actors need to participate more actively in the licensing routines. CS10 argues that the number of public hearings needs to be expanded as the opportunities for participation are insufficient in the current arrangement. CS8 advocates that public participation need to be enforced from the beginning to the end of the licensing process, and CS6 ponders that the public needs information to effectively participate in the BELP. Finally, ES3 suggests that the BELP needs to have other instances for public consultation and legitimization, other than only the current formal hearing format.

Interviewees from both civil society and the governmental sector point out the need to develop normative guidelines for the BELP (CS2 2009; CS4 2009; CS5 2009; CS7 2009; ES8 2009; ES11 2009; GOV2 2009; GOV3 2009; GOV4 2009; GOV5 2009; GOV8 2009; GOV11 2009). Some insights are provided. For instance, CS2 argues that often the required scope for the technical studies is not clear (QRA & EIA); CS4 and GOV4 advocate the need to think about strategic environmental assessment in order to facilitate the performance of the BELP; CS5 argues that there is need to improve the ways to identify the impacts and risks and to mitigate those impacts and risks; CS7 complains that the 'rules of the game', regarding the environmental licensing, are frequently unclear – supported by ES8 and GOV2 who say that not only the environmental legislation is unclear but often excessive, and GOV8 draws attention to the need to regulate the public hearings and the routines of the BELP. In order to address these questions, ES11 claims that the environmental agencies need to take some time to discuss the technical requirements for the studies since some items from the study's term of reference are technically unnecessary. Another point is brought by GOV11 and GOV3, arguing that uniformity is needed in the actions between the many environmental agencies, pointing out, for instance, differences in the criteria of risk acceptance between the states of Rio de Janeiro and São Paulo. Finally, GOV5 focuses on how the BELP lacks a complete management cycle, encompassing analysis, decision, implementation, management, and control.

It is possible to infer from the interviews that the BELP needs to develop follow-up protocols (CS6 2009; ES1 2009; ES5 2009; ES11 2009; GOV2 2009; GOV3 2009; GOV5 2009; GOV9 2009). The interviews indicate that the BELP lacks solid practices for control and management. CS6 points out that the BELP does not audit the implementation and performance of the programs discussed in early stages of the licensing. After the issuing of the Operation License, the environmental agency fails to follow those programs. GOV2 and ES5 agree arguing that the BELP misses mechanisms to follow the operation of the projects. GOV5 adds to that claiming that the environmental agencies too often focus on the analysis and decision about risks and impacts but seldom perform the control and management of such risks and impacts. GOV9 emphasizes that the follow-up is ‘extremely scant’; the environmental agencies direct a great deal of attention to the pre-installation stages and, as soon as the project is installed, the attention fades away: ‘there is a new thing coming up’.

Another point identified by interviewees refers to lack of resources and infrastructure in the environmental agencies. CS5, CS7, ES4, and ES11 point out the relatively low preparation of the staff at environmental agencies, and the need to invest in continuous qualification. Furthermore, GOV2, GOV3, and ES4 suggest that the environmental agencies need more specialists due to the high number of processes they have to analyze.

The lack of independence, or impartiality, of the consulting companies from the developer is another identified issue of concern in the BELP (CS3 2009; CS4 2009; CS5 2009; CS8 2009). CS3 advocates that the government should pay for the technical studies as opposed to the current arrangement where the developer finances the studies. CS5 agrees, arguing that the consulting companies cannot have any economic tie with the developer. Addressing this issue, CS8 suggests that the studies should be contracted by an independent actor and CS4 advocates for an independent revision of the technical studies as well.

Two final topics arise at this stage of the interviews. The first is the need to integrate the risk policies with use and organization of the urban land (CS1 2009; ES1 2009; ES11 2009). The second is to think about pre-assessment of risks and impacts (ES3 2009). These two topics will be discussed more deeply later in this document, in Sections 5.2.8, 5.2.9, and 5.2.10 as they were object of specific questions during the interviews.

Participant-observation: The researcher recalls that IBAMA lacked organization and normative guidelines to help the environmental specialists perform their activities. It was common for there to be a change of agendas with very short notice (for instance, postponing or scheduling a field trip in a Thursday or Friday prior to a trip in the following Monday). It was also common for there to be a lack of detailed guidelines for the elaboration of terms of references and evaluation of environmental and risk studies.

5.2.6 Technical information

The EIA and the QRA are the main technical inputs supporting decision making at the federal level. Some participants cite other studies that are also applied, though with less latitude (among others, the program for risk management, the program for mitigation and control of impacts, and the plan for social communication). It is noteworthy that some interviewees from the environmental agencies indicate that QRAs are applied in a few types of projects only, such as transmission pipelines, thermal power plants (conventional and nuclear), rails, and mining. In general, interviewees acknowledge the positive influence those studies bring to the BELP (CS5 2009; CS6 2009; CS8 2009; ES1 2009; ES2 2009; ES3 2009; ES4 2009; ES7 2009; ES8 2009; GOV1 2009; GOV2 2009; GOV3 2009; GOV5 2009; GOV10 2009; GOV11 2009). Ideally those studies contribute an impartial and scientific perspective into the decision-making process.

However, interviewees argue that there are a few concerns as well. The first relates to the limited <u>availability of those studies</u> to all stakeholders involved in the licensing processes (CS2 2009; CS4 2009; CS5 2009; CS6 2009; CS7 2009; CS8 2009; CS10 2009; ES1 2009; ES9 2009; ES11 2009; GOV1 2009; GOV2 2009; GOV4 2009; GOV5 2009; GOV8 2009). CS2 explains that, according to the law, the studies should be made available to everyone but their availability is then described as 'ridiculous' (very limited). CS10 reinforces this, pointing out the need for a transparent process to make those studies available to the general public. CS4, CS5, CS6, and CS7 complain that it is difficult to get information from the environmental agencies, though they all recall the legal rights to the information they have. For instance, CS8 argues that often in the discussion of a new project there is only one or two copies of studies available to the population of a medium city (something around 200 to 300 thousand people), which makes it difficult for individuals of the public to have access to a copy of the technical study. GOV1, GOV2, and GOV8 recognize that the access to information is still limited in the BELP. However, ES11 and GOV4 consider that, although not perfect yet, this situation has improved in recent years. CS2 brings his/her experience,

> "I search the intricacies of IBAMA's website and find some things. I have other ways to achieve it. But I cannot get everything. It is not transparent; it is not transparent at all. The process is not only the technical information, it is an exchange of letters, a lot of things that is in limbo, inaccessible." **CS2, interview 2009.**

Moreover, even if the technical studies are made available, interviewees say that it is usually difficult to <u>comprehend them</u> (CS3 2009; CS5 2009; CS7 2009; GOV2 2009; GOV8 2009; GOV9 2009). CS3 claims that it is impossible to comprehend QRAs, alleging that only specialists in the area of the study can understand them;

> "It is impossible. It is only understood by those who work in that area; otherwise they are not understood at all. That is clear. There are only technical details in those studies". **CS3, interview 2009.**

CS5 agrees saying that the language applied in those studies is too technical. CS7 argues that the studies need to be translated into a clearer language so they can reach the broad audience that comprises the various stakeholders affected by a typical licensing process. However, GOV2 ponders that he/she has not yet come across an adequate way to translate the technical text into language that is accessible to the general public but still precise, and GOV8 agrees saying that is also necessary to prepare the audience to better assimilate such information.

Finally, two issues associated with the quality of these studies are indicated by participants. The first is the low quality of the studies delivered by the consulting companies to the environmental agencies (CS1 2009; CS3 2009; CS5 2009; CS6 2009; CS8 2009; GOV11 2009). For some interviewees, it seems that the consulting companies have not been able to keep up with the high demand for environmental studies (CS6 2009; ES1 2009; ES6 2009; GOV7 2009). As a possible consequence, CS1 points out the 'awful quality' of some of the studies; and CS8 argues that some of them are even completely meaningless. The second issue is the impartiality of the information presented. Some interviewees claim that the studies are biased, with an apparent intent to defend the project and its implementation (CS1 2009; CS3 2009; CS4 2009; CS5 2009; GOV1 2009). CS1 explains that the technical studies often only explore the benefits of the projects, omitting or disregarding the negative side of the installation and operation of such a facility. CS3 adds to the seriousness of this assertion arguing that, during the licensing routines, the environmental agencies only analyze the information brought by the developer; to which CS5 advocates that the environmental licensing process needs to be based on impartial studies.

Participant-observation: The researcher recalls that several times the public complained that they did not have access to the technical studies prior to a public hearing. Often these studies are not even consistent enough to start the licensing processes and were returned to the consulting companies for rework. As for the risk analysis, the researcher recalls that the QRAs were not comprehended by the majority of the environmental specialists at IBAMA and were barely discussed with the general public.

5.2.7 Sense of justice and inclusivity

As discussed early in this document, the BELP is considered by interviewees to be one of the few, if not the sole, governmental decision-making process open for public participation in Brazil. Interviewees identified that this public input is still limited. It was also discussed that this fact occasionally leads to the misuse of the BELP since individuals and groups tend to use it to bargain for compensations and favors. The interviewees also pointed out that the technical studies feeding the decision making bring a rationale to the decision making, but they are often biased, pro development and pro project. And, finally, a great deal of economic and political influence in the performance of the BELP was also identified. Thus, the assessment of sense of justice in the licensing processes is a complex task. CS2 argues that

> “the degree of justice for all the stakeholders will always vary according to the context, according to the project, the quality of the public participation (…). There are many variables that relate to the effectivity of the environmental licensing, influencing the justice of the process as well”. **CS2, interview 2009**.

CS8 concurs saying that in Brazil the “environmental licensing processes are as fair as the Brazilian society”. Thus, they often mirror the inequity of the nation itself. CS1 points out that the concept of justice is complex and wonders about the purpose of the environmental licensing: to be fair or to be environmentally and technically appropriate. The interviewees indicate that, ideally, the environmental licensing pursues the best balance between the development and economic needs, the environmental needs, and the social needs.

The participants’ responses provide some evidence that, at least ideally, the BELP pursues justice and/or consensus for its decisions. However, CS2 warns that justice and consensus are relatively utopian, since there always are conflicts of perceptions. Interviewees present some inputs about how to achieve more balanced decision making, though. CS10, CS3, and CS4 reason that if processes do not accommodate public input they cannot be fair. In this direction, CS3 advocates that the environmental agencies should pursue a tighter relationship with local population and governmental administration. However, CS7 draws attention to the need to educate the local community so they can participate in the processes in a more effective way. CS8 agrees pointing out that unprepared populations can be manipulated by the proponents of the project. Some suggestions are presented to address this situation. GOV5 advocates that the licensing processes need to respect and accommodate differences. GOV8 indicates that the licensing processes need to have a holistic view rather than one only focused on the project being licensed.

Participants suggest that, to some extent, the concept of justice is linked to inclusiveness. When asked if the BELP was an inclusive process to stakeholders other than the developer, the consulting company, and the environmental agencies, interviewees reacted with two perspectives: (1) the BELP is not an inclusive process at all (CS2 2009; CS3 2009; CS4 2009; CS9 2009; CS10 2009; ES2 2009; ES4 2009; GOV7 2009; GOV9 2009); and (2) it is inclusive in theory, though with considerable practical limitations (CS1 2009; CS5 2009; CS6 2009; CS7 2009; CS8 2009; ES1 2009; ES7 2009; ES8 2009; ES11 2009; GOV1 2009; GOV2 2009; GOV3 2009; GOV4 2009; GOV8 2009; GOV10 2009).

Either way, interviewees provide inputs to improve participation and inclusiveness in the BELP. Firstly, some participants claim that the BELP needs to seek for equalization of power during its processes. CS1 points out that there is a considerable discrepancy in power of the stakeholders involved in a given licensing process. Usually civil society is on the weaker side of the chain, compromising public participation. GOV2 argues that it seems sometimes that some groups are privileged during the licensing routines. GOV4 supports this saying that the economic sector, for instance represented by developers and consulting companies, is usually stronger. As pointed out earlier by ES2, the environmental licensing often resembles ‘pork-barrel politics’. A few topics brought out in the interviews provide some directions suggested by participants to work out this inequity of power:

- The environmental agencies need to improve their communication protocols (CS1 2009; CS2 2009; CS3 2009; CS4 2009; CS6 2009; CS7 2009; CS8 2009; CS9 2009; ES1 2009; ES2 2009; GOV1 2009; GOV7 2009; GOV8 2009). GOV7 and GOV8 point out that the environmental agencies lack effective communication with all the stakeholders. CS1 and CS8 reinforce this point arguing that the information pertinent to the environmental licensing, either technical or administrative, needs to be better disclosed. As argued by CS2, mayors, local representatives, and local stakeholders need to be informed about the routines and milestones of the licensing processes. CS3 and ES2 add that this communication should not be bureaucratic. GOV1 provides other input advocating that the communication process needs to start as soon as the licensing process is started at the environmental agencies.
- Not only does communication fall short of good practices, but also the BELP needs to create new channels for public participation (CS1 2009; CS2 2009; CS3 2009; CS5 2009; CS6 2009; CS7 2009; CS8 2009; CS10 2009; ES1 2009; ES2 2009; ES3 2009; ES6 2009; GOV1 2009; GOV2 2009; GOV4 2009; GOV8 2009). In the BELP’s current arrangement, public participation takes place only at the first stage of the licensing process, through formal public hearings to discuss the EIA and, at the federal level, the QRA. CS8 makes this point succinctly by saying that “before the environmental permit you [civil society] don’t have any public participation and after the issuing of the permit you don’t have instruments to watch if what has been done matches what has been decided by the environmental agency.” CS7 agrees arguing that one has the right to information about the licensing processes. CS6 agrees pointing out that all stakeholders need to actively participate in environmental decision-making processes.

The claim for access to information finds ground in the Brazilian legislation. As mentioned earlier in this document, article 225 of Brazil’s Constitution states that “[e]veryone has the right to an ecologically balanced environment (…), imposing upon the government and the collectivity the duty to defend it and preserve it for present and future generations”. The constitution empowers both the government and the collective to defend and preserve the ‘environment’. However, very often interviewees stress that the public, or civil society, has been restrained from delivering this constitutional duty. In the BELP’s current arrangement the governmental role outweighs the citizens’. Evidence is found in the interviews and elsewhere (Abers 2000; Glasson and Salvador 2000; Fearnside 2002; MPF 2004; Coelho and Favareto 2008). Corroborating this view, CS1 argues that public participation starts only at the first stage of the BELP (discussion for Prior License); and it is ‘cut out right there’; if the project is approved, the community has the impression that there is nothing else to be done. CS6 agrees pointing out that after the Prior License the feeling is that everything is already decided and now the environmental agencies and the developer will decide about the remaining details behind ‘closed doors’. CS8 and GOV8 bring the same perspective saying that after the public hearings civil society can just wait for the deliberations of the environmental agencies.

It is important to note that the interviews indicate that the lack of participation is not only a direct outcome of the limited number of channels for public participation in the BELP. Interviewees also identified a need to prepare civil society to effectively participate in the environmental licensing processes (CS1 2009; CS4 2009; CS5 2009; CS6 2009; CS8 2009; ES1 2009; ES2 2009; ES3 2009; ES11 2009; GOV3 2009; GOV5 2009; GOV6 2009; GOV8 2009). CS1 reasons that it is worthless working on just one side of the problem, in this case the routines of the BELP, if civil society itself is not capable of participating. Similarly, CS5 and CS8 point out that the Brazilian civil society has often been absent, abrogating its constitutional duty. ES11 and GOV3 elucidate arguing that the educational and cultural level of part of the civil society compromises the full participation in the processes. GOV6 ponders that it is a governmental duty to provide civil society with conditions to participate. However, that is no easy task as elucidated by GOV3:

> “…in a scale of priorities, one will be interested for this kind of thing [the environmental licensing] in another occasion. There is this matter of education and qualification of people, but obviously these people need to meet their basic needs first [housing, food, employment, etc.] so afterwards they will have time and be able to participate in those processes”. **GOV3, interview 2009.**

Some final inputs were provided to address public participation and inclusiveness. CS2 advocates the use of information and communication technologies (ICT) to help make information available and promote participation. CS2 also points out that the public consultation needs to be diffuse rather than punctual and overly formal, as it currently is. ES2 and GOV9 recall that the BELP needs to follow up the questions brought from the public hearings. GOV1 understands that there must be a program for social communication in place, permeating all the BELP’s routines, from top to bottom. CS3 claims that other governmental actors can help the environmental agencies by disseminating information and stimulating participation. CS5 ponders that the timing for participation should be anticipated, encouraging the discussion of the terms of reference for the environmental studies with the civil society. CS6 defends that there is need to encourage a ‘habit’ in the civil society, a perception that their participation is valuable and necessary.

Participant-observation: The researcher recalls that the environmental licensing processes were always an object of criticism since they accommodate many different views about a project. There was always someone discontent with the deliberations of the environmental agencies, the project and its location, the benefits and impacts of the new activity, and so forth. However, this criticism sometimes needs to be relativized in light of details that were not disclosed or perceived by all involved stakeholders. For instance, once an NGO took a strong position against a project, supposedly advocating for the rights and integrity of a native population. However, some suggested that the real motivation of the discontentment was that the developer did not hire that NGO to carry out the environmental studies needed for the licensing process. Another time a team of environmental specialists arranged an informal hearing with fishermen affected by a dam, to listen to their complaints and needs, but when the meeting started the fishermen refused to talk to the environmental specialists and left the meeting right after the beginning, even though their city was distant from Brasília and four environmental specialists travelled there only to talk to them.

5.2.8 The application of QRA in the BELP

The interviewees were asked about the application of QRAs in the environmental licensing. Questions were intended to cover points related to the assessment, analysis, decision, and management of hazardous projects, with emphasis given to gas and oil transmission pipelines. GOV1 describes the QRA as a technical study, based on statistics and probabilities, which identifies critical points in a pipeline's right-of-way where special care during construction is needed. GOV8 says that the QRA talks about likelihood of failure of a given technological system, and its implied consequences. ES4 adds to this by saying that scenarios of severe consequence are quantified applying a methodology that encompasses the identification of the sequence of events leading to an event, the probability this event will ever happen, its physical outcomes (fire, ball fire, explosion, etc.), and the likely affected area surrounding the event. The result is risks rates, the outcome of the interaction of failures with physical vulnerability. According to CS1, a QRA essentially deals with the management of 'accidental scenarios'; the information a QRA provides is how a new project can affect the safety and integrity of the surrounding area. Based on the information provided by risk assessments, the environmental agencies decide about the installation/siting and operation of the project (CS1 2009; CS4 2009; CS6 2009; GOV7 2009; GOV8 2009).

There is evidence in the interviews to attest that the QRAs are a valuable tool helping the BELP to decide about hazardous projects[18]. However, there are also indications that QRAs need to improve their performance in Brazil. One clear perspective expressed by a great number of interviewees is the inherent complexity of the subject itself. When asked about the comprehensiveness of the results, about one-third to one-half of the interviewees said they do not understand the studies and their results. It is important to remember that all interviewees are familiar with the BELP, and, actually, most of them have a deep understanding of the process. Yet, QRAs are specialized studies, often very technical, such that their understanding can be very difficult. However, this can also indicate limitations in the application of such a tool.

A possible inference is that the studies are <u>too technical,</u> as explicitly pointed out by some participants (CS1 2009; CS8 2009; ES1 2009; ES10 2009; ES11 2009; GOV5 2009). CS1 suggests that because the QRA is so

[18] For instance, helping the organization of the urban land, the integrity of installations, and safety of the communities.

technical the affected communities and local stakeholders are not able to provide any insight about risks during the licensing processes. ES2 says that even when the consulting companies try to present the results in the public hearings, the message is still intangible for the majority of the audience. ES11 also concurs saying that it is unwise to present to the general public numbers such as 10^{-5} and 10^{-6}, the project's risk rates. CS8 summarizes this situation by saying that those presentations are 'not elucidative'.

Another criticism of QRAs is that they are too focused on trying to maintain the integrity of the installation and barely address the social system surrounding the facility. Usually, QRAs analyze with detail the technological system or infrastructure only, and provide little information about the community in the neighborhoods, as noted by a many of the interviewees (CS1 2009; CS4 2009; CS7 2009; ES1 2009; ES4 2009; ES8 2009; ES9 2009; ES10 2009; ES11 2009; GOV1 2009; GOV2 2009; GOV4 2009; GOV8 2009; GOV11 2009). GOV4 gives one example saying that risk analysis examines the equipment, reliability, likelihood of failure, direction of wind, but they hardly examine the socioeconomic circumstances of the affected population:

> "for us [environmental agency], doing field trips, they [the developers] require everything, helmet, safety boots, safety vest, need to warn the staff to block the line, and, then, you look to the side [of the rail] there are kids playing soccer just next to the railway". **GOV4, interview 2009.**

However, assuming that technological risk is the result of the interaction of two systems, a technological system and a human system, when asked to comment on how QRAs consider the human system the answers indicate that the current arrangement lacks concern about the human system (CS1 2009; CS6 2009; CS7 2009; CS8 2009; ES4 2009; ES8 2009; ES9 2009; ES11 2009; GOV1 2009; GOV2 2009; GOV3 2009; GOV4 2009; GOV7 2009; GOV8 2009; GOV11 2009). It is possible to infer a need to improve the assessment of information about the people that are going to interact with the hazardous project. ES9 argues that QRAs gather information about the cities and communities in a "cold way, no one goes there and check out if city X is growing towards the projected pipeline right-of-way". GOV2 elucidates saying that the QRA are too focused in the project's installation, with 'little concern directed to the people'. CS6, ES4, and GOV11 explain that the population is only quantified, in terms of how dense the area is and the total number of people living nearby.

Addressing this question, some interviewees also indicate a deficit in vulnerability assessments in the context of QRAs (CS1 2009; CS7 2009; GOV1 2009; GOV2 2009). The analysis of the interviews shows that the socioeconomic profile of the communities affected by the project is context-dependent and can contribute to the encroachment of pipeline's right-of-way (this is addressed again in the next section of this report). Vulnerability in the context of the social sciences is broader than the estimation of the intensity of an accidental scenario. CS7 illustrates this, saying that

> “it seems like there is just one population and this population is equal in any given neighborhood, city, or region, and the specialist in risk considers only one type of risk; the specialist does not take into consideration cultural issues, how the population will be affected, the fear of this population, the depreciation of households”. **CS7, interview 2009.**

CS1 extends this point arguing that the QRA needs to consider a holistic assessment of the local vulnerability, the incorporation of socioeconomic factors in the analysis, and the integration of different hazardous installations into the same analysis. After all, the population ‘sees’ the cumulative risks, not only the risk of the project being licensed. Explaining this point, for instance, an individual not only is subject to the risks of a new transmission pipeline sited in a right-of-way with three or four other pipelines already in operation, but, rather, to the cumulative risks of those pipelines sharing the same path.

Some interviewees also suggest a <u>need to integrate risk policies with land-use planning</u> (CS1 2009; CS6 2009; CS9 2009; ES1 2009; ES6 2009; ES7 2009; ES8 2009; ES10 2009; GOV10 2009; GOV11 2009). CS1 and GOV11 argue that the ideal of a QRA is to provide inputs for land planning; QRA needs to be explored to help the land-use planning. Contrary to this ideal, some participants claim that, most times, the QRA does not consider local planning at all. However, ES11 points out that petroleum companies usually apply a classification for the use of land in urban areas (class location), based on the decision about the pipeline’s thickness according to the population density in the vicinity, which considers, even if in a limited way, this integration between use of the land and risks.

Some participants also criticize the use of QRAs for <u>legitimizing the project</u> only (CS3 2009; CS5 2009; CS6 2009; CS8 2009). They allege that these studies are carried out only to corroborate the implementation of a new project. CS3 and CS8 say that the studies are made to be approved by the environmental agencies. CS5 argues that the information presented by them is biased and they have the sole intention to ‘sell’ the project. CS6 stresses this point arguing that the standards applied to evaluate the risks, and consequently approve the project, are inadequate and somewhat permissive when compared to other countries. ES3 and GOV11 point out that those criteria not only are inadequate but they also vary from state to state. They illustrate this drawing attention to the fact that the federal environmental agency and the agency of the state of São Paulo apply a different standard when compared to the environmental agency of the state of Rio de Janeiro. However, the risks are the same.

<u>Participant-observation:</u> The researcher recalls that he started working with risk evaluation at IBAMA (in 2003) without any formal training or familiarity with the topic. Moreover, the terms of reference for QRAs were also incomplete and superficial at that time. Although the current version of the term of reference for risk analysis of transmission pipelines, developed in 2006 with the contribution of the researcher, has improved considerably the scope of analyses, it is still evident the focus on the evaluation of the technological system in detriment to a more comprehensive evaluation of the local population, hazards, and implications in the use of the land.

