Scholar and Practitioner Views on Science in Environmental Assessment

by

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ABSTRACT

I investigated the views of environmental assessment (EA) scholars and practitioners about science in EA. Fifty-six online survey responses were received, including 35 scholars and 21 practitioners; thirteen practitioners were interviewed. The study indicates that EA scholars were more dissatisfied with the quality of science in EA than the practitioners and their perceptions were found to be related to their understanding of science and underlying expectations of scientific practices in EA. The study confirms a gap between science inside EA and science outside EA. Barriers to addressing this gap include EA stakeholders' different understandings of and expectations for the quality of science, the role of scholars in EA, and the purpose and objectives of EA. These disagreements imply insufficient and/or ineffective communications among EA stakeholders, which should be addressed if a more collaborative arrangement is to be developed for improvements in the quality of science in EA.

LIST OF ABBREVIATIONS USED

Cumulative effects assessment (CEA)

Environmental assessment (EA)

Environmental impact assessment (EIA)

Environmental impact statement (EIS)

Health impact assessment (HIA)

Human health impact assessment (HHIA)

Impact assessment (IA)

International Association for Impact Assessment (IAIA)

National Environmental Policy Act (NEPA)

Non-governmental organizations (NGOs)

Peter N. Duinker (PND)

Social impact assessment (SIA)

Strategic environmental assessment (SEA)

Sustainability assessment (SA)

United Kingdom (UK)

United States of America (USA)

Valued ecosystem components (VECs)

World Commission for Environment and Development (WCED)

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CHAPTER 1. INTRODUCTION

1.1 PROBLEM STATEMENT AND CONTEXT

Environmental assessment (EA) is a widely acknowledged formal political decision-making and environmental planning tool in many countries (Sadler, 1996; Noble, 2015). It can be traced back to the 1970s and was developed in the United States of America (USA) as a formal response by the government to increasing public concerns about the environmental impacts caused by human developments (Sadler, 1996). As a result, *the National Environmental Policy Act* (NEPA) was enacted in the USA in 1970 (Garner & O'Riordan, 1982). EA was then quickly and widely adopted in many other developed countries around the world (e.g., Canada in 1973, Australia in 1974, West Germany in 1975, and France in 1976) (Sadler, 1996; Glasson, Therivel, & Chadwick, 2005). In the later 1970s and early 1980s, developing countries (e.g., Brazil, the Philippines, China, and Indonesia), also followed the USA in introducing EA in their legislative frameworks (Sadler, 1996). By 2005, at least 120 countries had EA systems, including regulations, partial regulations, guidelines, and draft regulations (Glasson et al., 2005).

There is no single, universally accepted definition of EA. Initially, the focus of EA was to identify, predict, evaluate, and mitigate biophysical impacts of proposed developments or actions and the results of the evaluation were expected to inform decision-makers of those impacts prior to major decisions being made (Sadler, 1996; Cashmore, 2004; Glasson et al., 2005). Due to an expanding definition of EA and the environment, from the natural environment to both natural and human environments, social and economic impacts of proposed developments have accordingly been added to the EA agenda (Beanlands & Duinker, 1983; Ortolano & Shepherd, 1995).

The role of EA was further expanded in the 1980s when the concept of sustainable development was widely accepted around the world due to the book *Our Common Future*, that was published by the World Commission for Environment and Development (WCED) in 1987 (Munn, 1989; Munn, 1991). As an expected early-warning planning tool for natural resource management and environmental protection purposes, EA has been considered as a mechanism to achieve sustainable development; therefore, EA is also a sustainability assurance tool (Sadler, 1996). Subsequently, EA has become even more important since its potential to facilitate sustainable development has been identified (Munn, 1991; Lawrence, 1997; Glasson et al., 2005).