5.2.9 Encroachment onto pipelines' right-of-ways

The third group of questions in the interviews aimed at the identification of factors that can explain the encroachment onto right-of-ways (ROW) of gas and oil transmission pipelines in Brazil. The proximity of people living to those ROWs is a reality in almost all great urban centers in the country. Until 2004, the Brazilian legislation enforced a 15-meter safety distance between the edges of the ROW and any household or building, in which no edification was allowed to be constructed (that was referred as the *non aedificandi* area in the Federal Law 6766/79). However, at that time, a considerably large number of people were, and still are, living in those safety zones. Yet, in some situations the ROW became streets in neighborhoods in some Brazilian suburbs. Thus, the majority of the major pipelines of the Brazilian transmission network of gas and oil were in disagreement with this law (or so was the population living near those ROW). Seeking to accommodate this situation, the Brazilian congress modified the law 6766/79, which reads now

> "Art. 4º, § 3º – If necessary, a full non-buildable safety zone for pipeline ways will be required as part of their environmental licensing, considering criteria and parameters to ensure public safety and the environmental protection, as disposed by relevant technical standards". **Federal Law 6766/79, modified by the Federal Law 10932/04.**

The interviewees were asked if they could think of causes that lead people and communities to encroach on such ROWs. Two causes, somewhat complementary, are presented by participants. The first relates to the <u>lack of appropriate urban planning</u> in most Brazilian municipalities (CS1 2009; CS2 2009; CS7 2009; ES4 2009; ES6 2009; ES7 2009; ES8 2009; ES9 2009; ES10 2009; ES11 2009; GOV4 2009; GOV8 2009; GOV9 2009), both at the time of the implementation of the pipeline and in the later control of its risks. CS1 and CS2 argue that very often the main cause is the lack of urban planning; they claim that urban expansion is often very chaotic. CS7 and ES10 point out that pipelines are often too old, being in operation for some decades sometimes; they explain that when those pipelines were installed there was nobody living there, but the disorganized growth brought people close. ES1, ES8, and ES4 agree saying that the local government was inefficient at controlling this encroachment. ES6 probably summarizes this situation when he/she says that the Brazilian state has not grown at the same pace as the population. Conjecturing about the future, ES6 and ES7 state that, without a solid policy regulating the use and occupation of the land, this problem will keep happening. In terms of solutions, GOV1 goes so far as to say that a pipeline's ROW needs to avoid urban areas.

On the other hand, the social component also seems to contribute to this situation. According to some participants, the second input relates to the <u>vulnerability of the population</u> (CS3 2009; CS5 2009; CS9 2009;

ES1 2009; ES3 2009; GOV2 2009; GOV3 2009; GOV4 2009; GOV8 2009; GOV10 2009; GOV11 2009). ES1 ponders that the encroachment (or approximation of people to the ROWs) relates to the perception that the population located close to these facilities will be taken care of. ES3 supports this saying that, due to the poverty in the country, people often get closer to an installation anticipating any sort of benefit. ES10 points out that one of these benefits is the opportunity to have a road since the developer needs to frequently move up and down the ROW. CS9 points out that people will live in areas where they can find jobs, so the facility can represent this opportunity for employment. Complimentarily, GOV11 recalls the need for dwellings in Brazil, while GOV10 ponders that the land in the vicinity of such facilities has less economic value and therefore are more affordable for housing.

The interaction of these two aspects, the lack of management of the urban land and the implications from local social vulnerability, seems to be the main cause for the encroachment. GOV2 points out the importance of understanding the socioeconomic factors that push people towards risky areas in order to put in place measures to avoid this problem. GOV11 says that it seems that people are not aware of the risks of living near transmission pipelines, or any other industrial facility, and GOV4 argues that lack of education of the population associated with the lack of urban planning policies have contributed to the encroachments.

<u>The role of the environmental agency, the municipality, and the QRA:</u>

Once the interviewees discussed perceptions about the causes leading to the encroachment, they were asked to think about the roles of the environmental agencies, the QRA, and the local municipality in the matter. There is no consensual understanding about the influence of the <u>environmental agencies</u> in this issue. Some participants understand that the agencies do fail in the follow-up and control (CS2 2009; CS7 2009; ES1 2009; ES7 2009; ES9 2009; GOV2 2009; GOV4 2009; GOV8 2009), while some think that the environmental agencies are not related to this issue at all (CS1 2009; ES6 2009; GOV3 2009; GOV10 2009; GOV11 2009). However, there are indications that the environmental agencies may have an influence in the encroachments, after all. CS2 advocates that the environmental licensing does not overlap other areas of the public administration, making it difficult to control the encroachment. CS7 and ES7 point out that the environmental agencies have important limitations carrying out following-up activities. ES1 points out that the lack of integration between land-use policies and risk policies in the environmental licensing routines may compromise the safety in the surroundings of hazardous installations. GOV2 and GOV4 ponder, then, that one of the main goals of the environmental licensing process is to help with the social and environmental zoning.

On the other hand, those that do not see any interrelation between encroachment and the BELP argue that the problem is mainly restricted to the use and organization of the urban land, which should be performed by <u>local administration</u>. CS1 argues that the municipality, and only the municipality, is in charge of the organization of the urban land. CS6 advocates that the administration of the municipality needs to determine the classification of the land and ensure that this classification is not infringed; an industrial area should be reserved for industrial use only, while a residential zone cannot accommodate an industrial installation. ES2 and ES7 comment on the importance of the city's master plan in this matter. However, it was also pointed out that few municipalities in Brazil have the technical and financial apparatus to effectively organize and control the use of land. In fact, ES11 states emphatically that the municipalities usually do not have resources to perform even the basic activities. As well, some participants advocate that a new installation can represent a political and economic bonus in the local context through the generation of jobs and taxes. According to them, the municipalities want the economic benefits of a new industrial or technological installation; they also want to stimulate the real estate business. Some interviewees point out that restrictions and control of the land in this scenario is seen as a burden (both economic and political) to the local administration.

However, the analysis indicates that the relationship between environmental agencies and municipalities needs to be considered as well. The environmental licensing of a transmission pipeline is conducted either at the federal or state level. On the other hand, people, land, risks, and impacts are local (municipality). Lack of integration between these two levels of the Brazilian state, stressed in the environmental licensing, is indicated by a few participants as a cause for the encroachment as well. CS2 argues that the environmental agency does not see the municipality, and vice-versa. CS6 and ES1 argue that the integration of these two levels of the governmental body is needed to control the encroachment. ES3 stresses this issue, saying that this lack of integration is the biggest 'gap' in the BELP. These interviewees conclude by drawing attention for the need for promoting the articulation of the local government with the environmental agency, aiming at the development of a solid master plan for the city (CS1 2009; CS2 2009; CS3 2009; CS5 2009; CS7 2009; ES3 2009; GOV1 2009; GOV2 2009; GOV11 2009). As pointed out by ES3, "the rigor with which the issue of land-use and occupation in Brazil is discussed is not exactly what should have been happening".

Participant-observation: The researcher cannot recall a single meeting with local regulators in charge of the urban planning or the city's master plan, in Brasília or during field trips, to discuss integrated actions to better manage encroachment of right-of-ways or enhance safety of affected populations. Moreover, this interaction was neither predicted by the formal and normative routines of the environmental licensing processes, nor discussed in the public hearings during the time he served at IBAMA (between 2002 and 2006).

5.2.10 Issues related to BELP follow-up activities

The last group of questions addresses the performance of the BELP in the follow-up (or monitoring) routines. This specific aspect of the BELP was commented on by participants throughout the interviews, in a scattered way. However, it is important to understand in some detail how participants assess the follow-up of the environmental licensing processes; in other words once the Operation Licensing is issued, how do the environmental agencies carry out the management and control of the projects (that is commonly referred as the post licensing by participants)? Participants describe the post licensing activities as scarce, imperfect, and sometimes absent in the BELP. Analyzing the interviews from the civil society sector firstly, CS1 argues that the BELP's follow-up is 'absolutely deficient', CS7 and CS5 that it is 'nearly absent', and CS3 that IBAMA does not perform the post licensing at all. Some causes for that are pointed out: CS10 and CS2 explain that the environmental agencies do not have staff to supervise the operation; CS9 adds to this saying that generally activities of control and management bring political onus with often negative repercussion to who performs it. However, CS5 claims that follow-up is made when the developer needs to reissue the environmental permit, typically four to ten years after the current OL was issued.

The economic sector does not have a much different perception about the performance of the follow-up. ES11 argues that the follow-up is not carried out because of the limited staff in the environmental agencies. ES6 agrees claiming that the state is not organized and it does not have enough people to do the follow-up. ES8 acknowledge the problem but points out that the situation has gotten better in recent years exemplified by the fact that the environmental agencies now do field trips to inspect the installation and operation of new projects.

In the governmental sector, GOV11 brings a different perspective when he/she says that in the state of São Paulo the state environmental agency enforces a more effective management of technological risks; on the other side, the environmental agencies are frequently inspecting the facilities; and, finally, the projects need to prove that they are still safe when the time comes for reissuing the Operation License. However, at the federal level GOV10 and GOV8 acknowledge that the follow-up is deficient. GOV1 recognizes that the environmental agencies try to keep up with the demands of the follow-up but they do not have resources for that; this in turn compromises the management of old pipelines. GOV9 argues that it has spent a great deal of money during the BELP to identify risks and impacts but after the Operation License there are no monitoring routines to check whether those risks and impacts are happening. GOV2 claims that risk management in the BELP has been 'relegated to ostracism'.

Criticism and inputs

Recognizing that the BELP falls short of protocols to enforce follow-up and management, the interviewees provide some criticism and inputs that can contribute to the identification of directions to improve the 'post-licensing':

a) The lack of an integrated action of the governmental actors is a serious problem for some participants. CS1 points out that the environmental agencies are not the sole actor in charge of the follow-up. For instance, CS1 understands that the integration between the BELP and the 'civil defense'[19] is poor, claiming that the results of the QRA 'die' in the BELP; they need to be disclosed

[19] The civil defense is an organization that acts at local level – "the system of protective measures and emergency relief activities conducted by civilians in case of hostile attack, sabotage, or natural disaster" from the Merriam-Webster Collegiate Dictionary.

to the civil defense as well. In the same direction, CS3 advocates more involvement of local actors in the control and management of hazardous installations; ‘otherwise it becomes too unreal’.

b) Some interviewees indicate the need to improve communication protocols in the processes to help in the follow-up. For instance, CS2 misses a more effective use of information and communication technologies (ICT) supporting the BELP routines.

c) Often the participants argue that the management and follow-up is biased towards the hazardous installation. For instance, CS6 claims that the actions carried out in the current arrangement are not only limited but also too focused on the control of the integrity of the facility only, ‘as if nothing is going on around it’.

d) The BELP lacks standards, indicators to assess the performance of the follow-up, as pointed out by ES1.

e) There is need to articulate risk management practices of all installations affecting a given population and the use of the land near hazard-prone areas. For example, ES3 advocates the need to pursue an integrated follow-up, encompassing not only the project under licensing but also other facilities and the local estate real planning.

f) Some participants point out that the environmental licensing seems to end with the operation license. As explained by CS5, the environmental agencies need to have it clear that licensing does not finish with the issuing of this last permit; it needs to be extended until the decommissioning of the facility.

g) Aiming to improve this scenario, ES8 suggests that the environmental agencies should have a specific team of specialist in charge of and working only with the post-licensing.

Those inputs somewhat reinforce the need to improve the licensing routines of the BELP in general, and the regulation of hazardous projects in specific. It is noteworthy that many interviewees pointed out that technological risks are not expected before the beginning of the operation. The BELP needs to consider vulnerabilities, perceptions, and impacts during the three-license stage but the risks of a transmission pipeline are expected only in the operation. However, as inferred from the interviews, the follow-up seems to be a weak link in the chain of events that constitutes the Brazilian environmental licensing.

Participant-observation: The researcher recalls that, as a coordinator for environmental licensing at IBAMA (between 2005 and 2006), he often needed to prioritize activities related to the initial phases of the licensing processes in detriment to the monitoring and control of projects in operation due to high number of processes and the limited number of environmental specialists to carry out the technical evaluations. For instance, at that time there were several old facilities and installations (prior to the CONAMA 237/97 that regulated the environmental licensing in Brazil) operating without an environmental permit because the team of environmental specialists did not have time to direct efforts to their regularization.

Box 5.1 – Complexity in the environmental licensing of pipelines

Question: One frequently observes a great number of people living very close to pipeline's right-of-ways. Can you think of causes for that?

> "I think there are two things. Firstly, we have some very old tracks. (...) As you have followed at IBAMA, we try to bring developments of new tracks to the countryside. So what happens? Let's take an example of a new track. New tracks we try to sit in rural area. However, in some moments, for instance because of the landscape in the region or the question of the distribution of gas or oil, we have to change the route to bring it a little closer to the city. Hence, sometimes the track ends up going in places that, let's say, has more human concentration. We try to get away from it, but sometimes we end up bringing it closer. (...) What happens in the past? Those tracks that have a high human concentration, they did not have people living nearby. However, a region, for example São Paulo, is a region that has grown very much. So, what happened? We ended up at that time, years ago, siting terminals, refineries, in a region that was uninhabited at the time, but the population growth was high, and that vector of growth pointed to the pipeline. So, a pipeline right-of-way that we try to keep mowed, maintaining the characteristics of the vegetation to control erosion (...). All this, André, I think attract people. Hence, the right-of-way is an attractive, triggering the access. Then, it is easy to get there and settle next to the pipeline because our right-of-ways have no fences, nothing (...)."

Question: So, to what extent do you think this is an issue related to the environmental licensing process?

> "No, I see a different problem there. It is a problem closely related to the municipality. Because the city has to have the master plan, it does need to have it very clear. For example, in the pipeline right-of-way, those local licensing requirements, to enforce what the law says. So, there is a governmental problem. The environmental licensing, of course, issues the licenses based on the law that exists. The environmental agency takes the law and enforces what the law requires. However, there is confusion in this point, because the developer, in quotes, has no management over the government. And I think the enforcement of the master plan is crucial. Only now the municipalities are beginning to develop master plans, to understand their municipalities. I think this aggravates the issue (...) There is a federal decree regulating public utility, which is correct, which oversees what is best for the nation to the detriment of the citizen. We have to see what is best for all the population; some individuals will end up needing to withdraw in favor of the nation. [However] there is a conflict among the federal, state, and county levels; the understandings are not the same. Then, we have another issue. For example, the mayor does not have sufficient financial resources to manage the municipality. Then, when you have a project or anything else in the city, the mayor sees that as a way to have some gain. Sometimes he does not see it for the city, but he sees it as a personal or political gain: "hey, if this company comes here I can get jobs for my people and make it easier for my re-election". There are others who think differently, though: "I'm going to organize this, there is a good area where the project can be safe, and I can use the money to create an environmental conservation area". Others take advantage of that one item on the environmental licensing process that says "the developer has to present formal consent from the municipality" to use it for, in quotes, very crazy things. (...) Once, a municipality had a community away from the route of a pipeline. The mayor made a complaint because he wanted it to pass in that community. We explained that there were technical problems for that ... but he was not concerned with the community. He wanted the pipeline to cross the community because he would have a chance to make bargains with us". **Source: Interview 2009.**

5.3 Summary of the interviews:

The main insights presented in the interviews are summarized next. The subsections below collect the inputs from each of the ten described themes, those inputs underlined for easy identification in Section 5.2, generating a list with the essence of the points articulated by participants.

5.3.1 Summary of the positive aspects

The analysis of the interviews indicates that the BELP (1) is a necessary instrument to implement the environmental agenda in governmental decisions in Brazil; (2) is important in the enforcement of the law and normative regulations; (3) helps in the meditation and solution of conflicts about any given dispute; (4) enforces and controls the quality of technical studies to identify impacts and risks; (5) generates knowledge through these required studies; (6) anticipates and mitigates impacts and risks; (7) structures the follow-up in a systematic way; and (8) is open to public input and participation.

5.3.2 Summary of the negative aspects

The analysis of the interviews shows that the BELP, in theory, has strong ideals but the practical and contextual implications imposed by Brazil's geographical dimension compromise the performance of the BELP. The interviewees point out (1) the frequent detachment of the BELP from reality; (2) the lack of resources in general, (3) the low qualification and insufficient number of specialists and (4) the frequent lack of professionalism in the environmental agencies; (5) the low quality of the technical studies supporting the analysis and decisions; (6) the governmental lack of interest in the social and environmental agenda; (7) the political and (8) economic influences in the BELP; (9) the lack of integration of the environmental agenda with planning policies and national goals; (10) deficient public participation and input; and the use of the BELP (11) to legitimize decisions already made by governmental actors and (12) to bargain for compensations.

5.3.3 Summary of the missing points

The interviews indicate that the BELP lacks (1) public participation to support the decision making; (2) normative guidelines to structure the performance of the BELP; (3) the development of follow-up routines; (4) resources (financial, staff, infrastructure, logistic, etc.); (5) impartiality of the consulting companies when carrying out the technical studies; (6) policies to incorporate the land-use and organization into the risk practices; and (7) a methodology to pre-assess risks and impacts.

5.3.4 Summary of the technical information

Technical studies, especially the EIA and the QRA, play a fundamental role in the BELP. Their application needs to be encouraged to assure optimized and realistic decision making. However, some limitations are present in the current arrangement: (1) the studies are not easily available to all stakeholders, and (2) even if they are available, they are not easy to comprehend by the general public; (3) there is a need to improve the quality of these studies; and (4) the impartiality of the information presented need to be constantly enforced.

5.3.5 Summary of sense of justice and inclusiveness

The BELP is considered to be one of the few participatory decision-making processes in Brazil, if not the only one. Although fairness in governmental decisions is somewhat utopian, the conception of the BELP encourages social and environmental justice. The sense of justice in the BELP is influenced by the extension of inclusion in its routines and decisions. However, interviewees suggest that the (1) inequity in economic and political power among stakeholders leads to the need to (2) improve the environmental agencies' communication skills, (3) create new channels for public participation, and (4) prepare the civil society for the challenge.

5.3.6 Summary of the application of QRAs in the BELP

QRAs are applied in the BELP to assess and decide about hazardous processes. Although (1) QRAs are a solid method helping the BELP officials to consider the risk variable in the decision making, some participants argue that their performance can be improved. The studies are often (2) too technical to be understood and discussed with a general audience (and sometimes even environmental specialists at the environmental agencies). There is a (3) preeminence in the assessment of the technological system over a broad vulnerability assessment. Risk policies (4) are not usually integrated with land-use planning. And, there is a general perception, especially in the civil society sector, that those (5) studies are only applied to legitimize the projects.

5.3.7 Summary of the encroachment of pipelines' right-of-way

Interviewees acknowledge the encroachment in a great number of right-of-ways in Brazil (not only transmission pipelines, but also railways, roads, transmission power lines, etc.). From the analysis of the interviews it is possible to infer two factors that may indicate the causes of this process: (1) the lack of appropriate land-use planning and (2) the local social broad vulnerability. It is also possible to infer that the (3) environmental agencies, (4) the local administration, (5) and the integration of these two have a stake on this matter.

5.3.8 Summary of the follow-up

The environmental agencies usually do not have enough personnel and resources to perform a good follow-up of the hazardous facilities. Interviewees describe these routines in the BELP as (1) deficient; (2) nearly absent; and (3) political burden to politicians and regulators. However, they also provide inputs on how to improve it, such as (4) the integration of the BELP with other governmental actors and (5) the need to observe that the environmental licensing does not finish with the OL.

5.4 Conclusions on the interviews

The BELP is considered by interviewees as a fundamental instrument in the implementation of the environmental agenda in Brazil. Several positive aspects are pointed out supporting this decision-making process (Section 5.2.1). In the specific context of risk regulation, the BELP is also important for regulating the integration of hazardous facilities in urban areas since it has a set of technical measures in place to estimate risks and enforce safety. However, interviewees also criticized the BELP for a considerable number of reasons (see also Box 5.1). The fundamental limitations preventing optimized management of risk exposure are listed below:

1. Firstly, cumulative risks are not integrated since projects are licensed individually. However, the population is exposed to the aggregated risks. For instance, if a pipeline is going to share an existing right-of-way, one individual 'sees' the risks of all pipelines using that route.
2. Second, the BELP does not integrate risk regulations with the policies for land-use. Risk assessments should be feeding the city's master plans. According to the interviews, that is one of the plausible causes for the encroachment of pipeline's ROW.
3. Third, the BELP lacks channels for public input and the communication process is deficient, making licensing processes barely inclusive.
4. Fourth, the BELP has serious structural and normative limitations, compromising its performance. As pointed out by one of the interviewees, the Brazilian state does not grow at the same pace as the country's demands.
5. Fifth, the BELP lacks solid practices to follow its decisions. The BELP privileges the discussion of new projects over the control of the existing ones.
6. Sixth, there is preponderance to the analysis of the inputs brought by the developer and the project, in detriment to the inputs provided by the civil society and the needs of the affected populations and communities.

Brazil lacks forums to discuss demands such as the country's budget, the nation's strategic planning, the social injustice and misery, the lack of urban infrastructure and basic services, the lack of resources in the municipalities, and many other issues of local and national importance. Many times, this contextual pressure is released at the first opportunity available, usually the BELP. As pointed out by one interviewee, in the end

> "land title regularization; the lack of policies for traditional and indigenous populations, including the quilombos [traditional Afro-American populations]; even the lack of an environmental policy in the states and municipalities; it all flows into the environmental licensing, making it more complex. That makes it [BELP] to be a repository of all aspects that are missing in the country." **GOV7, interview 2009**.

Then next chapter elaborates on current strengths and limitations assessing the BELP’s performance related to the regulation of technological hazards based on a few qualitative indicators drawn from the literature and the research’s conceptual framework (Chapter 4).

Chapter 6 – Case Study: Assessing IBAMA's Environmental Licensing Process

This chapter draws on the results from the interviews and surveys, the literature, participant-observation, and the research's framework to evaluate the performance of the BELP in the regulation of hazardous installations and facilities. The performance evaluation is based on the twelve themes identified in the research's conceptual framework: pre-assessment of risks, concern assessment, precautionary appraisal, risk reduction at source, communication, environmental and risk education, public participation, environmental justice, governmental integration, land-use planning, specific routines for risk management, vulnerability assessment, resilience plan, and follow-up.

6.1 Assessing the performance of the BELP

The objective of this chapter is to assess Brazil's relative position compared to the proposed opportunities to improve its risk-based decision making, discussed in the conceptual framework. Complementarily, this evaluation also serves to assess the significance and presence of the research propositions in a practical situation. The evaluation draws on the twelve themes suggested by the conceptual framework (Table 4.1) that are applied as qualitative indicators to evaluate IBAMA's performance in the licensing of gas and oil transmission pipelines (Table 6.1). Although the term *indicator* is often recognized as quantified measure in the literature on social sciences, the research understands that indicator is also an appropriate term to describe how well the BELP performs each of the twelve themes, even if only in a qualitative way. Please also note that two themes of the conceptual framework were assessed separately: communication and education leads to communication (3A) and environmental and risk education (3B); and public participation is expanded to public participation (5A) and environmental justice (5B). This separation aims to facilitate and bring more detail to the assessments. It is also important to mention that the survey results will be presented in this chapter (and also in Chapter 7) as complementary qualitative information – as discussed in Section 3.4.1.2, the surveys are not used to provide any statistical inference due to the small sample size and the relatively high concordance in the responses.

Table 6.1 – Qualitative indicators for performance evaluation.

1 - Pre-assessment of risks	6 - Governmental integration
2 - Concern assessment	7 - Risk reduction at source
3A - Communication	8 - Land-use planning
3B - Environmental and risk education	9 - Specific routine for risk management
4 - Precautionary appraisal	10 - Follow-up
5A - Public participation	11 - Vulnerability assessment
5B - Environmental justice	12 - Resilience plan

As framed in the case study, this research focuses on processes carried out by IBAMA at the federal level. IBAMA's performance is assessed in two ways. The first one identifies whether the issue is addressed in the current frame of IBAMA's licensing processes. Two answers are expected: (1) present or (2) absent. Given that the indicator is present, the second evaluation assesses a qualitative performance of that indicator. Three answers are expected: (1) good, where the indicator is appropriate; (2) somewhat good, where the indicator is appropriate in some aspects, but deficient in others; and (3) poor, where the indicator is deficient or inappropriate. All evaluations are based on the inputs from interviewees, literature in the area, and the observation of the researcher as an insider. The results of the first question of the research survey also endorse the assessments at this stage (Table 6.2). The strategies for validation described in Section 3.4.2 are employed thoroughly to support the results and limit research bias.

Table 6.2 – Result of surveys, question #1.

Survey question # 1: *If you have the opportunity to improve routines in the Brazilian environmental licensing processes, how important would be working on the following actions?*

Item	**Related theme in the conceptual framework**	**Not Important**	**Somewhat Important**	**Very Important**	**Don't Know**	**Total**
a) Improve the quality of the environmental studies	Risk reduction at source; Vulnerability Assessment, Resilience Plan, Follow-up	0	2	28	0	30
b) Expand the opportunities for public participation	Public Participation; Concern Assessment; Communication and Education	2	10	17	1	30

Item	Related theme in the conceptual framework	Not Important	Somewhat Important	Very Important	Don't Know	Total
c) Develop norms and procedures for the environmental licensing processes	Integration of governmental actors; Land-use control around ROW;	1	4	25	0	30
d) Increase the transparency of the decisions	Public Participation; Communication and Education; Concern Assessment	0	7	23	0	30
e) Develop new protocols for communication and disclosure of information	Public Participation; Communication and Education; Concern Assessment; Follow-up	0	7	23	0	30
f) Reduce the political influence in the processes	Precautionary Appraisal; Public Participation; Follow-up	3	9	18	0	30
g) Improve the integration between planning and licensing	Integration of governmental actors; Land-use control around ROW; Resilience Plan	0	1	28	1	30
h) Improve the environmental education programs	Public Participation; Concern Assessment; Communication and Education	3	14	11	2	30
i) Optimize the time and cost of the processes	Precautionary Appraisal; Risk Reduction at Source; Public Participation	3	9	18	0	30
j) Improve the protocols for follow-up and management	Vulnerability Assessment; Resilience Plan; Specific Routine for Risk Management; Follow-up	0	3	27	0	30
k) Reduce the economic influence in the processes	Precautionary Appraisal; Public Participation; Follow-up	2	11	13	4	30

6.1.1 Pre-assessment of risks

Definition[20]

According to Renn and Roco (2006c:165), "[p]re-assessment builds on the observation that collective decisions about risks are the outcome of a 'mosaic' of interactions between governmental or administrative actors, science communities, corporate actors and actors from civil society at large". Renn and Walker (2008:125) continue stressing the "emphasis on the development of a proactive approach to management of potential risks before serious hazards evolve".

Importance

[20] Rather than comprehensive, the definitions presented in this section attempt to describe how the concepts are interpreted to carry out the evaluation of the case study.

Pre-assessment can anticipate situations before they arise, and in doing so, influence local and regional planning to avoid risks in the future. It involves identifying potential harm well before it becomes a real event. As pointed out by Amendola, "[r]ecent paradigms call for a participatory procedure, in which the different stakeholders are involved early in the risk analysis process to 'characterize' risks, even before they are given a formal assessment." (2002:17). This way, stakeholders from diverse institutions have the opportunity to identify measures that need to be put in place and establish a common plan to avoid exposure to risks early on in the process. Moreover, according to Renn and Walker (2008:125), pre-assessment of risks is also "seen as basic requirements for stakeholders to enter into a productive exchange of views and ideas with risk assessors and risk managers." Pre-assessment also benefits the affected population since they open a channel for clarifications prior the discussion of risks carried by QRAs. On the other side, decision makers and risk managers also take advantage of this information to inform a more realistic risk assessment.

Assessment

Several interviewees indicate that pre-assessment of risk is not carried out in the BELP. For instance, CS1 points out that the pre-assessment of risks is not done by the IBAMA. Rather, the discussion about the risks starts when the developer hands in the QRA to the environmental agency. However, he/she acknowledges that an earlier discussion seems to be a good idea for some installations, though complicated to pursue. CS5 argues that public participation needs to start as early as the beginning of discussion of the terms of reference for the studies in the Prior License. CS6 and CS8 advocate that civil society needs to have a more active role in the discussion of risks of pipelines, for instance participating in the discussion of its route. CS7 draws attention to the need to incorporate the social component into the scope of QRAs. CS9 stresses, though, that the BELP is missing such a methodology. In the literature, Nicolaidis (2005) and Souza et al. (2007) argue that the BELP lacks opportunity for public input in the elaboration of term of references for the risk studies.

Conclusion: item absent.

6.1.2 Concern assessment

Definition

Concern assessment deals with risk perception, social concerns, and the social-impacts imposed onto the human system exposed to a hazard (Renn 2008). Concern assessment also deals with different perceptions and perspectives about the same hazard (Renn and Walker 2008).

Importance

Concern assessment is important in the understanding of the communities being exposed to the hazard: what is their knowledge about the project; what are their expectations and worries about the proposed activity; how do they expect their lives to change with the project? In this sense it has to be seen as an opportunity to let the affected population manifest concerns and clarify doubts, an open channel informing both the QRA and risk management. As in the pre-assessment of risks, concern assessment also serves to develop a more realistic view of the risks.

Assessment

Concern assessment is foreseen in BELP's formal framework, through public hearings to discuss the studies at the Prior License stage. However, interviewees are divergent in their views about the effective use of this channel to assess concerns. For instance, GOV4 believes concerns are not assessed; the population has no idea about the pipeline's risks. GOV11 adds saying that the risk communication is nearly absent in the BELP. However, ES9 counter argues claiming that sporadically consulting companies gather socioeconomic information about the local population, when the specialist has the opportunity to inform and take note of locals' concerns. Either way, it seems misplaced. Concern assessment should inform the QRA, not the other way around. In the current arrangement, the population is informed about the risks at the time of the discussion about the QRA (MPF 2004; Nicolaidis 2005; Souza et al. 2007; Montano and Souza 2008), which indicate a preponderance of the technological system over the human system in both the QRA and decision making.

Conclusion: item present; performance poor.

6.1.3 Communication and Education

6.1.3.1 Communication

Definition

Communication is broad. In this context, the focus is on communication among stakeholders from different areas during governmental decision making. That includes both the technical and administrative information about the processes and projects, through formal and informal channels.

Importance

The access to information is a pre-requisite for democratic and transparent governmental decisions. In the specific context of risk policies, communication is also fundamental in the construction of a solid assessment, decision, and, especially, management of risks.

Assessment

Communication is inherent to the BELP. However, the number and quality of the channels are insufficient (Fowler and De Aguiar 1993; Diegues 1998; Glasson and Salvador 2000; Oliveira 2000; Alonso and Costa 2002; Cappelli 2002; Little 2003; MPF 2004; Nicolaidis 2005; Assunção 2006; Kirchhoff 2006b; Souza et al. 2007; Lima and Magrini 2009; Loures retrieved Jan 2010). Interviewees from the civil society group complained consistently about the lack of opportunities to make themselves heard and about the limited information provided by the environmental agencies. This limitation is also acknowledged in the other two groups. One recurrent criticism is that communication is often too formal and made in technical language. That compromises public participation. CS10 exemplifies this perspective

> "I search in the meanders of IBAMA's website and find some things. I have other ways to find it. But I cannot get everything. It is not transparent. And the licensing process is not only the technical information; it is also the exchange of official letters, a lot of things that is in limbo, inaccessible (…) [moreover,] the number of public hearings, sometimes I get very upset with this issue. You cannot randomly say it is going to have four or five, or one or two public hearings". **CS10, interview 2009.**

Conclusion: item present; performance poor.

6.1.3.2 Environmental and risk education

Definition

Environmental and risk education refers to the preparation of the population to have an active stake in the decision making and control of risks. Stakeholders need to be familiar with the basics of the licensing processes' routines. They also need to have basic knowledge about the projects, risks, and impacts expected. To some extent, it is associated with communication.

Importance

Education helps in two complementary ways: instigating participation in quantity and quality. As argued by Beck (1992:35), "education and attentiveness to information open up new possibilities of dealing and avoiding risks". The BELP has much to benefit from constant and more qualified public participation offering insights on the projects and decisions being made, but qualified participation very often also implies consistent actions towards educating people. In the context of risks, it also contributes to the management of the hazardous facilities since it enables the human system to participate proactively in the discussions about safety measures.

Assessment

Environmental and social risk education overlaps with communication. In fact, education is often compromised or facilitated by efficient communication among actors. Thus, the information needs to be available in diverse channels, with appropriated language, so that the involved actors have the opportunity to learn about projects, risks, and impacts. However, the BELP seems inefficient in transferring the knowledge from the studies to its stakeholders (Oliveira 2000; MPF 2004; Nicolaidis 2005; Assunção 2006). For instance, ES11 and ES10 argue that, in the specific case of risks, the information is too abstract and technical, a number, indicating a need for translation of the technical language in benefit of education. CS8 points out another limitation alleging that few studies are made available to the general public before the hearings. Interviewees often perceive that education is not a core goal in the licensing processes, helping in the construction of the decisions. Rather, it is often just an instrument applied to justify the projects and provide guidelines to protect the facility: "usually you see a very *en passant* discussion of potential risks and problems that it will occur and in the end the environmental education comes to save us all, after it is all done" (CS8 2009). An explanation for that is offered by Alonso and Costa (2002), when they argue that the social sciences are not present in the decision making of environmental matters in Brazil.

Conclusion: item present; performance poor.

6.1.4 Precautionary appraisal

Definition

According to Sandin et al. (2002:288), "[t]he basic message of the precautionary principle (…) is that on some occasions, measures against a possible hazard should be taken even if the available evidence does not suffice to treat the existence of that hazard as a scientific fact". Another approach is presented by Cameron (1999:243), "[p]recaution accepts that uncertainty in both outcome and practical response is a precondition of action and devises techniques to plan always for the worst outcome".

Importance

Precaution offers a more conservative approach compared to prevention[21]. As pointed out by Balzano and Sheppard, in the context of the decision making regarding risks the *precautionary principle* is applied "as a paradigm for response to potential risks to the environment or health when scientific data are uncertain" (2002:351). Hence, precaution works on the realm of uncertainty, of the unknown. It offers a perspective pro safety whenever the outcomes of actions are not clear.

Assessment

If precaution refers to deciding in uncertain conditions, it is hardly considered by the BELP addressing risks (dos Reis 2007). For instance, in the case of transmission pipelines, the only component likely to consider precaution is the criteria for acceptability of risks. However, as discussed by Kirchhoff and Doberstein

[21] Prevention is the outcome of the expected, known events.

(2006), and pointed out by CS4 and CS6 in the interviews, the Brazilian standards are more permissive compared to other nations. That weakens this argument. CS1 provides another insight pointing out that some decisions are taken before any analysis is made, for instance the elaboration of a QRA, demonstrating the use of the precautionary appraisal - at least in theory. CS8 argues that the BELP provides the civil society with an opportunity to know the project before it is installed. However, even in these cases it is difficult to distinguish the boundaries between precaution and prevention. CS7 and CS1 elucidate this saying that the BELP does not consider the social perspective and the use of land many times, although decisions are still made; so we cannot say that precaution is enforced.

Conclusion: item present; performance somewhat good.

6.1.5 Public participation

6.1.5.1 Public Participation

Definition

Public participation refers to the channels opened up by the BELP for public input and the consequent use of them by the general public. In the context of risks, it encompasses participation during the definition of guidelines for risk assessment, the discussion, assessment, and decision about the results, and the elaboration of programs for risk management.

Importance

Public participation is an important measure for inclusiveness and justice (Greenberg 1993; Walker et al. 1999; Davies 2001; Walker et al. 2001; Acselrad 2002; Amendola 2002; Herculano 2002; Enserink and Monnikhof 2003; Bryson 2004; Jacobson et al. 2005; Cutter 2006; Pelling 2007). Participation and discussion of collective issues in a democratic environment contribute to the transparency of the decisions. In the context of risks, it is also important for effective control and management of risks. Risks arise from the interaction of a technological system with a human system. Hence, to understand risks people need to be heard. Furthermore, public participation is a right in the BELP.

Assessment

Similarly to communication and education, there is a general discontentment with public participation in the literature (Diegues 1998; Glasson and Salvador 2000; Oliveira 2000; Alonso and Costa 2002; Cappelli 2002; Little 2003; MPF 2004; Nicolaidis 2005; Assunção 2006; Souza et al. 2007; Loures retrieved Jan 2010). Public participation usually takes place only at the hearings conducted by the environmental agency to present the results of the technical studies supporting the first step of the process (PL). Some of the interviewees approach the need to develop other channels for participation in the BELP. CS8 and CS6 describes their perception of public participation in the BELP

> "the licensing agency has months, sometimes years to analyze the process. So does the developer. However, the social participation is very limited, confined to public hearings (…) and it is commonplace practices such as the developer mobilizing his workers, or the population that will temporally benefit from the project with jobs, to go there and push for the project's approval. Little is being discussed." **CS8, interview 2009.**

> "sincerely, it is not encouraging at all. Participate in a process, if you are out of it, if you are not a major actor in this process… and of course, to participate you must have information… so, if you want to take it to the end you have to have a lot of energy, must have lot of patience, you better be sure, I really want to participate…". **CS6, interview 2009.**

Some other inputs are also pointed out. Public participation is often weakened by political and economic pressure; it has been used to legitimize rather than consult; it is often compromised by the socioeconomic profile of the participants; and public hearings often take places in unfriendly facilities and inconvenient times. As well, the results of question 1b show a slight polarization between segments in this matter (Table 6.3). All nine participants from the group civil society answered that it is very important to expand opportunities for public participation in the BELP. On the other hand, seven interviewees from the economic sector consider the topic either not important or only somewhat important.

Table 6.3 – Question 1b by segment.

*__Question 1b (by segment):__ *If you have the opportunity to improve routines in the Brazilian environmental licensing processes, how important would be to expand the opportunities for public participation?*

Item	Not Important	Somewhat Important	Very Important	Don't Know	Total
Overall	2	10	17	1	30
Civil Society	0	0	9	0	9
Economic Sector	2	5	3	1	11
Government	0	5	5	0	10

Conclusion: item present; performance poor.

6.1.5.2 Environmental justice

Definition

As defined by Bowen et al. (1995:641), "[e]nvironmental justice is the policy rubric within which issues such as environmental equity, environmental discrimination, and environmental racism are embedded (Torres

1994; Celobter 1994). From the standpoint of politics this rubric acknowledges that environmental decision making involves the role of power and conflict".

Importance

Environmental justice has been identified as one important contribution to better control of hazard exposure (Goldman 2000; Acselrad 2002; Fothergill and Peek 2004; Cutter 2006; Arnold 2007). As pointed out by Tarlock, the "[e]nvironmental equity is premised on the notion of fairness in the distribution of environmental hazards, particularly those of a technological origin" (Tarlock cited by Bowen et al. 1995:641). Since risk management is a continuous process, the decisions taken in the light of this concept are likely to persist in the mid and long run. The point to be made relates to agreement, harmonization. If the operation of a hazardous facility near a community is a consensual decision between the community itself and the managers of the facility, the coexistence between these two systems is likely to be less problematic. Justice in this case supports management, since once side does not overpower the other.

Assessment

In theory, one of the implicit goals of the BELP is to promote justice in a broader sense (for instance, local impacts can serve to a national goal). However, the understanding of what is fair is contextual and complex. Analyzing the interviews and scholarships in the matter, one can come across situations where representatives from civil society complain that they do not have an effective stake in the process (Oliveira 2000; Alonso and Costa 2002; MPF 2004; Nicolaidis 2005; Jacobi and Alimonda 2006); the environmental agency complains about the excessive political and economic influence in its routines (Little 2003; Assunção 2006; Castro 2006; Borinelli 2007); the consulting companies complain about the lack of criteria from the environmental agencies (Egler 1998; Assunção 2006; dos Reis 2007); and the developer complains about the costs of the environmental licensing. The equalization of all perspectives and interests involved in a typical licensing process is not an easy task. Yet, the BELP could be better structured to pursue environmental justice. It is important to mention that interviewees advocate that a process cannot be fair if it is not inclusive and participative; if it does not have technical and normative guidelines structuring its routines and decisions; and if decisions are still based on political and economic factors.

Conclusion: item present; performance poor.

6.1.6 Governmental integration

Definition

Governmental integration refers to the ability of the environmental agencies to communicate with other governmental actors during the routines and decisions of the BELP. For instance, it encompasses the integration of the different governmental levels regulating the use and occupation of land or siting of hazardous facilities, such as the Brazilian electricity regulatory agency (ANEEL) and the agencies for traditional populations and historic places (IPHAN) and aboriginal populations (FUNAI).

Importance

Governmental integration is important to establishing and pursuing a common goal, a common welfare. It optimizes decisions, integrates risks and impacts, and diminishes costs and time for decisions in the BELP. In the specific context of risks, transmission pipelines are licensed by the federal and state levels of the Brazilian government. On the other hand, the municipalities are responsible for the regulation of the land. Hence, integration between such levels in Brazil's regulatory processes is fundamental for management and control of risk exposure.

Assessment

Governmental integration is expected by the formal structure of the BELP. In theory, other governmental stakeholders are consulted during the processes (Glasson and Salvador 2000; Little 2003; Goldemberg and Barbosa 2004). As indicated by CS2, "the 'environment' encompasses many issues, so the environmental decision depends on many governmental actors. There are so many institutions involved in the licensing procedures that make it very complex". However, the integration and harmonious action of those governmental actors are still not appropriated in the BELP (Egler 1998; Glasson and Salvador 2000; MPF 2004; Nicolaidis 2005; Assunção 2006; Borinelli 2007; Lima and Magrini 2009). For instance, there is clear evidence of lack of integration between the environmental licensing of hazardous activities and land-use planning. Another instance of the lack of an integrated action is shown by the absence of regional and integrated thinking when addressing risks. Installations and facilities are licensed individually. CS3 points to a third way that the lack of an integrated action can compromise the BELP by saying that currently the environmental licensing is carried out only with the information provided by the developer and consulting company. The environmental agencies often do not consider information provided to the processes by other stakeholders. ES11 and GOV5 draw attention to a fourth source of the lack of an integrated action, the frequent conflict of interest among the governmental actors due to political and/or economic reasons. Federal, state, and local levels can be representing differing party and ideological views. GOV10 indicates a fifth level related to the lack of integration between the environmental agenda and other governmental agendas, such as the national and strategic planning. Interviewees also identify that the BELP lacks mechanisms to promote or make this interaction any better.

Conclusion: item present; performance poor.

6.1.7 Risk reduction at source

Definition

Similarly to the precautionary appraisal, risk reduction at source also deals with hazards in an anticipatory manner. However, these two indicators have an important difference that reflects the nuances of the concepts of precaution and prevention. Risk reduction at source deals with prevention, with available information, usually applying QRAs to understand a project and propose safety measures before it starts operating.

Importance

Risk reduction at source is a core element in the control of risk. For instance, it permits changes in the pipeline's route and changes in the project specifications and materials to make it safer. If a community is to be affected by a hazardous facility, risk reduction at source helps to minimize the likelihood that any accidental event will harm people. For instance, transmission pipelines can be buried deeper in the ground, or be encapsulated with concrete above the ground to prevent cracks. Another example is the use of filters to prevent risks in air and water contamination.

Assessment

Although precaution is hardly seen in the BELP, prevention is often applied helping to minimize risks at source. QRAs scrutinize the facility's project and often indicate modifications to improve safety (Kirchhoff et al. 2007; Yogui 2008; Gardiner et al. 2009). ES1 explains that the risk assessments, focusing on the project, permits alterations before its installation begins; it is still possible to do something. ES10 adds to this saying that "risk analyses are important to us so that we have a vision of what can happen and what we have to make arrangements for"; and ES4 complements saying that risk analysis "shows every possible scenario and procedures the company has to put in place, to make sure that it [risk] is not happening, and if it happens, how to minimize the consequences".

However, risk reduction at source usually works on only one project. It does not consider other hazardous installations in the vicinity that also represent a source of risks. For instance, a household in the area of influence of a pipeline's right-of-way is subjected to the risks of all the pipelines sharing that ROW, regardless if regulators are deciding about only one pipeline. In such a scenario, it is very likely that the decisions about risks are going to be disarticulated, especially if there are multiple governmental entities licensing each of those pipes. In the case that just one agency regulates all pipelines, another complication comes from the limitations in calculating cumulative risks. There is still no clear answer in the literature as to how to estimate risks from multiple sources, or the 'cascade effects' (Assmuth et al. 2010).

Conclusion: item present; performance somewhat good.

6.1.8 Land-use planning

Definition

This indicator refers to the control of land-use around hazardous facilities. For instance, according to Cozzani et al. (2006:171) "[t]he principle behind LUP [land urban planning] is that incompatible activities, such as handling of dangerous substances and residential areas, should be separated by sufficient distances. These distances should be proportional to the level of risk confronted by the receptors". The implementation of such measures (or safeguards), if needed, can help on the management of exposure. This concept is also addressed in Section 2.2.

Importance

As described in the Special Report 281 of the United State Transportation Research Board, "[t]he primary objectives of pipeline-related land-use measures are to reduce the risk of damaging the pipelines by keeping human activity away from their immediate vicinity and to minimize the exposure of those living and working near a transmission pipeline in the event of an accident" (TRB 2004:viii). It is important again to acknowledge that risks are not the product of just one technological system; it rather comes from the interaction between hazards and the human system, people and communities. Hence, an effective way to avoid exposure to risk is controlling the proximity of people and residences. With no people there are no risks.

Assessment

For many interviewees the lack of land-use policies based on risk standards is a serious limitation of the BELP. This is supported by the Brazilian literature on the matter (de Souza Jr 2000; Assunção 2006; dos Reis 2007; Souza et al. 2007; Montano and Souza 2008). CS2 illuminates this

> "the environmental licensing is disconnected to other licensing procedures. It does not make sense to license a project if this licensing process is not tied to a master plan. But in Brazil this does not happen because the cities do not have master plans yet. And the cities do not have the capacity to do those master plans either." **CS2, interview 2009.**

In fact, land-use and risk management integration is a consolidated practice in Europe (Godschalk et al. 1998; Burby et al. 2000; Christou and Mattarelli 2000; Boholm and Löfstedt 2004; Cozzani et al. 2006; HSE 2008). The interviews indicate that there is need to pursue practices and even legislation to integrate these two aspects (land-use and risks) into a sole decision-making process in Brazil. ES3 points out that "the firmness with which the issue of use and occupation of land is discussed in Brazil is not exactly what should happen".

ES7 agrees saying that “we are very strict in the licensing, and it has to be indeed, we need to approve the best project possible, but then we forget it until an accident happens. Then we will need to work correctively since the event has already taken place”.

Conclusion: item absent.

6.1.9 Specific routine for risk management

Purpose

Traditionally risk management is part of the risk assessment, the last step in a chain that also involves assessment, analysis, and decisions (Muhlbauer 1992; Molak 1997; McColl et al. 2000; Cox 2002; TRB 2004). In this arrangement, the discussion of risk management takes place relatively close to the end of the decision-making processes. However, as discussed in this document, technological risks due to the operation of transmission pipelines are expected only with the operation of such a pipeline (there is no inventory of gas or oil before the pipeline is granted operational status). A specific routine addressing ‘management’, running concomitantly with the routines addressing ‘risks’, can anticipate the discussion of practices for better control of exposure (and stress the importance of the human system). The early insertion of ‘risk management’ in the ritual of the BELP can also lead to an improved follow-up.

Assessment

A specific routine for risk management is not present in Brazil, as it is a new measured proposed by the research’s conceptual framework. In the current arrangement of the BELP, the design of risk management practices is based on and carried out only after the results of the QRA. The detachment and anticipation of the discussion of the risk management program can help balance out the importance that both systems, technological and human, have in the regulation of risks.

Conclusion: item absent.

6.1.10 Follow-up

Definition

This indicator refers to the follow-up (or monitoring) of plans and programs that have been agreed at each step of the environmental licensing (Prior License, Installation License, Operation License). It also encompasses routines to control and manage the operation, risks and impacts, of the facility.

Assessment

The report of the interviews (Section 5.2) directly addresses this matter. Interviewees describe BELP's follow up as 'deficient', 'nearly absent', and a 'political burden'. This same criticism is found in the literature (Eve et al. 2000; Marinho and Minayo-Gomez 2004; MPF 2004; Prado Filho and Souza 2004; Nicolaidis 2005; Assunção 2006; Borinelli 2007).

Conclusion: item present; performance poor.

6.1.11 Vulnerability assessment

Definition

Watts and Bohle (1993:46) argue that "vulnerability is a multilayered and multidimensional social space defined by the determined political, economic and institutional capabilities of people in specific places and specific times". Cutter (1996) talks about three different themes in vulnerability assessments: vulnerability as risk/hazards exposure; vulnerability as social response; and vulnerability of places. The concept of vulnerability is also addressed in Section 2.3 and Appendix D.

Importance

Vulnerability assessment is important to understand the 'human system'. Vulnerability in the context of the 'hazard and risk sciences' needs to be a comprehensive, holistic concept (Cardona 2004; Birkmann 2006). Rather than a static state, vulnerability is a complex and dynamic process that changes over time. Moreover, vulnerability is not only the estimation of the physical effects of a typical QRA. It also needs to encompass the perspectives on the human system, the socioeconomic profile of the population affected by hazardous installations. This information is fundamental in the development of a realistic risk management program.

Assessment

A limited type of vulnerability assessment is frequently carried out by QRAs in the BELP. This assessment is restricted to the estimation of vulnerable areas, susceptible to physical and chemical effects (such as a fire or an explosion). According to the classification introduced by Cutter, the current arrangement of the BELP considers aspects of the first theme (risk/hazards exposure) only. CS1, CS6 and ES4 elucidate this

> "In fact, the study of risk as it is done today, calculating the risks, it goes into the calculation of individual and societal risks. The incorporation of the essential aspects of the surroundings is very limited because the only thing we do is to count how many people live nearby. How many will die or how many will not die, that is, in terms of inclusion [of social information] in the process it is very limited. I mean, why don't we work with vulnerability of the area in those risk studies, which would be a more interesting concept to incorporate these issues?" **CS1, interview 2009.**

> **“**the study quantifies in terms of land-use and occupation. From what I see, the population only is quantified. They are the data entry for the curve. You need to know, count the number of inhabitants and then determine if they are exposed to that fatality rate”. **CS4, interview 2009.**

> “A QRA describes the operation of the project, description of the project, a historical analysis of the most common types of accidents for that kind of installation; it makes the identification of hazards that can occur when the installation is in operation. From there you select what is severe, and for these catastrophic scenarios you run a quantitative analysis, considering the sequence of occurrences that might lead to that scenario, the chances that it will ever happen, and then you simulate various types: a fire, a cloud, a fire jet, an explosion , a fire ball in case of natural gas, and with the results of these simulations you run a calculation with probits to see the vulnerability, which is the percentage, probability of death, if someone is always there. The result that you get from this, you have the risk that this project poses to the civil society, then you have the likelihood to, say, one in one million that an accident happening there kills someone.” **ES4, interview 2009.**

The analysis of the interviews indicates that, in the context of the BELP, the vulnerability assessment is limited when compared to practices described in the literature (Cutter 1996; Morrow 1999; Wisner et al. 2004; Birkmann and Wisner 2006; Birkmann 2007; Andrey and Jones 2008).

Conclusion: item present; performance poor.

6.1.12 Resilience plan

Purpose

In social sciences, resilience is important to prepare exposed populations to cope with hazards and risks (Burby et al. 2000; Pelling 2003; Murphy 2007). According to Adger (2000:347), “[s]ocial resilience is an important component of the circumstances under which individuals and social groups adapt to environmental change (…) Resilience increases the capacity to cope with stress and is hence a loose antonym for vulnerability”. The resilience plan helps to articulate social vulnerability, industries and infrastructural systems, land-use, and risk management into an integrated plan to manage risk exposure.

Assessment

A specific routine for risk management is not present in Brazil, as it is a new measured proposed by the research’s conceptual framework. IBAMA’s current practices in place to manage risk exposure are mostly focused in the integrity of the facility only. Hence, the resilience plan becomes an opportunity to balance out the importance given to both the technological system and the human system in the BELP.

Conclusion: item absent.

6.1.13 Summary of BELP's performance

Table 6.4 summarizes BELP's performance. As described in the introduction of this Chapter, two types of assessments are applied, 'presence' and 'quality'. Presence indicates if the BELP has measures in place to perform the indicator: ✔ is used for yes, and ⊘ for no. In case of yes, quality ranks the indicator in three different levels: ☑ ☑ ☑ for good (the indicator is appropriate), ☑ ☑ for somewhat good (the indicator is appropriate in some aspects, but deficient in others), and ☑ for poor (the indicator is deficient or inappropriate). Please refer to sections 6.1.1 to 6.1.10 of this document for details about this classification.

Table 6.4 – Summary of the BELP's performance (Presence: ✔ = present in the BELP; ⊘ = absent in the BELP; Quality: ☑ ☑ ☑ = good; ☑ ☑ = somewhat good; ☑ = poor).

#	Qualitative Performance Indicator	Presence	Quality
1	Pre-assessment of risks	⊘	--
2	Concern assessment	✔	☑
3A	Communication	✔	☑
3B	Environmental and risk education	✔	☑
4	Precautionary appraisal	✔	☑ ☑
5A	Public participation	✔	☑
5B	Environmental justice	✔	☑
6	Governmental integration	✔	☑
7	Risk reduction at source	✔	☑ ☑
8	Land-use planning	⊘	--
9	Specific routine for risk management	⊘	--
10	Follow-up	✔	☑
11	Vulnerability assessment	✔	☑
12	Resilience plan	⊘	--

Chapter 7 – Proposing a More Comprehensive Framework for IBAMA's Regulation of Risks

Having addressed steps 1 through 6 in Figure 1.1 (p. 11), this chapter addresses the issue of designing a more comprehensive framework for IBAMA's regulation of technological risks. Section 7.1 presents a brief introduction to the design. Section 7.2 discusses how to incorporate the social sciences into the routines of IBAMA's environmental licensing. Section 7.2 presents the inputs of the surveys and how they support the redesign. Section 7.4 elaborates on the more robust framework for IBAMA, discussing changes in the Prior License, Installation License, Operation License, and follow-up cycles.

7.1 Introduction

Brazilian decision making has not been comprehensive enough to regulate technological risks. As observed in the literature (Alonso and Costa 2002; Nicolaidis 2005; Jacobi and Alimonda 2006; Souza et al. 2007), interviews, and the results of the performance evaluation, IBAMA's regulation of gas and oil transmission pipelines is mostly based on the inputs provided by technological system. The discussions about risks in the environmental processes often spin around the technical details of the QRAs and the hazardous facilities. Little attention is paid to understand the human system surrounding the technological system and how the interaction of human and technological systems affects risk rates. For instance, if one considers encroachments in the Brazilian case, it is apparent that Brazil's risk-based approach has not been able to avoid the increase of risk exposure simply because QRAs are not the decision-making processes themselves. Moreover, it is very likely that this scenario will get worse if the current arrangements to licensing transmission pipelines are not reviewed.

7.2 Inputs from the surveys

The first five questions in the surveys served to support the redesign of IBAMA's regulation of technological risks. They seek to assess firstly how important it is to improve the current approach (questions 2 and 6) and then to evaluate the significance of incorporating the human system in the new framework (questions 3, 4, and 5). Question 2 asks participants about the need to improve components of the quantitative risk assessment and BELP's risk-based decision making. According to the results all seven items need to be improved: the terms of reference for the quantitative risk studies; the quantitative risk studies themselves; the programs for risk management; the criteria to evaluate acceptability of technological risks; the protocols for risk communication; the integration of land-use practices with risk regulation; and the integration of risk of multiple facilities affecting the same population. As pointed out above, the survey is not analyzed in a quantitative way. Rather, it is used to corroborate information from the literature and the interviews.

Also relating to the current arrangement, the last question (question 6) asks participants about the best timing to discuss risks: during the routines of the Prior License, the Installation License, or the Operation License. According to twenty-two participants, the discussion has to feed the decisions of the first permit, the Prior License. Some of them justified this position in the interviews alleging that the risk rates are important for the evaluation of the socio-environmental suitability of a project (*viabilidade ambiental* in Portuguese). For seven participants the assessment of risks can be delayed until the routines for the second permit, the Installation License. One often reason mentioned for that is that at the early stages of the BELP the companies do not have enough information to carry out a realistic QRA.

Table 7.1 – Result of surveys, question #2.

Survey question # 2: *If you have the opportunity to improve routines related to the regulation of risks in the Brazilian environmental licensing process, how important would be to improve the following components?*

Item	**Theme in the Conceptual Framework**	**Not Important**	**Somewhat Important**	**Very Important**	**Don't Know**	**Total**
a) The terms of reference for quantitative risk studies	Vulnerability Assessment; Resilience Plan; Specific Routine for Risk Management; Follow-up	1	4	23	2	30
b) The quantitative risk studies	Vulnerability Assessment; Resilience Plan; Specific Routine for Risk Management; Follow-up	0	5	23	2	30
c) The program for risk management	Vulnerability Assessment; Resilience Plan; Specific Routine for Risk Management; Integration of Governmental Actors; Land-use Control around the ROWFollow-up	0	3	25	2	30
d) The criteria for acceptability of technological risks	Vulnerability Assessment; Resilience Plan; Specific Routine for Risk Management; Follow-up	0	3	25	2	30
e) The protocols for communication of risks	Public Participation; Comunication and Education; Follow-up	0	5	23	2	30
f) The integration of risk decisions with land-use decisions	Integration of Governmental Actors; Land-use Control Around the ROW; Follow-up	0	5	23	2	30
g) The integration of the risks from many installations affecting the same area or group of people	Vulnerability Assessment; Resilience Plan; Specific Routine for Risk Management; Follow-up	2	4	22	2	30

<u>**Survey question #6:**</u> *Considering the sequence of events in the environmental licensing, what is the best timing to deliver to the environmental agencies the quantitative risk assessment?*

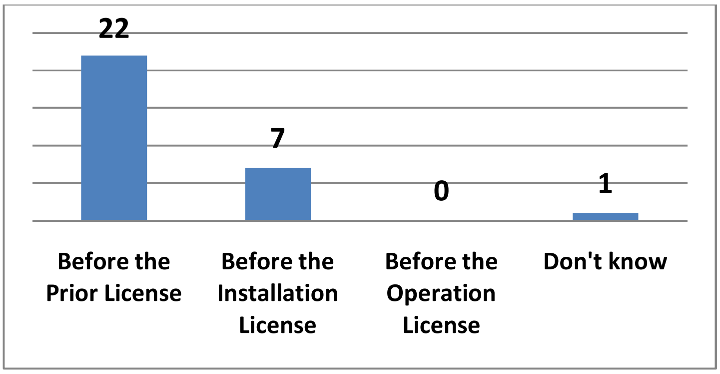


Figure 7.1 - Result of surveys, question #6.

Questions 3, 4, and 5 serve to corroborate the need to incorporate the human system in the new framework. <u>Question 3</u> asks participants to 'relativize' the importance of risk assessments over risk management programs. The question reads: *pursuing safety for the populations in the vicinities of gas and oil transmission pipelines, which do you think is most important?* For twenty-two interviewees both are equally important; five understand that risk management is more important than risk assessment, while two say that risk assessment is more important than risk management. One participant did not have an opinion on the subject. <u>Question 4</u> takes the same approach, but now comparing the risk assessments to the city's master plan. Twenty-two participants answer that both are equally important; four indicate that the city's master plan is more important, while three think that risk assessment is more important. One participant did not have an opinion on the subject. Finally, <u>question 5</u> confronts risk assessment to a good assessment of the socioeconomic profile of the population affected by the risks of a hazardous facility. The answers are polarized; fifteen participants say that the risk assessment is more important, while fourteen indicate that both are equally important. One participant did not have an opinion on the subject. It is important to mention that none said that the socioeconomic assessment is more important than the risk assessment. The socioeconomic assessments refer to a holistic vulnerability assessment, in the terms discussed in the literature of natural hazards and geography. The question used the term 'socioeconomic assessment' to avoid misinterpretations with the vulnerable areas calculated by QRAs. However, it seems that the term was not clear to the interviewees. Nonetheless, nearly half of the replies indicate that both vulnerability and risks are important in the regulation of technological hazards, which can also indicate some resistance to change coming from stakeholders that are already familiar and applying QRAs in the licensing routines – though the survey results cannot support this point.

Survey question 3 and 4: *Pursuing safety for the populations in the vicinities of gas and oil transmission pipelines, which do you think is most important?*

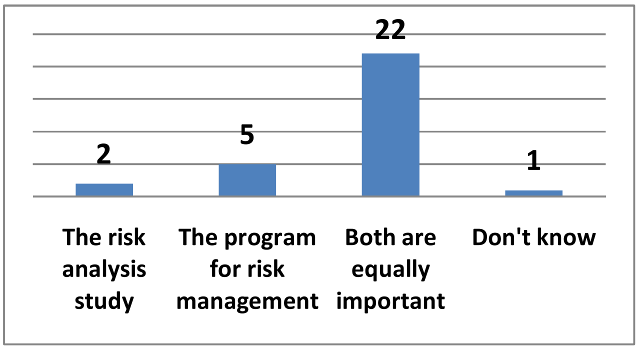
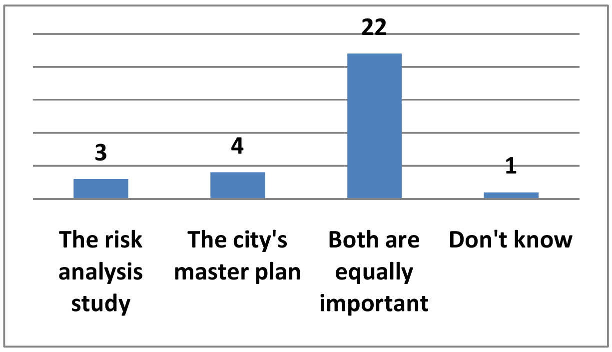
Question #3	**Question #4**
	

Figure 7.2 – Result of surveys, question #3 & 4.

Survey question #5: *Pursuing safety for the populations in the vicinities of gas and oil transmission pipelines, which do you think is most important?*

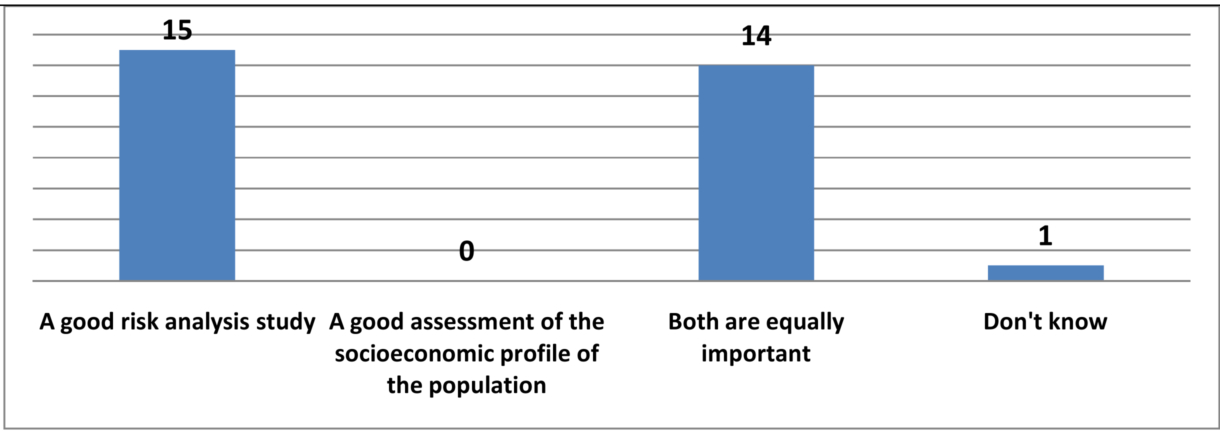


Figure 7.3 – Result of surveys, question #5.

7.3 Incorporating the 'social sciences' in the IEL of technological risks

The research's conceptual framework proposes measures and actions to transform risk-based into risk-informed decisions, embodying the regulatory processes of technological risks with concepts and thinking from social sciences that bring the human system to play a much more active role. The practical implications of this framework are used to redesign the routines of the regulation of technological hazards at IBAMA. Firstly, there is a need to stress the importance of the social perspective in governmental decision makings. As depicted in Figure 7.4, the human system has to be another 'highway' feeding the decisions. The current Brazilian approach focuses too much in the discussion of the hazardous facilities and undervalues the impact that changes in the human systems may have in the risk profiles. Hence, decisions need to be informed by both sides of the same problem, the agent and the receptor of technological hazards, the hazardous facilities and the people affected by them.

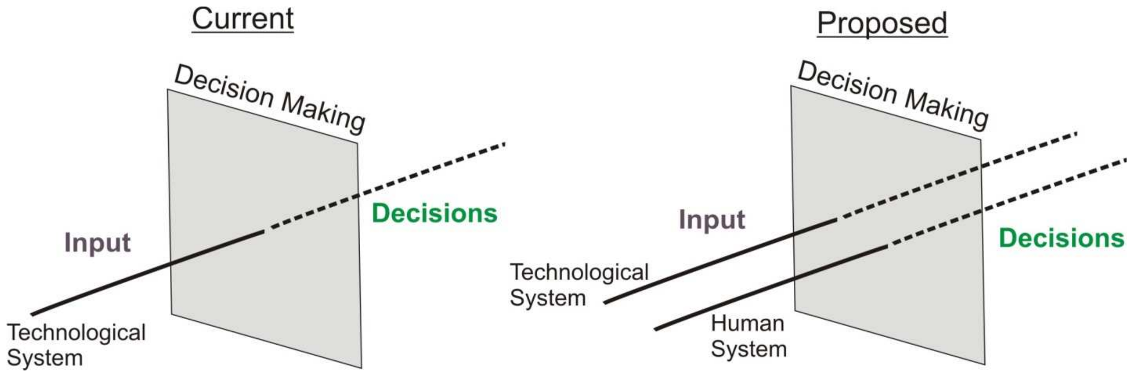


Figure 7.4 - Technological and Human Systems informing the decisions in the BELP.

Acknowledging the stake that human systems have in processes implies accommodating their needs and inputs as well. The BELP applies environmental impact assessments (EIA[22]) to consider socioeconomic information about the populations affected by a new project (Egler 1998; Glasson and Salvador 2000; Prado Filho and Souza 2004; Kirchhoff 2006b). However, decisions about risks are not taken based on the results of the EIA; they are made comparing risk levels against thresholds of risk acceptability (Kirchhoff and Doberstein 2006). The redesign of IBAMA's framework does not seek to integrate EIA to QRA. Rather, it improves and increases the volume of socioeconomic information in the regulation of technological risks. Perhaps this information, or part of it, is already available in the EIAs so that it can be used. Regardless, the redesign must encompass new sources of input in early stages of the processes.

Management of risk exposure occurs in the long run. The current IBAMA's framework concentrates efforts in the early life of a pipeline's project, in detriment to the complete life-cycle. The assessment of risks is carried out to support decisions related to the first permit, the Prior License. After that much can happen during the process until the last permit is issued, the Operation License. It takes time for a project becomes a real installation. Meanwhile, the boundary conditions and the socioeconomic profile of the affected population can change. The same is expected throughout the operational life of the transmission pipeline. Without proper management, in perhaps ten years that first picture of the interaction between the hazardous facility and the human systems is no longer accurate. In the current IBAMA's framework, risk management programs are expected to run after the beginning of the pipeline's operation. However, by this time it is very likely that the programs will have become obsolete or unrealistic. Moreover, the risk management practices in this context are also too focused in the integrity of the installation. As a way to improve follow-up (or

[22] EIA and QRA are applied simultaneously in the BELP, following the same regulatory framework. In Brazil, EIA assesses impacts (socioeconomic, physical, and environmental), while QRA accounts for technological risks. These two technical studies inform the decision-making process of hazardous installations.

monitoring) practices, the redesign of the IBAMA's framework detaches risk assessment from risk management. This proposition helps stressing that risks come from both sides, not only from the installation. It also emphasizes that regulators have to think about people and the control of urban development in the beginning of the discussions about the project itself. This discussion cannot be relegated to the end of process, when the decisions have already been made.

Finally, it is crucial to have a solid transition between analysis and decisions about risks to the control and management of exposure to technological hazards. The most important role of IBAMA in regulating risks must be to ensure that its decisions do not compromise the safety of the populations when the project becomes a hazard, when the pipeline starts operating. That must be the focus, deciding to prevent risks when they are real. Many interviewees stated that the BELP has been used as a certification process only, where developers seek legitimization of their projects. For instance, the application of thresholds for risk acceptability reinforces their statement. Those thresholds are an important starting point to assess whether an installation is safe to operate. However, they present a very narrow perspective about the complete dimension of the regulation of technological hazards. Thresholds need to be used for the purpose they serve best, which is to indicate how close a transmission pipeline can go to an urban development. They are useless the other way around, in anticipating how and when the urban development pushes people towards the pipelines. Hence, the redesign of IBAMA's framework needs to strengthen and better articulate the deliberations of the environmental licensing processes. In this account, it is important to point out that decisions will not persist without good communication and broad participation of all those stakeholders affected by or involved with the project.

7.3.1 Opportunities for the Brazilian case

Three figures were used to think about the application of the practical measures of the conceptual framework in IBAMA's environmental licensing processes. Firstly, Figure 7.5 presents the "steps for risk assessment" applied by IBAMA and the environmental agency of the Brazilian state of São Paulo (CETESB). The figure depicts aspects of the Brazilian decisionistic model and the risk-based approach to account for technological risks, showing the focus on the evaluation of risk levels to support the decisions regarding the implementation of hazardous installations in Brazil: the description of the project; identification of hazards; estimation of physical effects; estimation of frequencies (of failures); calculation of risks; and evaluation of the project based on contrasting risks rates against acceptability criteria. If the project is approved, risk management actions are proposed to ensure the integrity of the installation and the safety of affected populations (CETESB 2003: 18).

As already pointed out by this thesis, the core of the BELP is constituted by three environmental licenses: the Prior License, the Installation License, and the Operation License (see also Section 5.1 and Appendix A). Figure 7.6 shows the main routines of each licensing cycle, as well as proposed measures to improve the

BELP. The boxes in yellow represent the main actions related to the cycle of the Prior License. The boxes in red represent the actions related to the cycle of the Installation License. The boxes in light green represent the actions related to the cycles of the Operation License and the post-licensing (monitoring and control). The boxes in blue, derived from Table 4.1, represent a brainstorm of proposed actions to be studied and incorporated into the BELP.

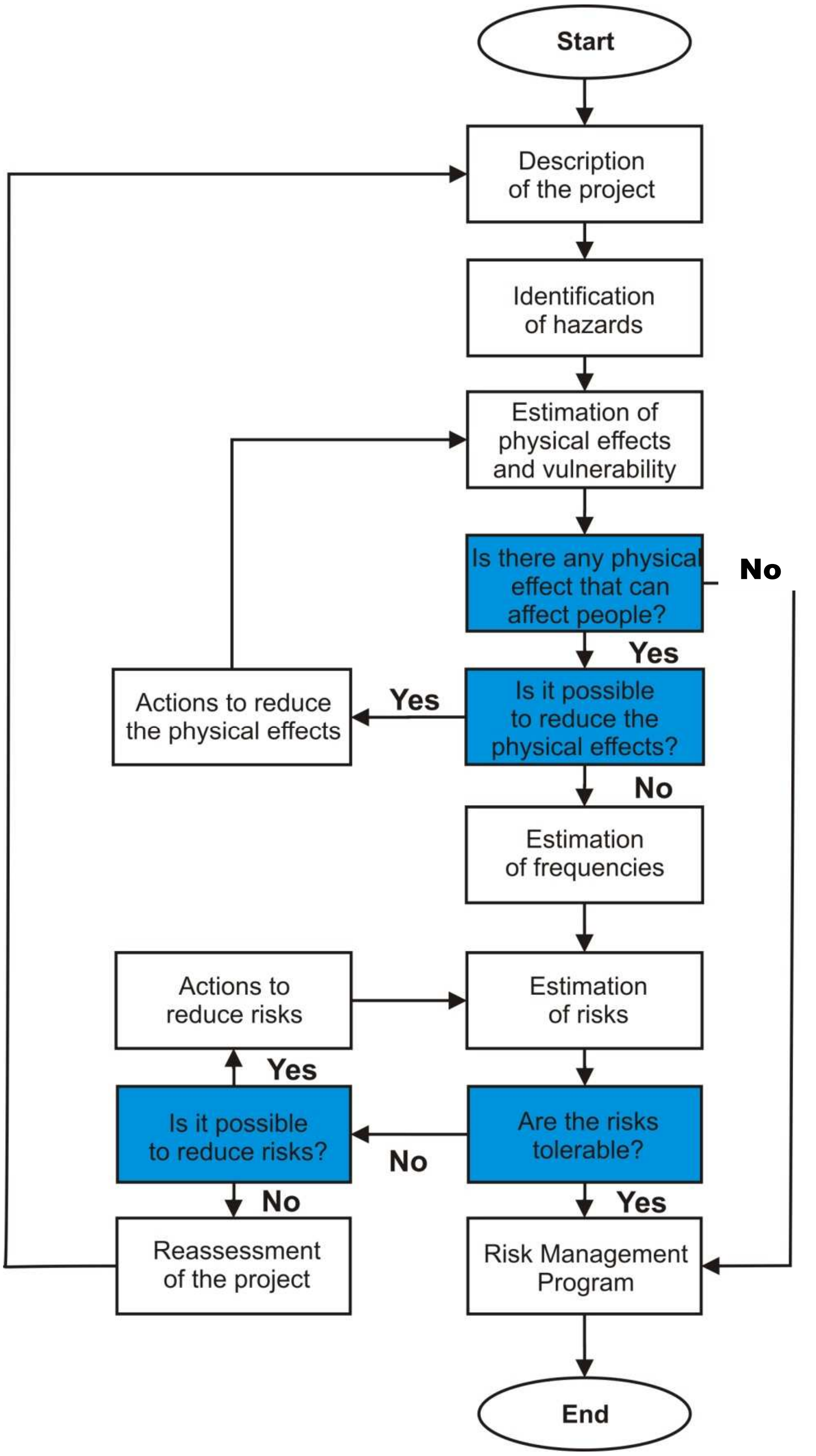


Figure 7.5 – Steps for technological risk assessment in Brazil. Reproduced from CETESB (2003).

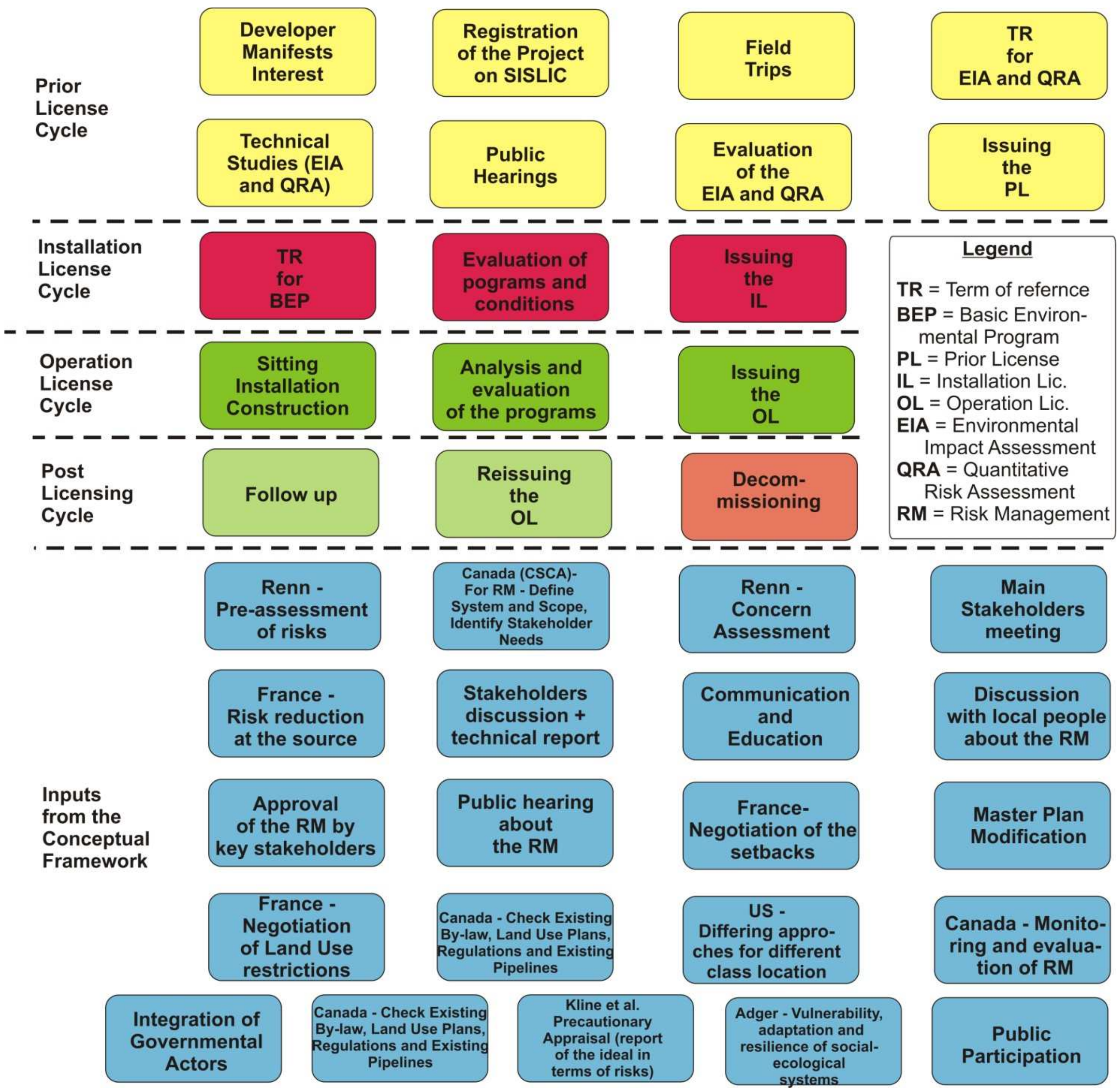


Figure 7.6 – Box of measures to improve the BELP.

Finally, Figure 7.7 integrates current routines and the proposed measures, combining the boxes presented in Figure 7.6 and the themes of Table 4.1 into a single figure. The intention of this figure is to provide the researcher with a visual opportunity to think about the best ways to fit the suggestions and discussions presented in this research into the current setup applied by IBAMA. The results of this analysis are presented in the next section, where the research proposes a more comprehensive framework for regulation of technological hazardous installations for IBAMA. Communication and public participation are apart in the figure (big yellow box in the left bottom corner), as they are expected to be applied through the process.

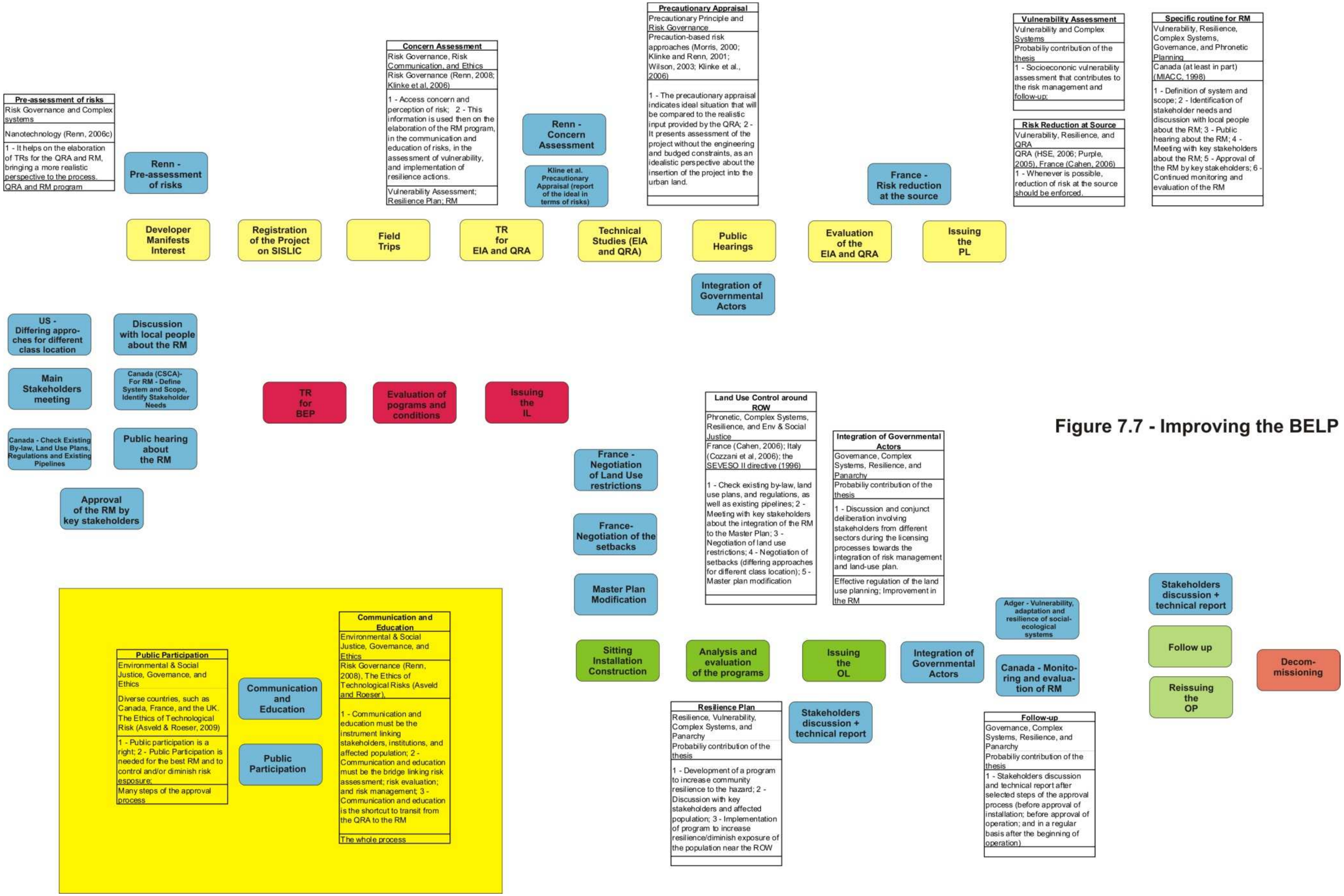


Figure 7.7 – Improving the BELP

7.4 Redesigning IBAMA's framework for technological risk regulation

The development of a more comprehensive framework for IBAMA's regulation of technological risks draws on the literature review and research's conceptual framework (Chapter 4), the description of the Brazilian case (Chapter 5), and the assessment of the BELP's performance and results of the surveys presented in this chapter. It builds upon the current framework, reorganizing its procedures and bringing in a few new measures to make it more holistic. The major milestones of the current process are the elaboration of the terms of reference and subsequent quantitative risk assessment for the Prior License, followed by the development of guidelines for the risk management program in the Installation License, and the implementation and follow-up of the risk management program after the Operation License (please refer to Appendix A – – for more information about IBAMA's framework).

The proposed model detaches the assessment of risk from the *management* of risks. Traditionally, risk management is the last step of a sequence that involves assessing, evaluating, and then managing the facility's risks. However, in order to consider the human system as well, risk management is not linked to the technological hazard anymore. The new model also incorporates routines to accommodate:

- *pre-assessment of risks*, which carries out a preliminary (qualitative) evaluation of risks to define the installation's place and conditions.
- *land-use planning*, which brings the discussion of the city's master plan to the core of environmental licensing;
- *vulnerability assessments*, which assess the human system nearby;
- *resilience plan*, which is comprised of the three previous measures and has as goal to better manage risk exposure; and
- *communication program*, enforced throughout the process as a way to integrate steps and stakeholders.

Figure 7.8 presents a summary of both frameworks, current and proposed, presenting the main routines to account for technological risks. The suggested model is explored in the next subsections.

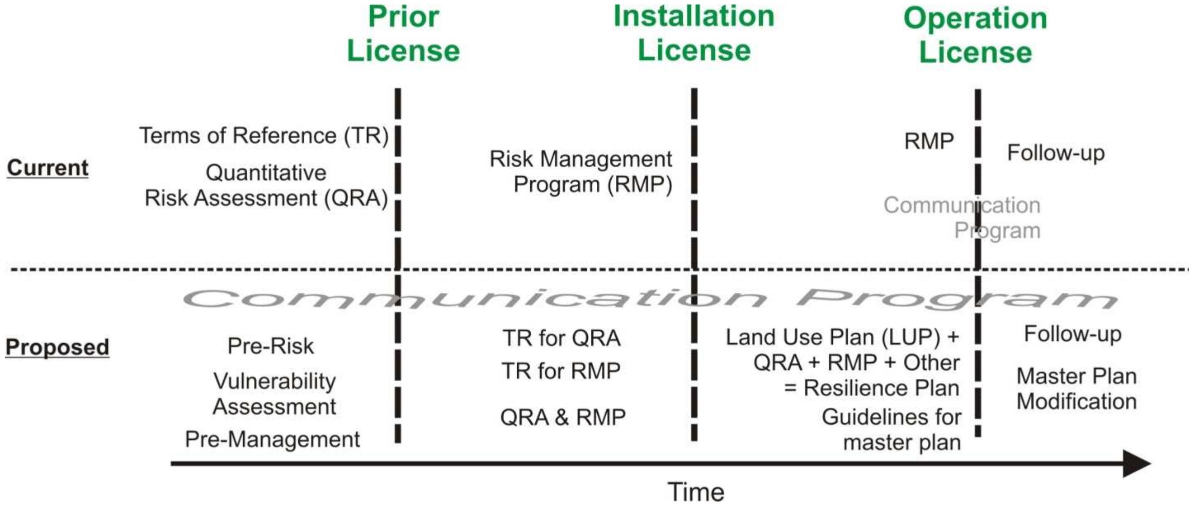


Figure 7.8 – Current and proposed framework for IBAMA's regulation of technological risks.

7.4.1 The Prior License cycle

The Prior License's cycle serves to assess the project's socio-environmental suitability. Information in this first step is used to determine whether the project's risks and impacts compromise the installation of the facility in a specific spot (CONAMA 1997). In the case of pipelines, it discusses proposed pathways and the implications for the environment and communities of a few alternatives. This redesign proposes three procedures, to account for technological risks: (1) pre-assessment of risks; (2) vulnerability assessment; and (3) pre-management of risks.

Pre-assessment of risks:

Survey question #6 asks participants about the best timing to deliver the QRA to the environmental agencies. Replies indicate that some of the interviewees are concerned that a late discussion of quantitative information about risks compromises the purpose of the first licence and the assessment of socio-environmental suitability. On the other hand, some participants point out that in the early stages of environmental licensing the companies carrying out the risk assessments often do not have a complete set of technical information to elaborate a consistent study of risks. The new design proposes an intermediate solution for that, contemplating both the importance of discussing alternative locations for projects and the limitations a full risk assessment faces in the beginning of the licensing process. This alternative, *pre-assessment of risks*, comprises the elements of the precautionary appraisal and risk reduction at source. It consists of a qualitative evaluation of the projects' harms based on known techniques such as the PHA[23] – Preliminary Hazard Analysis (ILO 1993; Taboas et al. 2004; Ericson 2005).

> "The preliminary hazard analysis (PHA) technique is a safety analysis tool for identifying hazards, their associated causal factors, effects, level of risk, and mitigating design measures when detailed design information is not available. The PHA provides a methodology for identifying and collating hazards in the system and establishing the initial system requirements for design from preliminary and limited design information. The intent of the PHA is to affect the design for safety as early as possible in the development of program". **(Ericson 2005:73)**

This technique applies a qualitative matrix to estimate risks. On one axis of the matrix is the qualitative information related to the severity of the events, and in the other the expected frequency of these events. The point of confluence of the two axes gives the estimation of the risk. For example, consider a gas transmission pipeline operating several meters from a community with a few houses. A crack in the pipeline can lead to severe consequences such as a dense fire. However, such an event is very unlikely to happen. Using a matrix like the one shown in Figure 7.9, a group of key stakeholders come to the conclusion that the severity of this event is critical (index III) but, in turn, it is unlikely that the event will ever occur (index C). This assessment results in a qualitative estimation of a medium level of risk (index 2).

[23] PHA, or Preliminary Risk Analysis (PRA) is suggested by this research but many other qualitative risk assessments can also be applied, such as the HAZOP (Hazard and Operability Analysis) and the FMEA (Failure Modes and Effects Analysis).

Severity \ Frequency	A	B	C	D	E
I	2	3	4	5	5
II	1	2	3	4	5
III	1	1	2	3	4
IV	1	1	1	2	3

	Risk
1	Very Low
2	Low
3	Medium
4	High
5	Very High

	Severity
I	Negligible
II	Minimal
III	Critical
IV	Catastrophic

	Frequency
A	Extremely remote
B	Remote
C	Unlikely
D	Likely
E	Frequent

Figure 7.9 – Assessing risks with the preliminary hazard analysis – four classes of consequences/severity and five classes of frequencies. Adapted from Rausand (2005: 24-25).

The preliminary hazard analysis is a technique already applied in the BELP (CETESB 2003; IBAMA 2005) as a component of the QRAs scope. Hence, it does not imply the need for development of a new study. It rather detaches and anticipates the results of the PHA to an early stage of the discussions leaving the evaluation of quantified risks for later, when the location alternative is already defined. The results of the PHA will be used as first (exploratory) general guidelines indicating best alternatives for the facility location. Risk reduction at the source, the precautionary appraisal, and the ALARP (As Low As Reasonably Practicable) approach can also be enforced to require changes in the project to bring risks to a lower level.

Such a qualitative approach saves time and money during the licensing processes. It also seems to be more appropriate to the Prior License cycle, which in its essence assesses propositions and ideas. Moreover, it does not compromise safety since this first permit does not authorize any procedure for installation or siting. On the contrary, the PHA contributes to the next step indicating to stakeholders the hotspots that will require deeper assessment with forthcoming quantitative analysis.

Vulnerability Assessment:

Vulnerability assessment offers a complementary perception to the pre-assessment of risks described above. While a PHA evaluates risks from the technological system viewpoint (how the facility affects people), the vulnerability assessment seeks to understand how human systems are affected by hazards. This information is very important to contextualize the area, identify special needs, and propose actions that fit the reality of the community being studied[24]. The scope of a vulnerability assessment encompasses:

- Background information about the socioeconomic and educational profile of the population, as well as the type and quality of the households.
- The identification of the community's level of organization so managers and decision makers can put measures in place to involve the community and local stakeholders accordingly in the discussions of the new project.
- The identification of concerns that these people may manifest. Concerns need to be seen as inputs for the QRA and communication protocols in the next steps of the BELP.
- The pursuing of data related to the trends of urban development. It is crucial at this point to identify the patterns of expansion, how fast the community is growing, and in which directions the development is headed.

A great part of the information required for this assessment is already present in other routines of the BELP. The EIA (technical study) carries out a comprehensive socioeconomic analysis of the affected population that can be available for this vulnerability assessment, which can optimize costs and efforts.

Pre-Management of risks:

A pre-management program integrates the pre-assessment of risks and the vulnerability assessment, taking into consideration the inputs from both technological and human systems. It merges the two perspectives in support of a common goal: the management of risk exposure in the future. The pre-management program rests in three core elements: the identified hotspots, vulnerability information, and broad communication protocols.

- Firstly, the pre-assessment of risks identifies the points of concern, the hotspots. In the case of a non-continuous (point-based) facility the hotspot is its planned location; for linear systems they are the points where interaction between human and technological systems, such as a street or a neighborhood, is likely to occur.
- Secondly, the pre-management program gathers information from the vulnerability analysis for each of those identified spots. This includes data such as the current city master plan, if existent; the identification of local leaderships and key stakeholders; the definition of class locations[25], if this technique is applied at all; and reports on the urban growth patterns. The combination of all of this information gives a good picture about the feasibility of the project in each hotspot.

[24] Often a typical QRA only counts the number of households and then infers the population exposed, many times in an indirect way using census data and/or aerial photos.
[25] Class location is often used in the regulation of transmission pipelines, indicating population density. "A class location unit is defined as an area that extends 220 yards, or 1⁄8 mile, on either side of the centerline of any continuous 1-mile length of natural gas pipeline" (TRB 2004).

- Since risk and land-use planning are regulated in different instances, communication among the involved stakeholders; and between stakeholders and the local affected population is very important. Lack of good communication practices jeopardizes the interaction between the pre-assessment of risks and the vulnerability assessment. Moreover, proper protocols for continually transferring information and collecting data need to be inherent elements of any program for technological risk management.

A primary objective of the pre-management stage is to identify all spots that represent points of concern, such as where the city's master plan prohibits industrial installations or segments of the facility that are in the path of urban development. Decision makers will have an opportunity to disapprove any location alternative that is or will be unsafe. Complementarily, another objective is to provide an initial and valuable input to land urban planning and the city's master plan. If the project's chosen area does not represent a threat, local planners and stakeholders will have concrete input into guiding the development of their municipalities.

Summary:

Figure 7.10 depicts the interrelationship between these three first measures. Vulnerability assessment refers to the human system, while the technological system is represented by the pre-assessment of risks. The interaction of these two plans, supported by broad communication protocols, leads to a common ideal, the management of technological risks.

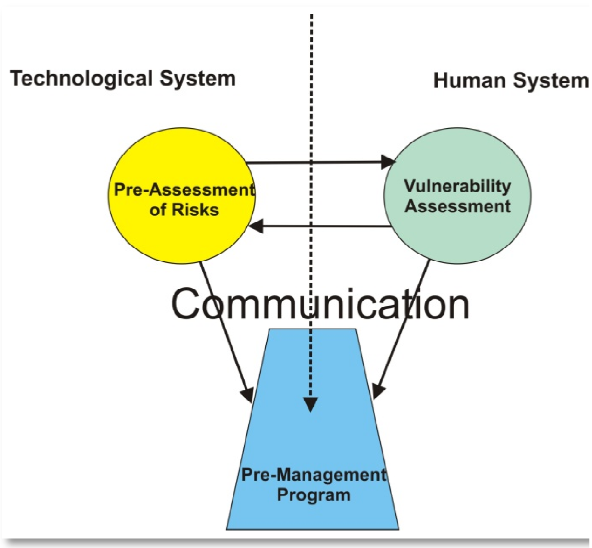


Figure 7.10 – Interrelating pre-assessment of risks, vulnerability assessment, and pre-management.

7.4.2 The Installation License cycle

The Installation License cycle takes over the procedures after the project's socio-environmental suitability approval. The current arrangement prescribes that in this cycle the environmental agencies analyze the programs proposed to mitigate and control the impacts and risks identified in the previous permit cycle by the EIA and QRA. Follow-up regarding the regulation of risks is carried out through the risk management program (RMP). At the end of the cycle, decision makers define whether the project is suitable under the conditions it is proposed. The installation, construction, or siting starts only after the permit is issued.

The new design builds on the suggestions presented for the Prior License cycle. It is composed of two major studies, the QRA and the RMP. The only difference in the QRA is that now it focuses on the hotstops only. Since the PHA identified the points of concern for the quantitative analysis, the QRA is directed at those spots only. All other routines are the same, including the evaluation of the risks and applying criteria for tolerability of technological risks. Two benefits come with this approach. Firstly, the terms of reference for these assessments benefit from the PHA and vulnerability assessment inputs. Secondly, since the project is about to be built, the technical information feeding the QRAs is more substantial and the results can be more realistic.

As for the RMP, a new approach is proposed that follows-up the pre-management started earlier in the process. The idea is to discuss both the QRA and the RMP at the same time. This change is needed because the boundary conditions need to be controlled as soon as regulators decide on the installation of the project. As pointed out in this research, technological risks coming from a hazardous facility are expected only after the beginning of the operation. However, the management of exposure cannot wait because it also depends on the human system. Hence, the RMP predicts this and discusses measures that seek to control the impacts in the risk profile coming from the population nearby. To accomplish these goals, the scope of the RMP comprises:

- The proposition of measures and actions to guarantee the integrity of the installation. This first set of information is already present in the current BELP setup. One of the outcomes of a typical QRA is the identification of routines that need to be put in place to ensure the safety of the installation.
- The proposition of measures and actions to manage the risk profile for each hotspot. The vulnerability assessment plays a fundamental role in the identification of routines that need to be established to manage risk exposure. Communication protocols for risk management need to be presented based on the background information of the affected population and their level of organization. The RMP also needs to elaborate on the perspectives of local development, identifying factors driving growth, likely impacts in the risk profile, and actions to prevent future urban development to influence the risk exposure. In case the municipality has a master plan, it is an opportune time to present its directives as well.

The RMP needs to be presented and discussed with local stakeholders and the affected population in public meetings. The management of risk exposure depends critically on the development of partnerships and the involvement of stakeholders, the affected population, and decision makers in a continuous and participatory risk management process. The transition from analysis and evaluation to the management of risks will likely be compromised without broad commitment and solid ties among stakeholders, particularly the locally-affected community.

7.4.3 The Operation License cycle

In the current assessment, this last cycle of Brazil's regulatory process assesses whether the installation is able to operate. At this point, the proposed programs to manage risks should be ready to run since the technological facilities become a real threat with the beginning of the operation. The developer also puts in practice programs for risk communication, usually informing the local population of the harms of the installation and the safety procedures in place.

However, the results from this research case study show that very often the environmental agencies withdraw their participation in the processes after issuing this last permit, which compromises the follow-up routines after the beginning of operation. Considering that the Operation License may be the last permit issued by the BELP for a period of time up to ten years[26], the new design suggests a more complete assessment and evaluation process in this step. Instead of deciding about a relatively simplistic risk management plan, it is proposed that a Resilience Plan (RP) be developed. The RP comprises:

- Ongoing discussions regarding vulnerability, land-use planning, and risks. The RP is the result of the integration of these three elements into a methodology for managing risk exposure.
- The integration of the RMP results into the land-use planning, suggesting guidelines to modify the city's master plan, or a framework for a new plan if the municipality does not have one.

The goal of the RP is to enforce, once more, a proper articulation between regulators of the land-use and regulators of the technological facility, defining measures and delegating responsibilities for each part in the follow-up (or post-licensing as commonly mentioned in the BELP). The RP is also another opportunity to involve the local stakeholders, emphasizing their prominent role in the management of exposure since they can be ultimately both agents and receptors of the risks.

7.4.4 Follow-up

The last step of the new design is the follow-up. It is expected that during the previous stages of the decision-making processes stakeholders had the opportunity to clarify their roles and to articulate a common approach to control the exposure to the risks of the technological system being discussed. Complementarily, that will be the appropriate time for local regulators to put in place an updated city's master plan, or implement one if the municipality does not have one before the implementation of the hazardous facility.

[26] The operation license is granted for a period between 4 to 10 years. After that, the permit is continually reissued until the decommissioning of the facility.

7.5 Conclusions to the Brazilian case

7.5.1 Knowledge about the Brazilian environmental licensing process

This research provides an in-depth description and criticism of the BELP, carried out through participant-observation and analysis of the literature on the Brazilian case and interviews with thirty-two representatives of governmental institutions, economic sector, and civil society. Chapter 5 identifies positive, negative, and missing aspects of the routines of the BELP, which complements other scholarships in Brazil (Glasson and Salvador 2000; Alonso and Costa 2002; Little 2003; Goldemberg and Barbosa 2004; MPF 2004; Nicolaidis 2005; Castro 2006; Kirchhoff 2006b; Borinelli 2007; Souza et al. 2007; Lima and Magrini 2009). As for the regulation of hazardous facilities, the research identifies the role that IBAMA plays in the federal level, being responsible for the licensing of large projects. The technical studies supporting this decision making are identified, as well as the procedures in place to discuss their results. Finally, the research reviews the licensing of gas and oil transmission pipelines, the application of QRAs in these processes, the encroachment of their right-of-ways, and the routines for following-up after the beginning of operation, offering new information to the few works in the area (Kirchhoff and Doberstein 2006; dos Reis 2007; Souza et al. 2007; Montano and Souza 2008).

7.5.2 The performance of the BELP addressing technological risks

Chapter 6 contributes an evaluation of the BELP. This assessment is based on the literature on the Brazilian case, interviews and surveys with thirty-two participants, and participant observation. The study identifies that the BELP is deficient in ten out of the twelve proposed qualitative performance indicators: pre-assessment of risks; concern assessment; communication and environmental/risk education; public participation and environmental justice; governmental integration; land-use planning; specific routines for risk management; vulnerability assessment; resilience plan; and follow-up. In the last two indicators, the precautionary appraisal and risk reduction at source, the BELP's performance is considered only regular. It is noteworthy that this research has not identified similar comprehensive evaluation of Brazil's risk regulatory processes in the literature, although a few works overlap with some of the points discussed in Section 6.1 (de Souza Jr 2000; Kirchhoff and Doberstein 2006; dos Reis 2007; Souza et al. 2007; Montano and Souza 2008; Yogui 2008).

Table 7.2 – BELP's performance in fourteen indicators.

Performance	# of indicators
Good	0
Regular	2
Insufficient or poor	12

7.5.3 A new framework to address technological risks in the BELP

Considering the results from the BELP's assessment and evaluation of performance, the research proposes a more comprehensive framework to be applied at IBAMA, aimed at the improvement of the environmental licensing routines of hazardous installations in Brazil. Conceptually, the proposed design acknowledges the human system and its interaction with the technological system in a common space as fundamental components of the licensing routines. Communication must be continuously enforced throughout the entire process.

- In the first licensing cycle (Prior License), three new technical studies are proposed: pre-assessment of risks, vulnerability assessment, and pre-management of risks. These three preliminary studies are organized so that the pre-assessment of risks identifies hotspots that should be considered in detail. Complimentarily, vulnerability assessments are carried out for these hotspots to identify, for instance, socioeconomic profiles and patterns of urbanization. Finally, the pre-management of risks integrates these two studies and propose preliminary actions for risk management.
- In the second licensing cycle (Installation License), the process carries out the quantitative risk assessment and proposes a risk management program. The QRA is simplified to the hotspots identified in the previous licensing cycle. The risk management program considers not only the discussion of risks, but also the integration of these risks to the urban land and the role that the local population and stakeholders have to play in the processes.
- In the third licensing cycle (Operation License), the resilience plan is carried out. This plan integrates the two systems, technological and human, articulating the risk management program and land-use planning in the same study with the goal of managing exposure to technological hazards. This cycle also elaborates the guideline for modifying the city's master plan, or the implementation of a new plan if the city does not already have one.
- Finally, the post-licensing is carried out and the proposed guidelines for the city's master plan are implemented. It is expected that the previous steps in the process were used to establish ties and distribute responsibilities among all pertinent stakeholders for the effective management of exposure.

It is important to mention that this proposed design is based on the particularities of the Brazilian environmental licensing processes. It is very likely that other jurisdictions, with similar regulatory arrangements, can benefit from this more comprehensive framework and the discussions carried out on Chapter 5, Chapter 6, and Chapter 7. However, this research acknowledges that decision-making processes are particular to each nation or jurisdiction, as discussed earlier in this document, since they are built on a series of local particularities, such as governmental institutions, legislation, and socio-cultural background. Throughout this dissertation, information about Brazil is presented as a way to contextualize the case study. As for the BELP, Appendix A – presents a brief description of Brazil’s environmental licensing process, description that can also be complemented by some other works in the literature (Fowler and De Aguiar 1993; Diegues 1998; Egler 1998; Eve et al. 2000; Glasson and Salvador 2000; McAllister 2005; Kirchhoff 2006b; Coelho and Favareto 2008; Lima and Magrini 2009).

7.5.4 Limitations of the proposed redesign

The research anticipates three limitations to the implementation of the proposed design. Although this new framework is based on the results and inputs from the case study, it is still theoretical. The implementation of a new framework in Brazil’s case may need to accommodate adjustments, often required when conceptual ideas area applied in real-life cases. Second, the proposed measures and studies need to be further developed with the definition of minimum scope, especially for the vulnerability assessment and risk management program. Third, the limitations of the BELP, discussed in the case study (Chapter 5) and the performance evaluation (Chapter 6), are a serious threat to the implementation of this approach.

However, these limitations also represent an opportunity to strengthen the BELP. The discussion of a new model to approach risk recycles the current practices and contributes to the incorporation of new perspectives in the regulation of technological risks. The discussion of terms of reference for the proposed new studies deepens the understanding of Brazil’s contextual implications for the management of risk exposure. Finally, a participatory and comprehensive decision making, with defined and shared responsibilities among stakeholders, improves the BELP as a whole as the regulation of risks and impacts need to be more holistic. In this scenario, the environmental agencies will have the opportunity to concentrate efforts on their duties and let co-regulators fulfill their share of responsibility in the processes as well.

Chapter 8 – Implications for theory and research contributions

The results and findings of this study have implications for the theoretical assumptions underpinning the regulation of technological risks. Section 8.1 elaborates the research's perspectives about six topics on the literature on technological risks. Section 8.2 presents contributions from the Brazilian case study to some debates in the social sciences and trends in the literature on regulation of technological hazards.

8.1 Implications for theory

The findings and results of this research address the research question in six complementary ways. First, they corroborate the need to pursue more comprehensive integration between human and technological systems under the same regulatory process (EIA best practices should be used as benchmark). Second, they identify the importance of pursuing strong transitions in the steps of the regulatory processes as a way to strengthen the routines for management and monitoring. Third, they indicate that a specific routine for risk management benefits the integration of policies and resolutions addressing the human systems, the technological systems, and land-use planning. Fourth, they suggest that regulatory processes should pursue mechanisms to manage exposure, rather than solely manage the risks identified by traditional QRAs. Fifth, they support the development of a resilience plan, comprised of the integration of the risk and exposure perspectives in a same program. Finally, the research reflects these five points in the Risk Governance framework, suggesting an adaptation of this model for the regulation of hazardous linear installations.

8.1.1 The need to incorporate 'human systems' into the regulatory processes

<u>Claim</u>: Technological risks arise from the interaction of two systems, one technological and the other human. This research supports the use of the term human systems as a counterpoint to technological systems in regulatory processes. The term reinforces discussions and advances in the social sciences that stress the need to include the social component into the decision-making processes.

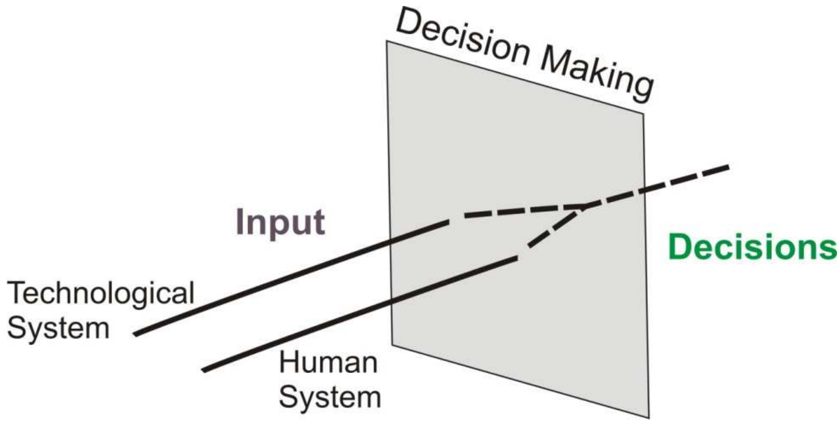


Figure 8.1 – Human and technological systems feeding the decision making

Information about and from the affected population needs to play a core role in the regulatory processes of technological hazards. As pointed out by Burton et al. (1978: 20), "it is *people* who transform the environment into resources and hazards, by using natural features for economic, social, and aesthetic purposes". This research shares this view and supports an integrated approach to regulate hazardous facilities. It understands that technological risks have two main components: a technological system, the hazardous facility or installation; and a human system, the people and their communities affected by those hazards. Risks are the outcome of the presence of these two systems in the same space: without the hazard (agent) or the human population (receptor) there are no risks, as probably first pointed out by O'Keefe et al. in 1976.

Hence, the regulatory process needs to be informed by both technological and human systems in a complementary and continuous way. In this sense, it is important that these processes take advantage of the recommendations from the literature on natural hazards and vulnerability, broadly discussed in the social sciences and especially geography, that stress the importance and role of local people and communities in the regulation of hazards (White 1961; Burton and Kates 1963; O'Keefe et al. 1976; Burton et al. 1978; Chambers 1989; Beck 1992; Watts and Bohle 1993; Cutter 1996; Hewitt 1997; Cutter et al. 2003; Pelling 2003; Cardona 2004; Wisner et al. 2004; Birkmann and Wisner 2006; Villagrán De León 2006).

However, often regulatory processes are too biased towards the inputs of the technological system. As presented in the case study, economic and political demands associated with governmental ineffectiveness, lack of compromise with the social-environmental agenda, and the nature of the technical studies, among other causes, can compromise these processes and are likely to limit inputs from human systems in decision making. The use of a counterpoint, the human system, pushes regulators to expand their scope of analysis and look for inputs coming from the affected communities as well. For instance, the design shown in Figure 8.1 proposes that the human system should be one of the two major sources of inputs informing the decision making, alongside the technological system. In this figure, these two parallel components converge during the deliberations prior to decisions and their integration guides the development of actions onwards (e.g., risk management and exposure programs).

It is worth noting that the importance of a comprehensive understanding of the human populations in the regulation of hazards is not new in the social sciences or literature on risks. For instance, when Burton, Kates, and White (1978) discussed measures that communities could apply to address natural hazards, such as the “control of natural events and their effects”, “comprehensive damage reduction”, “combined multi-hazard management”, and the collective action towards “adoption of adjustments”, they expressed long ago concerns about the fundamental role that the affected populations have in the matter. Similarly, Hewitt (1997) stresses the importance of a comprehensive understanding of the socioeconomic profile of the affected people and elaborated on the need to develop a set of measures based on impacts and implications that the human actions and decisions would have on vulnerability and risks. Another example is given by Birkmann and Wisner (2006: 7) who argued that, when choosing methods to assess vulnerability (and subsequently risks), a few key questions should clarify what directions drive regulatory processes: “who and what is vulnerable?”; “vulnerable to what?”; “who wants to know and why?”; and “what circumstances and context shape the daily life of the affected?”

This research understands that the likely dissimilarities between the regulation of technological and natural hazards can be related to the differences between the disciplines addressing them. While the literature on natural hazards is mostly comprised by works of scholars from the social sciences (and especially geography), the literature on technological hazards is commonly centered in the engineering disciplines. As social scientists have devoted great attention to communities and places, engineers have pursued the understanding and integrity of their technological systems. The analysis of both bodies of literature conducted during this research suggests that there is still a gap between them, although recent works on risk governance (Thompson and Rayner 1998; Thompson et al. 1998; De Marchi 2003; Klinke et al. 2006; IRGC 2008; Renn 2008), risk-informed decision making (Amendola 2002; TRB 2004; Ersdal and Aven 2008), and the literature on EIA (although mostly focusing on impacts) have addressed the matter claiming for a better integration between these two sides of the same problem.

Finally, this research advocates that the use of the term ‘human system’ (or any other similar term) in contrast to ‘technological system’ can provide a rhetorical basis for better equalization of this two important components, instigating the engineering disciplines and regulatory processes applying quantitative assessments to pursue a more holistic evaluation of risks. Regulators and risk specialists would be motivated to expand their scope of analysis. The term also reinforces the inherent contextual particularities of risks, which includes acknowledging that people and their communities (Cutter et al. 2003; Pelling 2003; Cardona 2004), local institutions and regulatory bodies (Amendola 2002), and the circumstances involved in the risk analysis (Aven 2007) are frequently unique, susceptible to great variations from place to place.

8.1.2 The need for better transition between analysis and decisions, to management and control

<u>Claim:</u> *Weakness in the transitions of the regulatory processes compromises the management of risks, and consequently the management of exposure.*

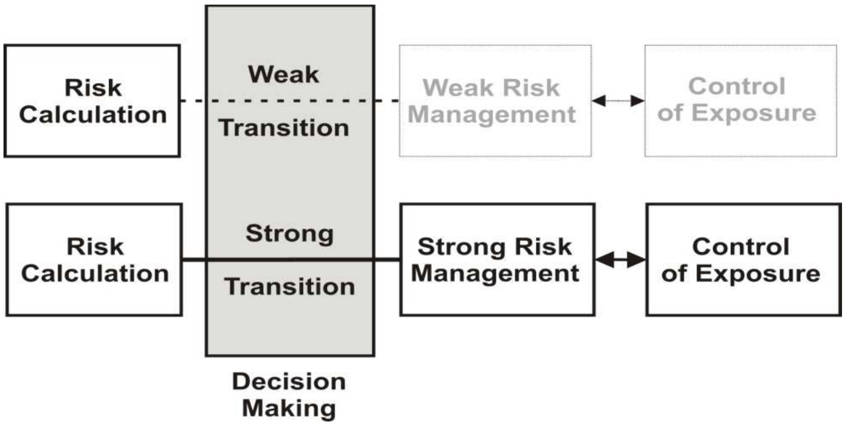


Figure 8.2 – Strong versus weak transition.

As described in this research, decision-making processes of new hazardous facilities may involve several stakeholders in a few regulatory steps – usually organized around the calculation, evaluation/decision, and management of technological risks. This research advocates that a strong transition between these steps is fundamental to avoid any negative implication in the management of risks and control of exposure in the mid and long term. The intermediary steps, evaluation and decisions about risks, need to provide solid bounds between involved stakeholders to properly connect the two steps in the extremities, the calculation of risks in on one side and management of risks/exposure on the other. The quality and comprehensiveness of the deliberations reflects in the management of risks and exposure in the future. The regulatory process is the forum in which to decide about technological risks but it is also the place and time (moment) to define a strategy to involve institutions and stakeholders, which aims to assure the most harmonious relationship between technological and human systems in a shared space.

To achieve this purpose, a strong transition needs to identify and delegate/share roles and responsibilities among stakeholders during decision making so that safety does not rely on the hands of a few regulatory bodies only, as often observed in traditional risk-based approaches. Rather, it lays responsibilities on the collective: affected population, local regulators and planners, representatives from the civil society and academia, developers, and governmental institutions. In this view, decision-making processes should be considered successful if it coordinates as many different perspectives on the same problem as possible, 'diluting the management load' on the local social fabric as well. Such an approach is grounded by movements in the literature for broad public participation (Gablehouse 2005; Murphy 2007; Pelling 2007; Boholm 2008) and social justice (Schlosberg 1999a; Asveld and Roeser 2009).

An example of the consequences of a weak transition is given by the case study. Brazil's environmental licensing applies a three-permit regulatory process to organize the discussions around the project's time-frame. In the first step, risk assessments are carried out to estimate the risk profiles. With this information, stakeholders and decision makers evaluate the overall implications the project brings and decide about the installation of the facility. In a third step, measures and actions are put in place to manage the risks identified for the operation of the proposed facility. The research results (Sections 5.2.10 and 6.1.10) indicate that transitions are potentially going to be weak in situations when local stakeholders do not have an effective stake or voice in the processes, responsibilities for the management are not delegated among all pertinent stakeholders, the local social vulnerability is not accounted for by regulators, and discussions about the use and organization of the land are not accommodated in the decision making.

8.1.3 Specific and independent routines for risk management

Claim: *Considering that technological risks are inherently associated with both human and technological systems, risk management practices cannot be a direct outcome of risk assessments only.*

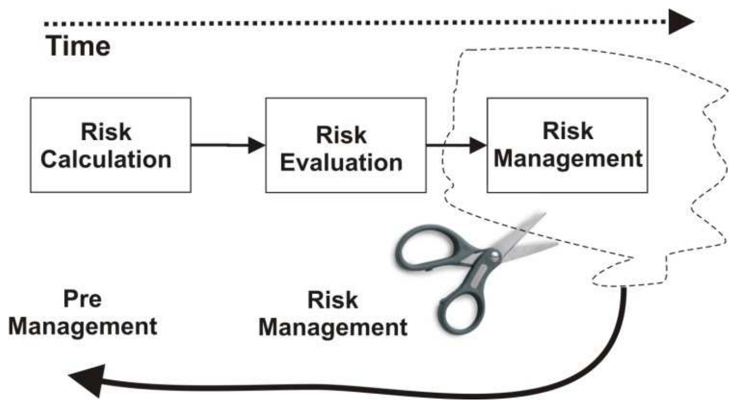


Figure 8.3 – Independent risk management

Traditionally, risk management is perceived as the last step in a sequence that also involves risk calculation and risk evaluation (McColl et al. 2000; CSChE 2004; Millstone et al. 2004; Klinke et al. 2006; Renn 2008). This approach seems appropriate when applied solely to technological systems. However, with respect to human systems, there are negative implications associated with the late implementation of management. As approached in the research's case study, managing risks is not a sole attribution of regulators or risk specialists. In many cases it also involves the cooperation and action of other actors in the implementation of programs and measures to ensure the integrity of the hazardous facilities and safety of human populations.

This research advocates that the sooner all pertinent stakeholders are involved in the discussion and understanding of their attributions in the processes the better. If the discussion is delayed, as a consequence of the previous estimation and evaluation, time is wasted and the whole process may be compromised. Regulatory processes need to take advantage of their routines to put in place instruments that force the establishment of a common and consensual view of the future, one that reflects an integrated management comprising both the agent and receptor of the technological risks.

To address this claim in the Brazilian case, this research recommends a new routine, pre-management, and supports the evaluation and approval of the risk management at the same stage that risks are being evaluated. These two actions would help strengthening the transitions between the steps in decision making (Section 8.1.2), and ultimately contribute to the better management of exposure. Pre-management routines should start concomitant with the discussion of the new project. It gathers information such as the locals' level of organization and vulnerability profile, the cities' master plans and policies for land-use and organization, and patterns of urban growth. These inputs are complemented by the information provided by the risk analysis in order to contextualize the needs of the forthcoming risk management. Following up, the risk management program consolidates the positions raised by the pre-management and structures a comprehensive plan that has the opportunity to be discussed and approved by the same forum that discusses and approves the risk results. This research understand that this represents a strategic advance in the regulatory process as it offers an opportunity for collective deliberations about strategies to cope with risks and brings more time to their implementation before any risk is real.

8.1.4 Regulatory paradigm: managing risks or exposure

<u>Claim</u>: The results of this research indicate that a comprehensive approach to regulate technological risks needs to pursue mechanisms to manage exposure, rather than managing risks only.

Figure 8.4 – Management of exposure versus risks

The reviews conducted by this research indicate that risk-driven (based or informed) regulatory processes concentrate a great deal of effort towards understanding and evaluating the implications that hazardous installations have for human populations. Decision makers seek information that gives them an indication that the technical aspects of the proposed facility will not compromise the safety of people living, in transit, or working nearby. In order to gather such an input, methods for assessing consequences and risks are applied to estimate levels of security or danger. These processes are driven in such a manner that in the end regulators are equipped with a series of concrete and rational indicators to support their decisions.

To be effective, these regulatory processes require a very well defined scope of study. The rationale behind these assessments is to accommodate the inherent uncertainties of the estimation of risk by defining assumptions and boundary conditions. For instance, information such as the project's specification, failure patterns, physical effects, and likely affected individuals is processed though models and algorithms that output an estimate of risks within a given confidence level. Any change in this set of inputs most probably modifies the final results as well, which stresses the importance of a proper and comprehensive identification of all variables influencing the risk calculation.

However, the reviews of several regulation processes and methods to account for risks carried out by this research indicate that too often the stipulated boundaries are confined to the hazardous installations only, as if risks potentially arise just from the presence and operation of these facilities in a given context. A practical example is given by the Brazilian case study, which applies a decision-making model centered in the estimation and evaluation of risks followed by deliberations to ensure the integrity of the hazardous installation.

This research supports the claims made by many disciplines in the social sciences and other fields, which suggest that the boundaries framing these regulatory processes need to be broader, comprehensive and holistic, so the processes also predict how other factors outside the limits of the hazardous installations affect the risk profiles (Amendola 2002; Klinke et al. 2006; Kristensen et al. 2006; Aven 2007; Perrow 2007; Ersdal and Aven 2008; Renn 2008; Asveld and Roeser 2009; Bea et al. 2009; Assmuth et al. 2010). Again, falling back on the research's case study, it is clear that factors such as population growth and urban development are also able to influence the risk profiles. A safe installation can become risky after a few years or decades due to the increase in the exposure to harm resulting from new urban developments, new buildings, and new people living in the range of consequence of accidental events.

Hence, the research findings suggest that decision makers should pursue more comprehensive alternatives to the regulation of hazardous installation. Rather than deciding on risk levels only, this research supports that such a regulatory process should also focus on measures to control the mechanisms that lead to any increase of people being exposed to harm. This management of exposure implies bringing to the center of the analysis a two-way assessment of the interrelationship between facilities and people, technological systems and human systems. Management of exposure encompasses controlling both the agent and the receptor of risks, and doing so does not imply disuse of risk informed decisions. On the contrary, management of exposure complements the management of risks. It is understandable that technological risks are inherently associated to the presence of a hazard, a threat. However, it is also clear that such risks are expected only with exposure, with the presence of people in the radius of consequence of those hazards.

8.1.5 Resilience plan

Claim: a resilience plan in the context of technological hazards is the result of the estimation of risks, the comprehension of local vulnerability, and the reflection of these two in the urban planning. The resilience plan is a more complete tool than traditional risk management programs.

Figure 8.5 – Resilience plan for technological hazards.

A resilience plan for technological hazards provides measures to managing exposure. Resilience is often seen in the literature as a counterpoint to vulnerability (Buckle et al. 2000; Pelling 2003; Hollnagel et al. 2006; Kaplan 2006; Manyena 2006; United Nations 2008; World Bank 2008). However, this plan does not necessarily embrace all the particularities of the concept, rather it borrows the essence of resilience. Understanding weaknesses and anticipating risks, the idea of such a plan is to articulate the interaction between the human and technological system, when they share a common space, towards better practices to manage exposure to technological risks. In practice, a resilience plan needs to comprise three main groups of actions: (1) managing risks; (2) controlling the use and occupation of land; and (3) articulating actors in these two previous fronts to ultimately manage exposure. In this sense, the resilience plan has to inform and be informed by the city's master plan and the installations' risk management programs. It is also important to have communication protocols and solid bounds between stakeholders in place so the resilience plan is a continuous process that keeps up with the changes in the boundaries coming from both systems.

This research advocates that a resilience plan is potentially a more complete tool than traditional risk management programs:

- Firstly, the term risk management is too often related to the installations, to the technological system. It is important to stress that decision makers need to incorporate a broader context into their understanding, they need to have a holistic view of the problem. The proposed resilience plan may bring this new perspective, a new balance of forces between installations and communities in the routines for controlling and following-up.

- Second, traditional risk management programs are often standardized procedures that follow premises from similar installations and historical data. The resilience plan should be local since it is context dependent (as should be the risk management). Hence, it pushes regulators and managers to pursue more realistic measures and actions to address the risks from hazardous facilities.

- Third, the resilience plan offers a better mechanism to integrate land-use planning and risk management practices. Since it brings the discussion of the city's master plan to a more central position, the resilience plan can contribute with propositions of any rearrangement that may be required to managing exposure (such as setbacks, safeguard measures, educational programs, etc.). In a following step, these contributions are used to formulate new guidelines for the master plan.

- Fourth, the resilience plan focuses on the management of exposure rather than the management of risks. As the plan acknowledges both human and technological systems, as well as the interaction of them, it works at a more comprehensive level that also embodies risk management practices.

- Fifth, as a prerequisite for its implementation, the resilience plan requires the enforcement of extensive protocols for communication. Traditional risk management programs often apply a one-way channel where regulators and managers communicate aspects related to the hazardous facility to other parts. However, since the resilience plan also comprises aspects other than the technological risk, such as vulnerability profiles and urban development patterns, communication cannot be narrow. Rather, it serves to articulate all involved stakeholders to discuss an ideally consensual plan.

- Sixth, the resilience plan divides responsibilities, sharing and delegating attributions to diverse stakeholders. The resilience plan is based upon a principle of co-responsibility, which respects the nature of the interaction human-technological systems. Traditional risk management programs often concentrate actions in the hands of the regulator and the managers of the hazardous facilities. The resilience plan proposes to extend this responsibility to other regulatory entities, local stakeholders, and the affected population as well.

8.1.6 Applying the risk governance model for hazardous linear installations

Based on the considerations addressed in Sections 8.1.1, 8.1.2, 8.1.3, 8.1.4, and 8.1.5, this research suggests an adaptation of the Risk Governance model (IRGC 2006; Renn 2008) to the specific context of the regulation of hazardous linear installations (such as gas and oil transmission pipelines). It proposes the adoption of the same structure of the model, comprised of four main routines that are integrated by extensive communication protocols. However, the results of this research suggest few adaptations in order to better manage the exposure to linear systems (as pointed out by Renn and Walker (2008: 338), "we recognize that no framework can give justice to the particularities of all applications"). Firstly, *pre-assessment* frames the problem with three measures: (1) qualitative risk assessments identify hotspots along the proposed project's pathway (points in the pathway with likely interaction between human and technological systems); then (2) vulnerability assessments gather relevant socioeconomic information for these hotspots (e.g., level of organization, concerns, educational and professional profile); and finally (3) pre-management identifies patterns of urban land-use and integrates information about risks and vulnerabilities for the hotspots in a comprehensive overlook of the local implications for the proposed project. Second, the component *assessment* encompasses the development of a quantitative risk assessment and a risk management program to inform decision making. These two technical studies focus only on hotspots. QRAs provide the risk rates for the decision about the acceptability of the hazardous installation, while the risk management program offers propositions for the local community to better cope with and manage exposure to the technological hazard. The next step, *characterization/evaluation*, differs from the original framework in the aspect that regulators will decide about exposure, rather than risks. Since the risk management program comprises not only demands and inputs from the technological system, but also from the human system and the space they share, regulators and local stakeholders will have the opportunity to debate about both risks and ways to cope with these risks. Finally, the *resilience plan* implements routines to manage risks (often related to the technological system) and exposure (often related to the human system), integrating and articulating the results and considerations from the QRA with the risk management program, integrating and articulating risk policies with land-use policies, and sharing and/or delegating responsibilities among relevant (and pertinent) stakeholders.

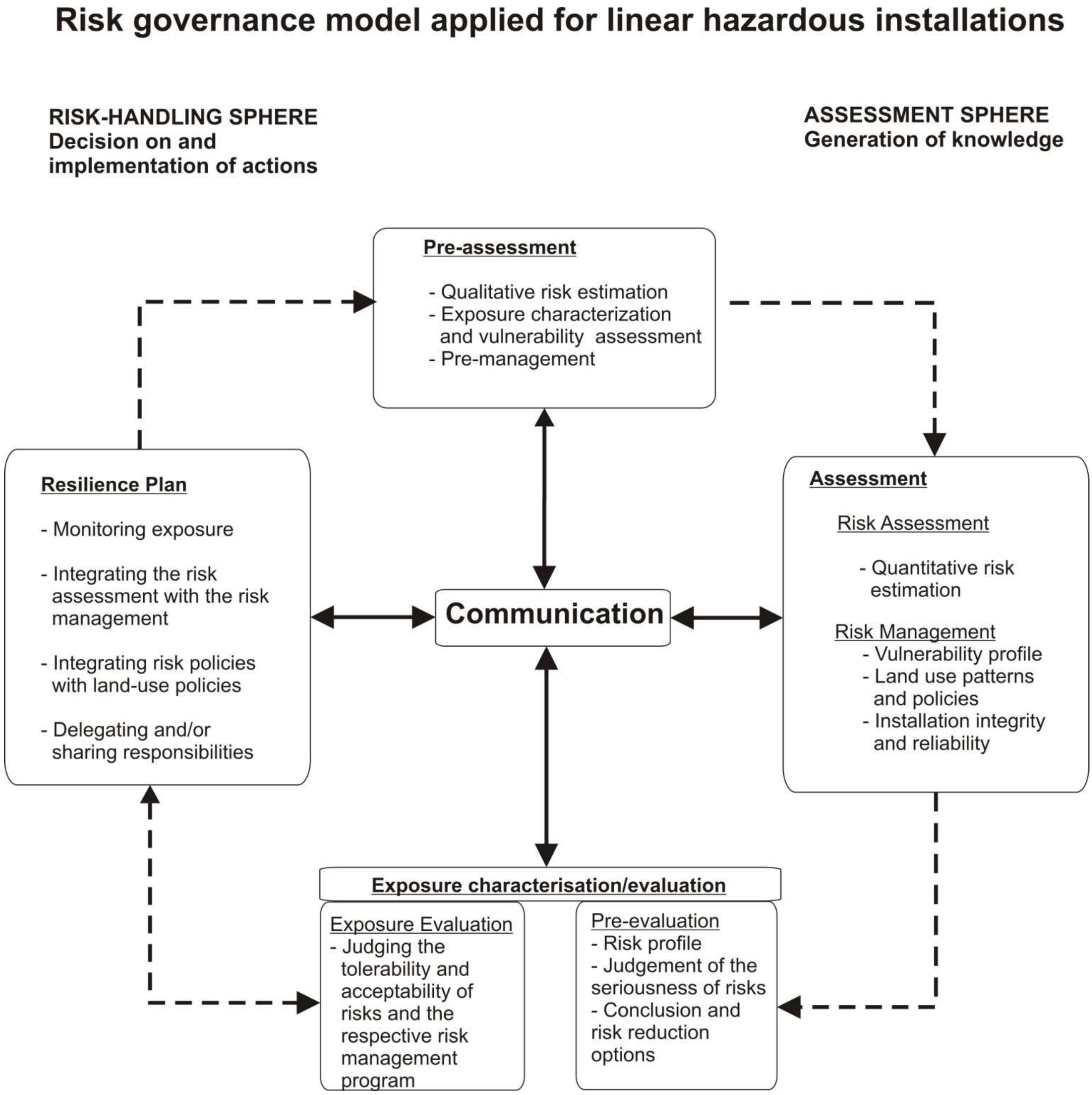


Figure 8.6 - Adapting the Risk Governance model for the regulation of hazardous linear installations. Adapted from Renn (IRGC 2006; Renn 2008).

Although the suggested model is not tested by the research, it benefits from consolidated discussions in the literature, insights from a case study, and the fact that the Risk Governance model is still relatively generic to propose a more specific framework to regulate hazardous linear systems. The research identifies constraints that prevent such an evaluation at this point. A detailed description of the scope for the vulnerability assessment, pre-management program, risk management program, and resilience plan is a comprehensive task that needs to be explored prior in both practical and academic spheres. As pointed out by Renn and Walker,

> "[t]he appropriate tools for understanding and developing solutions for particular risk issues will be dictated by the nature and context of the risk. Excellent guidebooks and manuals are already available on individual elements of the framework. But ultimately, experts with specialized training and skills relevant to those elements will be needed … We however do hope that this more comprehensive framework will contribute to the development of more balanced, more inclusive, and more effective risk governance strategies – ones that avoid the pitfalls of the past" (Renn and Walker 2008: 337).

8.2 Research contributions to the literature on technological risk regulation

A second group of contributions to the literature is presented in this subsection, where research findings inform some of the current discussions on technological risk regulation. Firstly, as described in Section 2.1.4.2, Limitations of a QRA from the 'social science point-of-view', there are many concerns in the literature related to the performance of risk-based regulatory processes. Table 8.1 offers some inputs to those questions based on the analyses of the case study. Due to the particularities of Brazil's environmental licensing process, the results should be representative of jurisdictions applying the same set of tools regulating hazardous facilities – mainly the enforcement of QRAs, followed by centralized decision making, and risk management focused on the technological system. However, as risk regulation is complex and context-dependent, the inputs presented in Table 8.1 should also be viewed with a certain degree of restriction since they reflect the performance of just one regulatory process, notwithstanding researche in other countries and regulatory processes can complement and be complemented by these findings. Overall, Brazil's risk-based approach shows considerable limitations from the social sciences point-of-view, as discussed by this research (Chapter 5 and Chapter 6) and the literature on the BELP (de Souza Jr 2000; Glasson and Salvador 2000; Alonso and Costa 2002; Little 2003; MPF 2004; Nicolaidis 2005; Kirchhoff 2006b; Souza et al. 2007).

Table 8.1 – Contributions from the research's case study.

#	Question	Outputs from the research's case study
1	Is it possible to achieve fair and comprehensive risk analysis in a risk-based study (Healy 2001; Apostolakis 2004)? If so, how? Is cost-benefit (or risk-benefit) analysis the best decision-making approach (Ersdal and Aven 2008; Roeser and Asveld 2009)? What is the best balance between precaution and cost-benefit analysis (Starr 2003)?	The results from the research's case study indicate that risk-based approaches decide based on a considerably narrow set of information (Section 5.2.2), often driven by economic and political priorities (Section 5.2.3 and 5.2.4), and with poor implications for social and environmental justice (Sections 5.2.7 and 6.1.5.2).
2	When approaching issues of intergenerational justice versus risk and uncertainty, is the QRA an appropriate approach (Davidson 2009)?	The Brazilian regulatory processes of technological risks have profound limitations in the management and control of risks throughout the facility's life-cycle (Sections 5.2.9 and 5.2.10), which compromises safety in the long run.

#	Question	Outputs from the research's case study
3	How do feelings and information influence in the balance between values and reasons (act) versus preferences and willingness to pay (legitimization)? What are the meanings attributed to uncertainties according to the filters proposed by Adams and Thompson (2002): psychology, economics, ideology, biology, and culture?	The BELP has deficient performance on the assessment and evaluation of socio-concerns about technological risks (Section 6.1.2), the use of precaution (Section 6.1.4), and the assessment of broad vulnerability (Section 6.1.10 and 5.2.7).
4	What is the role of the public? Do collective decisions influence individual risks? Is this fair (the collective deciding for the individual, who often is not represented)? Should decisions be participatory (Webler 1999; Davies 2001; Bryson 2004; Roeser and Asveld 2009)?	Usually, the public has a limited role in the Brazilian regulatory processes (Sections 5.2.7 and 5.2.5), most times only being informed of the projects and decisions. Communication in the processes is poor (Section 6.1.3.1) and often restricted to technical information (Section 6.1.3.2).
5	Is it possible to assess incommensurable risks applying cost-benefit or risk-benefit analysis (Hansson 2009)?	According to the case study, the assessment of incommensurable risks is compromised by the shallow vulnerability analyses carried out by QRAs (Section 6.1.10).
6	Given the gap that often exists between risk specialists and the civil society, has the communication of these risks been appropriate (Wester-Herber and Warg 2004; Boholm 2008; Lidskog 2008)?	The results of the Brazilian case indicate that there are protocols in place for risk communication. However, there are considerable limitations in the availability and content of this information that stress the existent gap between specialists and civil society (Sections 5.2.6 and 6.1.5).
7	Referring to the design of new technologies and projects, do the moral and ethical guidelines on the 'regulative frameworks' represent the perspectives of all actors? Have the social factors, for instance, been taken into consideration (Asveld and Roeser 2009)?	As discussed in the research's case study, the human system does not play a core role in the definition of new technologies or projects in Brazil (Chapter 7).
8	Referring to the ALARP (As Low as Reasonable Practicable), what is low, reasonable, and practicable? What is safe enough? Is tolerability to risk uniform across different people? How does tolerability become acceptability and approval (Adams and Thompson 2002)?	There are important limitations to the application of ALARP in the research's case study, since Brazil's criteria for acceptability and evaluation of technological risks is relatively permissive (Section 2.1.4.1) and uncertainty is a considerably strong factor compromising the results of QRAs (Box 2.1 and Box 2.3).
9	Referring to the 'FN' and 'Iso-risk' curves, do we need to develop new ways to judge technological risks (or is just ameliorating such curves - raising the bar - enough)?	Based on the results from the case study, this research advocates that the focus of technological risk regulatory processes need to be shifted from the management of risks towards a more comprehensive management of exposure (Chapter 7).

#	Question	Outputs from the research's case study
10	Considering the point of Adams and Thompson (2002:27) that "attempts to reduce the various consequences of risk-taking to a single common denominator will inevitably exclude legitimate voices", which voices are considered legitimate and which are not?	The case study indicates that very often the regulatory processes are applied to legitimize the new technologies (Section 5.2.4), and/or to serve to economic and political purposes (Section 5.2.3). The participation of other 'voices' is limited during the decision-making processes (Sections 5.2.2, 5.2.5, 6.1.3, and 6.1.5).
11	Since risk management is a balancing act, how is it possible to accommodate different stakeholders in harmonious decision making (individualist, egalitarians, hierarchists, fatalists)? Has the 'individualist' group of stakeholders been more important than the others (Adams and Thompson 2002)?	

Secondly, addressing the case study, the research discusses ways to transform risk-based into risk-informed decision making for transmission pipelines (Section Chapter 7), reinforcing the advice from diverse scholars addressing the matter in the literature (Section 2.1.4). In special, the United State Transportation Research Board of The National Academies, in its Special Report 281 – Transmission Pipelines and Land-use: A Risk-Informed Approach (TRB 2004), lays down some initial milestones in the elaboration of risk-informed decision making. This research builds on the recommendations from this Special Report to propose a more comprehensive framework for regulation of technological hazards in Brazil. In the suggested design, the inputs from risk analysis are complemented by comprehensive information about the local population and land-use and organization patterns. Although the results should be viewed within the contextual particularities of the case study, the core elements of the design (such as the pre-management, vulnerability assessment, and resilience plan) can be applied in other jurisdictions.

Thirdly, the research designs a group of twelve qualitative indicators to assess the performance of technological risk regulatory processes (Section 4.2.4 and 6.1): pre-assessment of risks; concern assessment; precautionary appraisal; risk reduction at source; environmental and risk education; communication; public participation; environmental justice; governmental integration; land-use planning; specific routine for risk management; vulnerability assessment; resilience plan; and follow-up. These qualitative indicators drawn on current trends in the literature on risk regulation (discussed in Section 4.1), organized into the research's conceptual framework (Section 4.2), and help assessing limitations and identifying opportunities to improve practices in decision-making processes of hazardous facilities in urban context. This research has not identified in the literature any other similar structured group of performance indicators.

Finally, drawing on the works of Kirchsteiger (1999), Millstone (2004), and Renn (2008), the research offers an organization of the literature on technological hazards regulation into three hierarchical groups (Section 2.1): models, approaches, and methods to account for risks in regulatory processes. Four models are identified –

technocratic, decisionistic, transparent, and risk governance. Five approaches are described – legalistic, consequence-based, risk-based and risk-informed, hybrid, and precaution-based. Among the several methods discussed in the literature, this research addresses the quantitative risk assessments. This organization helps to understand how decision-making processes for technological hazards are structured, the type of information these processes usually require, and the technical studies applied to inform their decisions.

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Appendix A – The BELP

The Brazilian Federal Law 6.938, promulgated in 1981, presents the framework and objectives of the Brazilian National Environmental Policy (BNEP), a structured step towards the consolidation of an environmental agenda in Brazil. The development of environmental quality standards, the assessment of environmental impacts, and the licensing of pollutant activities were some instruments and objectives of this environmental policy. This law also introduced the Brazilian National Environmental System (BNES) and its actors, including the Brazilian National Environmental Council (CONAMA: Conselho Nacional de Meio Ambiente), the MMA, and the IBAMA.

Of note is the fact that law 6.938/81 was one of the precursors in the discussion of an environmental licensing system, indicating that activities potentially harmful to the environment should undergo a formal assessment of impacts in order to evaluate the consequences to the surrounding area. This law assigned to CONAMA responsibility for discussing the framework of this new system.

CONAMA is the advisory and deliberative branch of BNES, constituted of representatives from different segments of the society, such as the federal, state and municipal governments, industries, trade unions, non-governmental organization (NGO), and the scientific community. Among CONAMA's attributions are the discussion and elaboration of guidelines, standards, and technical regulations concerning environmental policies.

In 1986, CONAMA deliberated and adopted resolution 001/86, a milestone in the implementation of the Environmental Impact Assessment (EIA) and the Brazilian Environmental Licensing Process. In 1988, following and ratifying this process, the new Brazilian Constitution stated in its Article 225 that "everybody has the right to have an ecologically balanced environment… being the Public Power and the collectivity responsible for protecting it and preserving it for the present and future generations".

Later, in 1997, CONAMA issued resolution 237, describing the roles of the governmental actors in the Environmental Licensing Process (ELP). According to this resolution, "the localization, construction, installation, extension, modification, and operation of projects and activities that can impact the environment depend on an environmental permit, issued by the competent environmental agency" (reference in Portuguese: CONAMA Resolution 237 from 1997, Article Second). As an instrument for the implementation of this guideline, CONAMA resolution 237/97 introduces the concepts of three environmental licenses: the Prior License (PL), the first license of the process, usually granted after the approval of an Environmental Impact Study (EIS) and a Quantitative Risk Study (if required); the Installation License (IL), usually granted after the approval of an Environmental Basic Project (EBP) and which allows the beginning of the construction/installation; and the Operation License (OL), granted after the approval of all necessary studies and any other prerequisites imposed by the competent agency. With slight variations from state to state, these licenses constitute the three central steps of a typical environmental approval process in Brazil.

CONAMA 237/97 is also a guideline attempting to harmonize the competencies in licensing of the three levels of the executive power in Brazil (Federal, State and Municipal). It delineates the attributions and jurisdictions of these actors and enforces that a project will be licensed in one level of competency only, although it also assures that the other actors will be listened to during the licensing process. In practical sense, however, due to the large number of existing entities involved in a regular licensing process, possible conflict of interests might happen. In such case, the Justice, the Public Ministry[27], the Ministry of the Environment and, in a smaller scale, the General Advocacy of the Union are institutions that usually mediate and solve any conflict related to the licensing's responsibilities.

According to CONAMA 237/97, the ELP should obey a hierarchical structure, based in an environmental impact grade. The Federal Level (national) is responsible for the evaluation and approval of projects that, for instance, are going to impact more than one Brazilian state or a neighboring country. To the State Level (regional) are designated, for instance, those projects impacting more than one municipality or those delegated by the competent Federal agency, IBAMA. Brazil is a Federation constituted by 26 States and a Federal District, each one of these components of the Federation has an environmental secretary or an executive agency running the environmental licensing processes at the State level. Finally, small and local impacts should be evaluated by the local authorities (Municipalities).

However, actually, the effective implementation of CONAMA 237/97 is limited either by the lack of or non-existent structure for the organization of governmental actors. According to Glasson and Nemesio (2000: 193), "the Brazilian characteristics and contrasts are reflected in the characteristics of environmental policies and practice (…) the problems are large, the processes are diverse, resources are very limited, and environmental impact assessment varies greatly in its nature and effectiveness depending on region, state, or municipality within which it is being carried out". In fact, the disparity among the States of the Federation is considerable. States in the southeast and south region have a more solid structure and consistent policies compared to those belonging to the north and northeast. At the municipal level, this scenario is even worse. Only a few of the 5,564 (IBGE 2008) Brazilian municipalities have an implemented and competent structure to carry out simple environmental evaluations.

In 1989, the Federal Law 7.735 created IBAMA, the Brazilian executive agency in charge of the implementation of the environmental policies in Federal level. IBAMA's responsibilities at that time spread from the control and licensing of pollutant activities to the preservation of ecological systems and natural resources. However, in 2007 the Chico Mendes Institute of the Conservation of the Biodiversity (ICMBio) was created, withdrawing from IBAMA part of its original responsibilities. However, IBAMA is still the federal agency in charge of the federal licensing activities, through its Directorship of Environmental Licensing (DILIC: Diretoria de Licenciamento Ambiental).

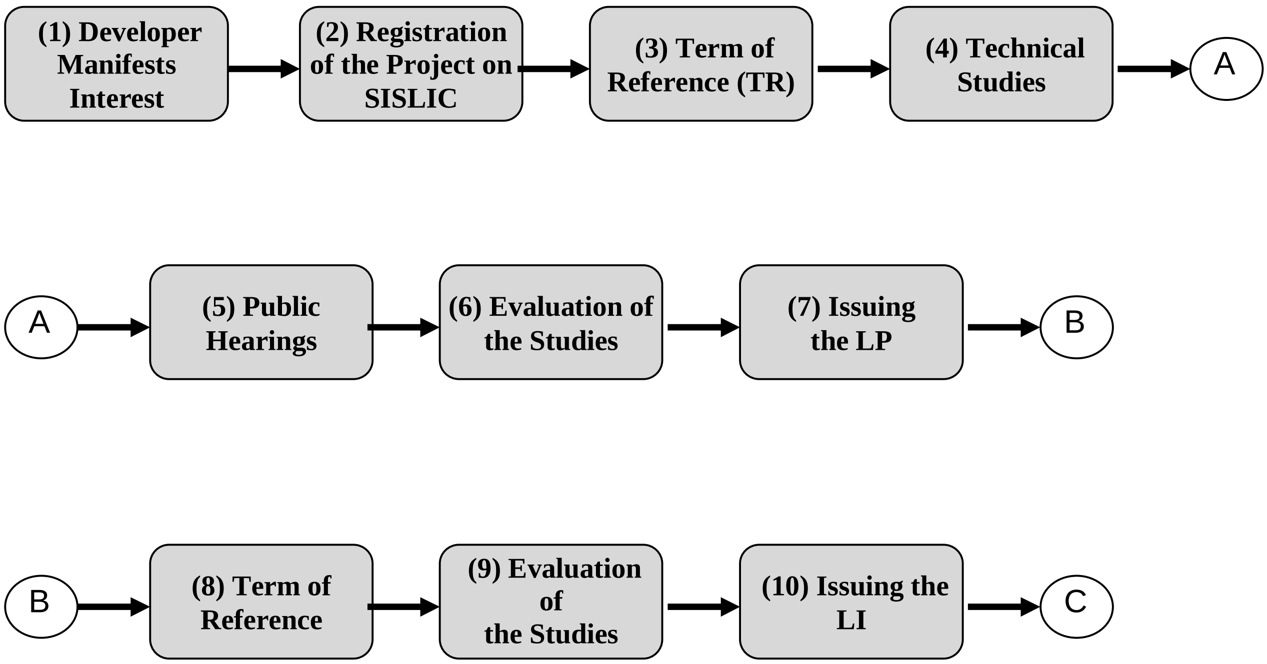
[27] Autonomous magistrates formed of public prosecutors, working both at the federal and state level.

DILIC is composed of three General-Coordinations: Petroleum and Gas (CGPEG), Power Electrical Infra-Structure (CGENE), and Transportation, Mining and Civil Projects (CGTMO). Each General-Coordination is also constituted by two Coordinations of Licensing. In a practical sense, these six Coordinations of Licensing evaluate the largest projects and activities in Brazil, such as dams, nuclear power plants, transmission pipelines, roads, mines, petroleum exploration, and so forth. Usually, environmental impact and risk assessments are evaluated simultaneously in parallel and complementary processes, by both the Environmental Impact Study and the Quantitative Risk Study (or Qualitative, depending on the case), respectively. These preliminary studies are the foundation of the licensing process, and are also critical for the elaboration of subsequent programs and studies, such as the Environmental Basic Project and the Risk Management Program.

Federal risk policies are mainly interrelated to the Environmental Licensing Process. The Coordinations of Licensing of IBAMA are, thus, the technical group in charge of risk regulation of large transmission pipelines in Brazil, as described in the next section.

The Framework of the BELP:

A simplified flowchart of the Brazilian environmental licensing process of a typical transmission pipeline is presented in Figure , based on IBAMA's normative guidelines (IBAMA 2008).



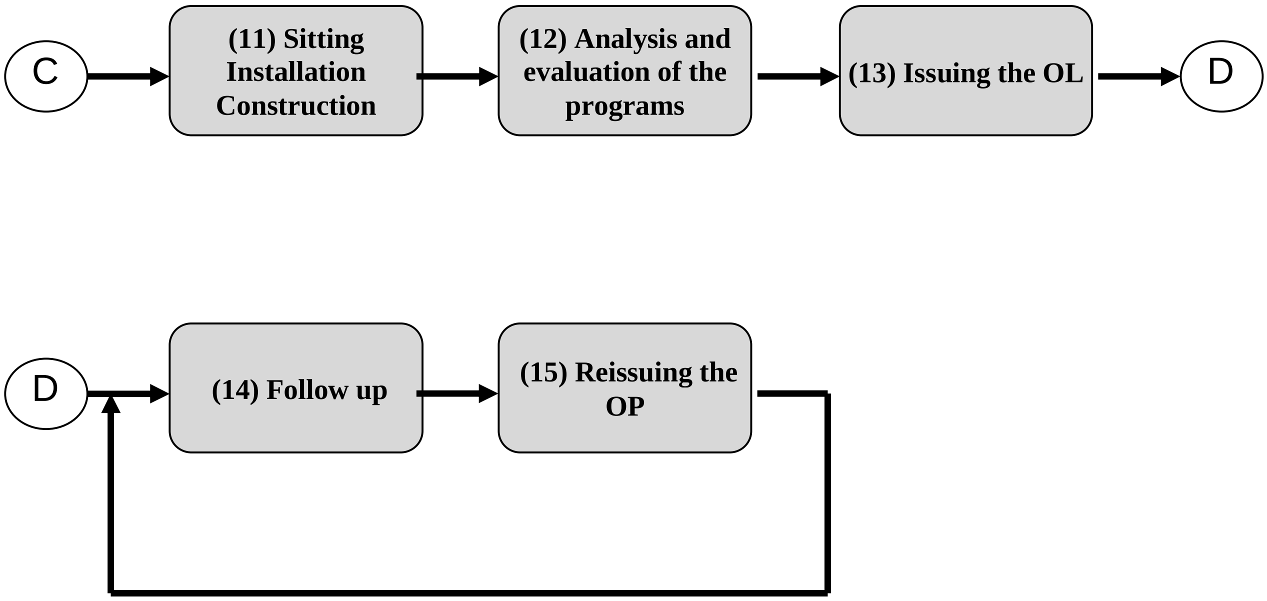


Figure A1.1 – Flowchart of the BELP of a typical transmission pipeline.

These fifteen actions are briefly described, as follows (IBAMA 2008):

Action 1: Developer manifest interest for a new project

- For instance, a developer decides to sit a new transmission pipeline connecting an oil field to a large city in Brazil.

Action 2: Registration of the project at IBAMA (environmental agency)

- The developer registers at IBAMA a protocol of intention to implement this new project.
- At this point, IBAMA has the opportunity to deny this project if the developer either does not provide IBAMA with all the required information or does not have a good environmental performance in the past years.

Action 3: Term of Reference

- IBAMA assigns an 'environmental licensing team' (ELT) that will be in charge of the process.
- This ELT might need a field trip before proceeding with the process.
- IBAMA requires the developer to carry out an environmental impact study (EIS) and a quantitative risk study (QRS).
- A term of reference (TR) is issued by the ELT for each study. In this stage, IBAMA consults other governmental institutions (federal, state, and local level). If these institutions have any contribution

to offer, they will be incorporated into the TR. NGOs or any other institution representing the civil society are usually not consulted at this step.

Action 4: Studies are presented to IBAMA

- The developer carries out the two studies and presents them to IBAMA. Alongside with the studies, it is also presented an environmental impact report (EIR), a shorter and condensed version of the EIS with accessible language to the general public.
- IBAMA compares the studies to the TRs. If the studies cover the scope of the TR and are accepted, IBAMA asks the developer to send a copy to all other governmental stakeholders involved in the licensing process (local and state environmental agencies, for instance).
- IBAMA also asks the developer to make the **EIR** available to the affected communities and municipalities. Communities, NGOs, local governments, and the citizen will have access to the EIR only. The EIS and QRS are usually not available to the general public.

Action 5: Public Hearings

- Public hearings are conducted by IBAMA. They should be requested by the civil society, however IBAMA usually enforces at least one public hearing for each project. In the case of a transmission pipeline, IBAMA has an informal policy of having at least one hearing in each important/large city crossed by the pipe.
- The format of the public hearing is developed into three main stages: (1) presentation of the project by the developer; (2) presentation of the EIR by the consulting company; and (3) discussions of the project and the technical studies, where the civil society has the opportunity to ask questions about the project, impacts, benefits, etc. to the developer, the consulting company, and IBAMA.
- IBAMA mediates the meeting (impartial). The hearings are open to everybody and the inputs gathered during the public hearing are annexed to the project's licensing files.

Action 6: Evaluation of the studies

- IBAMA evaluates the EIS and the QRS.
- IBAMA evaluates the questions and contributions presented during the public hearings.
- IBAMA consults other institutions about their considerations of the QRS and EIS.
- The ELT might have another field trip for final local considerations.
- The ELT issues a technical report with their consideration and recommendations.

Action 7: Prior License

- If all information presented is enough for conclusive decision making, IBAMA issues the Prior License (PL).
- This license may include other conditions that should be fulfilled by the developer in the sequence of the project.
- All affected municipalities must inform IBAMA that they agree with the installation of the project in their jurisdictions. If any county does not agree with this new project, a PL should not be issued.

Action 8: Term of Reference

- IBAMA issues the TR for the basic environmental plan (BEP - programs for mitigating impacts identified by the EIS), the deforestation study (if necessary), the risk management program (RMP), and the contingency plan (CP). IBAMA consults other governmental stakeholders for contributions for these new TRs.
- The developer carries out the studies and presents them to IBAMA.
- If the studies cover the scope specified by the TR, IBAMA accepts the study and asks the developer to make them available to all governmental stakeholders involved in the process.
- These studies are not available to the general public.

Action 9: Analysis of the Studies

- IBAMA evaluates the studies.
- The ELT might have a field trip.
- IBAMA evaluates the suggestions and impressions from all other governmental stakeholders involved in the process.
- The ELT issues a technical report with their considerations and recommendations about the studies and all other requirements from the previous steps.

Action 10: Installation License

- If all information presented is enough for conclusive decision making, IBAMA issues the Installation License (IL).
- This license may include other conditions that should be fulfilled by the developer in the sequence of the process.
- The developer can start the installation of the pipeline.

Action 11: Siting/Installing/Constructing

- The developer starts the siting/installation/construction activities.
- The developer must implement all the programs presented in the BEP.

- IBAMA should follow up these activities.
- The developer issues reports to IBAMA.
- IBAMA evaluates the reports.

<u>Action 12:</u> Pre-operation

- The developer finishes the siting/installation/construction activities.
- IBAMA assess and evaluates all programs and prior requirements.
- IBAMA evaluates the RM and the CP.
- IBAMA consults other governmental stakeholders about contributions.
- The ELT might have a field trip.
- The ELT issues a technical report with their considerations and recommendations about the studies and all other requirements from the previous steps.

<u>Action 13:</u> Operation License

- If all information presented is enough for conclusive decision making, IBAMA issues the Operation License (OL).
- This license may include other conditions that should be fulfilled by the developer in the sequence of the process.
- The developer can start the operation of the pipeline.
- OL is valid from four to ten years. Before the expiration of the license, the developer must start a new process to renew the license.

<u>Actions 14 & 15:</u> Follow up and Renewing (new license)

- The developer should provide IBAMA with reports about all the programs (each 4 months, 6 months, year, and so forth).
- IBAMA should evaluate these reports and follow up.

Appendix B – Interview Questions

#	Question	Purpose/Justification	Group
General questions for the identificatoin of the interviewee			
1	1.1 - Please, what is your name? 1.2 - What is your occupation? 1.3 - Institution/Organization?	Identification	General Information

Questions about the Brazilian environmental licensing process (BELP).			
Please consider IBAMA's environmental licensing processes			
2	2.1 - Can you think of three points (practices, actions, measures, or routines) that you consider to be strengths of the BELP?	Identification of strengths of the BELP. At this point I want to identify good practices of the BELP in general.	General Assessment
	2.2 - Can you think of three points that you consider to be limitations of the BELP?	Identification of limitations of the BELP. At this point I want to identify limitations of the BELP in general.	
	2.3 - Can you think of three actions, routines, measures, or practices that are missing in the current framework of the BELP?	Identification of spontaneous contribution to help answering the research question ('how can the BELP be improved to avoid and/or better control risk exposure due to gas and oil transmission pipelines?')	
	2.4 - Do you think the BELP is a inclusive process? Why/How?	Open question where I expect the interviewee to talk about 'communication' between IBAMA and stakeholders, instruments to public participation, and sense of fairness in the BELP.	Items: Public Participation and Communication and Education
		Prompt: (1) Is it easy to participate, contribute, be heard? Why/How? (2) is participation equally possible during the PL, IL, and OL processes?	
	2.5 - Do you think that the technical information of the projects licensed by IBAMA is assessable to stakeholders other than the developer, the consulting company, and IBAMA? Why/How?	Disclosure of the technical information is a concern for risk management.	

Questions about the BELP of technological hazards.			
Please consider IBAMA's environmental licensing processes of a new gas or oil transmission pipeline			
3	3.1 - Do you understand the results of QRAs? If yes, can you briefly explain them to me?	This research advocates that the BELP applies a decisionistic risk-based approach. The understanding of the results of QRAs by stakeholders is important for risk management purposes.	Items: Pre-assessment and Concern Assessment
	3.2 - How the results of the QRA are discussed with the affected population, local government (municipality), and other local stakeholders during the BELP?	Prompt: Can you think of three points related to the risks of transmission pipelines that you think are important to be communicated?	Items: Public Participation, Communication and Education, and Pre-assessment of risks
	3.3 - Please consider that a new pipeline is going to be installed in a large Brazilian city. Can you talk about how the QRA considers the ideal of precaution?	In the literature the precautionary principle is often understood as a counterpart for risk-based approaches and quantitative risk assessment. Prompt: (1) Do you think it is important to consider 'precaution'. Why/How?	Item: Precautionary Appraisal
	3.4 - Considering the same situation, what kind of information about the population living near transmission pipelines is considered by QRAs?	Information about the likely affected population is important for risk management purposes. Prompt: What kind of information about these people do you think need to be considered by QRAs?	Items: Pre-assessment, Concern Assessment, Vulnerability Assessment, and Specific Routine for RM
	3.5 - Do you think the licensing processes are fair to the affect population? Why?		Environmental and Social Justice
	3.6 - Do you know any practice in other jurisdiction that differs from what IBAMA currently applies for risk assessment & management of pipelines? If yes, can you talk about it/them?	Spontaneous contribution of the interviewee	Other practices

Questions about the integration of risk management to urban land planning			
Please consider the urban centers crossed by existing transmission pipelines			
4	4.1 - One frequently observes the encroachment of settlements onto pipeline right-of-ways. Can you think of any causes of this encroachment?	This research advocates that the lack of control and inefficient risk management practices can lead to encroachment of the pipeline ROW	Item: Integration of Governmental Actors and Land-use control around the ROW
	4.2 - To what extent do you think this encroachment relates to the BELP?	This research advocates that the current BELP has limitations in the control of risk exposure.	
	4.3 - Why do you think these people live so close to those pipelines?	Risk perception	
	4.4 - How do you think the QRA can help to prevent these encroachments? Why/How?	This research advocates that QRAs should be used as 'exploratory' tools. However, the control of such encroachments is broader than a single QRA.	
	4.5 - Can you talk about the role of the city's master plan in this matter?	This research advocates that risk management need to be integrated to the land urban planning.	
	4.6 - Can you offer any insights about how the BELP can address this matter?	Prompt: (1) for existing pipelines? (2) for future pipelines?	

Questions about the Follow-up			
Please consider the post-licensing of transmission pipelines			
5	5.1 - Can you talk about the management of the risks after the OL (operation license)?	Pipelines become hazards after the OL.	Item: Resilience Plan, Vulnerability Assessment, and Follow-up
		Prompt: Is it efficient? Is it appropriated? Is it complete? Why/How?	
	5.2 - Can you talk about the role of IBAMA in this matter?	This research advocates that risk management need to be local and inclusive.	
	5.3 - Can you talk about the role of the local government in this matter?	This research advocates that risk management need to be local and inclusive.	
	5.4 - Can you talk about the role of the affected population in the implementation of risk management practices?	This research advocates that risk management need to be local and inclusive.	

Conclusion		
6	6.1 - Do you have any question that you would like to ask me?	Open
	6.2 - Do you have anything further that you would like to say?	Open

Appendix C – Brief Review of Beck's Risk Society

"Risk Society: Towards a New Modernity" is a classic book written by German sociologist Ulrich Beck. Originally written in Beck's mother tongue, this English edition was first published in 1992 and has became a strong reference for understanding some aspects of the complex transformation societies worldwide have faced in current times. Beck defends three theses in his book: the appearance and raise of a "risk society", following the crescent industrialization and production of wealth; the individualization of societies, which comes with the individual's need to provide his or her own survival; and the "reflexive modernity", where the interrelations of the two first and the new roles of science and politics have changed the world. While attempting to cover such a broad content, Beck moves with elegancy from one point to another. His argumentation is precise and clear, although many times it could sound a little repetitive. Beck is bright in anticipating and unveiling the nuances that differentiate this new risk society from the traditional class and industrial society. In his view, individuals nowadays have a new connotation, risks have a new dimension, and the science has a new challenge.

The book is divided into three parts. In "Living on the Volcano of Civilization: The Contours of Risk Civilization", Beck introduces a new perspective, or even a new reality of risks. To live in this new era is to expect, to deal with and to be exposed to multitude of risks. In the second part, "The Individualization of Social Inequity: Life Forms and the Demise of Tradition", Beck deals with the actual trend of individualization in societies in contrast to the traditional concept of family, classes and social stratification. Finally, in the third part, "Reflexive Modernization: on the Generalization of Science and Politics", Beck discusses the paradoxical and dual role of science and the new dynamic of politics in this new conjecture.

Regarding the insights Beck brings to the man-nature relations, indubitably the first core of his work is of considerable relevance. As Beck contextualizes threatens and risks that man, industry, technology and science have imposed to the environment and humanity, the reader has the opportunity of thinking about ways to overcome this scenario while following the narrative. There is no simple answer encompassing all the questions raised by this critical turning point the world has been facing. However, the reflection towards the danger man has incurred the planet is worthwhile the anxiety of facing a sharp reality and perhaps a cloudy and hesitant future, as posed by Beck.

That said, the other two cores of the book become less important if one seeks understanding the interrelation among man, science/technology, and nature in modern life only. Dealing with the distribution of wealth and risks in societies is, to some extent, to deal with the way people live, act, and interact with nature and the environment; is to deal with the inequity and inequality among individuals, countries and hemispheres; is to face that, if on the one hand there is an increasing exploration of natural resources, on the other hand the amount of resources nature has provided humanity apparently have not improved wellness in a homogeneous way. On the contrary, as Beck argues, while wealth tends to concentrate in the upper social classes, the lower classes concentrate vulnerability and risks. Due to the importance of this first part of the book, it will be object of more attention, as follow.

Living on the Volcano of Civilization: The Contours of Risk Civilization:

Some nations have acquired the industrialized and developed status; many others are still pursuing this accomplishment. Technology and industry are now some of the fundamental pillars that societies are established upon. Hazards, once confined mainly to the forces of nature, now are intrinsic components of new technologies, goods, and services. In the present time, food has a considerable share of chemicals; telecommunication comes with an invisible menace in form of waves; the controversial uranium fuels electric power; the transportation system model and its atmospheric emissions poison the air and perhaps warm the planet. These are only few examples of the complexity and the risks of the modern life, as depicted by Beck. Not only nature threatens men anymore. Humankind has been threatening itself in such a scale never seen in history.

Beck shows risks of one's day-to-day life in a multi-dimension, intercalated layers fashion. His tone many times is crude and pessimistic, but his argumentation, comprehensiveness and lucidity make the discussion of such a complex issue a pleasure reading. Societies worldwide are vulnerable to an intangible number of sources and hazards, in a direct relation with the raise of the production of wealth: "in advanced modernity the social production of wealth is systematically accompanied by the social production of risks" (p. 19). The industrialization and development of the world is a great achievement humanity accomplished. However, there is a price for this and the raise of risks in everyone's life is a reality.

Beck also discusses two other interesting points in this first part of the book: (1) the close relationship between risks and poverty; and (2) the use of societies as laboratories to assess risks "live". According to Beck, the distribution of risks is not exactly fair among social classes, being the lower strata usually overloaded: "poverty attracts an unfortunate abundance of risks" (p. 35). Somewhat in the same extension, the raise of vulnerability is not equal in all social levels. Common factors that can reduce risks and diminish vulnerability, such as formal education, access to health care, reasonable incoming, housing, and so forth, are not available to a great part of the population in the world. In the second point, Beck argues that society became a laboratory, where risks are evaluated while people eat, watch TV, browse the Internet, use mobile phones, take medicines, and so forth. The implications of the many technologies in human health and nature are not quite fully understood even by sciences, though the crescent expansion of their use.

However, this first part of "Risk Society" has some issues that could be better addressed as well. Beck spends great part of the book dealing with the range of variables involved in the assimilation of the "costs" of the industrialization and this new model of society, but few is directed to the analysis of the "benefits" (if there is any consideration about it). Beck is a visionary explaining how risks would claim the world's attention in the years to come after his book. Indeed, risk management has been gaining a connotation compatible to the actual level and forms of vulnerability in the world. However, even considering the importance societies should give to the threats man faces nowadays, it is also important to observe the contribution of the industrialization and science in this new "risk society". If risk is simplistically measured in terms of life expectancy only, the era of the "risk society" has boosted the average quality and years of life of individuals in many societies without precedents in the history. The absence of this "trade-off" analysis is, perhaps, one of the weaknesses of Beck's work, but nothing that could diminish this impressive book.

Appendix D – Definitions for Vulnerability

The table below offers a compilation of definitions for vulnerability, reproduced from Cuter (1996: 531-532) and complemented by this research (year 1997 onwards).

Table A4.1 – Definitions of vulnerability. Extracted from (Cutter 1996: 531-532) and complemented by this research (year 1997 onwards).

Definition for Vulnerability	**Source**
Vulnerability is the threat (to hazardous material) to which people are exposed (including chemical agents and the ecological situation of the communities and their level of emergency preparedness). Vulnerability is the risk context.	Gabor and Griffith (1980)
Vulnerability is the degree to which a system acts adversely to the occurrence of a hazardous event. The degree and quality of the adverse reaction are conditioned by a system's resilience (a measure of the system's capacity to absorb and recover from the event).	Timmerman (1981)
Vulnerability is the degree of loss to a given element or set of elements at risk resulting from the occurrence of a natural phenomenon of a given magnitude.	UNDRO (1982)
Vulnerability is the degree to which different classes of society are differentially at risk.	Susman et al. (1984)
Vulnerability is the "capacity to suffer harm and react adversely".	Kates (1985)
Vulnerability is the threat or interaction between risk and preparedness. It is the degree to which hazardous materials threaten a particular population (risk) and the capacity of the community to reduce the risk or adverse consequences of hazardous materials release.	Pijawka and Radwan (1985)
Vulnerability is operationally defined as the inability to take effective measures to insure against losses. When applied to individuals, vulnerability is a consequence of the impossibility of improbability of effective mitigation and is a function of our ability to detect the hazard.	Bogard (1989)
Vulnerability is the potential for loss.	Mitchel (1989)
Distinguishes between vulnerability as a biophysical condition and vulnerability as defined by political, social and economic conditions of society.	Liverman (1990)
Vulnerability has three connotations: it refers to a consequence (e.g., famine) rather than a cause (e.g. drought); it implies an adverse consequence (e.g. maize yields are sensitive to drought; households are vulnerable to hunger); and it is a relative term that differentiates among socioeconomic groups or regions, rather than an absolute measure of deprivation.	Downing (1991)
Vulnerability is the differential capacity of groups and individuals to deal with hazards, based on their positions within physical and social worlds.	Dow (1992)
Risk from a specific hazard varies through time and according to changes in either (or both) physical exposure or human vulnerability (the breadth of social and economic tolerance available at the same site).	Smith (1992)
Human vulnerability is a function of the costs and benefits of inhabiting areas at risk from natural disaster.	Alexander (1993)

Vulnerability is the likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazards of place (risk and mitigation) with the social profile of communities.	Cutter (1993)
Vulnerability is defined in terms of exposure, capacity and potentiality. Accordingly, the prescriptive and normative response to vulnerability is to reduce exposure, enhance coping capacity, strengthen recovery potential and bolster damage control (i.e, minimize destructive consequences) via private and public means.	Watts and Bohle (1993)
By vulnerability we mean the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard. It involves a combination of factors that determine the degree to which someone's life and livelihood are put at risk by a discrete and identifiable event in nature or in society.	Blaikie et al. (1994)
Vulnerability is best defined as an aggregate measure of human welfare that integrates environmental, social, economic and political exposure to a range of potential harmful perturbations. Vulnerability is a multilayered and multidimensional social space defined by the determinate, political economic and institutional capabilities of people in specific places at specific times.	Bohle et al. (1994)
Vulnerability is the differential susceptibility of circumstances contributing to vulnerability. Biophysical, demographic, economic, social and technological factors such as population ages, economic dependency, racism and age of infrastructure are some factors which have been examined in association with natural hazards.	Dow and Downing (1995)
Vulnerability can be thought of as the other face of safety or security. Increased vulnerability means decreased safety. Vulnerability is a product of the circumstances that put people and property on a collision course with given dangers, or that make them less able to withstand or cope with disasters.	Hewitt (1997)
Vulnerability is the potential for losses or other adverse impacts. It is associated to the notions of 'positive, deprived, willful, pristine, primary and secondary' vulnerability.	Alexander (2000)
Vulnerability denotes exposure to risk and an inability to avoid or absorb potential harm. It is divided into physical vulnerability, social vulnerability, and human vulnerability.	Pelling (2003)
Vulnerability represents the physical, economic, political, or social susceptibility or predisposition of a community to damage in the case a destabilizing phenomenon of natural or anthropogenic origin.	Cordona (2004)
Conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards	United Nations/International Strategy for Disaster Reduction (UN/ISDR) – (2004)
Nearly all concepts of vulnerability view it as an "internal side of risk", closely linked with the discussion of vulnerability as an intrinsic characteristic of a system or element at risk.	Birkamann (2006)