EA was developed over 40 years ago, and the earliest EA-related best practice guidelines and environmental impact assessment (EIA) handbooks were published in the 1970s (e.g., Cheremisinoff & Morresi, 1977). Stronger scientific principles for EA practices have been established since the 1970s as a result of more attention (e.g. Holling, 1978). Due to a weak scientific basis for EA early on, two North American projects were funded by government agencies to investigate the possible solutions for the weakness of scientific basis for EA practices – one was American (Caldwell, Bartlett, Parker, & Keys, 1982), and the other was Canadian (Beanlands & Duinker, 1983). In addition, the trend in scientific literature on EA-related specific themes, for example, impact prediction, monitoring and follow-up, determination of impact significance, cumulative effects assessment, and public participation, has also been growing towards better scientific foundations during the past decades (e.g., Duinker, 1985; Duinker & Baskerville, 1986; Thompson, 1990; Arts, Caldwell, & Morrison-Saunders, 2001; Fitzpatrick & Sinclair, 2009; Gunn, 2011; Briggs & Hudson, 2013). In addition, there is a significant amount of guidance material for preparing EA documents (e.g., Practising Law Institute, 1973; Lee, 1974; Alcances, Supetran, & Anderson, 1983; Kreske, 1996; Eccleston, 2013; Canadian Nuclear Safety Commission, 2016). All these scientific documents and guidance materials are considered to be a scientifically sound, defensible foundation for EA practices. However, Mackinnon, Duinker, and Walker (2018) conducted a thorough literature review on scientific developments associated with EA since the 1970s and identified a large gap between science inside EA and science outside EA, which means that scientific quality in EA still requires improvement.

In addition, EA stakeholders seem to have different perceptions on the quality of EA performance (Duinker, 2013). On the one hand, the quality of EA practices is virtually always dissatisfying to EA reviewers (e.g., Canelas, Almansa, Merchan, & Cifuentes, 2005). The environmental impact statement (EIS) is a key product of EA systems and it has been commonly used to reflect the quality of EA practices performed by EA practitioners (i.e., proponents and consultants hired by proponents). The results of reviewing EISs indicate that there were big gaps between what should be done as described or guided in the literature and what had been done as stated in the EISs, e.g., in European (Glasson, Therivel, Weston, Wilson, & Frost, 1997; Thompson, Treweek, & Thurling, 1997; Barker & Wood, 1999; Gray & Edwards-Jones, 2003; Canelas et al., 2005), in Canada (Duinker, 2013), in the USA (Tzoumis, 2007), and in Bangladesh (Kabir & Momtaz, 2012).

On the other hand, an Australian survey found that EA practitioners were generally satisfied with the quality of scientific work done in EA (Morrison-Saunders & Bailey, 2003); similar findings were found in a Finnish survey (Jalava, Pasanen, Saalasti,

& Kuitunen, 2010). Even though these EA practitioners indicated that they were dissatisfied with the importance of science placed at different stages of the EA system, when they were asked to self-evaluate their performance, their satisfaction levels were generally very high (Morrison-Saunders & Bailey, 2003). In the Finnish survey, competent authorities, responsible to control the quality of EIS, were also targeted as survey respondents (Jalava et al., 2010). The role of consultants is to prepare EIS documents and help proponents to get their proposed developments approved, and the role of competent authorities is to review consultants' work for quality control purposes. Not surprisingly, even though both competent authorities and consultants considered the quality of EISs good, consultants presented a higher satisfaction level than competent authorities due to their roles in the EA process (Jalava et al., 2010).

Therefore, it is essential to understand the perception of different EA stakeholders on the quality of science embedded in EA practices. Effective EA decision-making needs scientific support (Morrison-Saunders & Sadler, 2010); effective scientific support needs a collaboratively harmonious relationship between EA scholars and practitioners and also a consensus on what are strong scientific approaches in EA practices (Greig & Duinker, 2011). There is considerable literature reporting theoretical and empirical studies regarding the role of science and the quality of scientific practices in EA. However, there have been a limited number of studies investigating the perceptions of EA practitioners on the scientific practices in EA (e.g., Caldwell et al., 1982; Sadler, 1996; Morrison-Saunders & Bailey, 2003; Jalava et al., 2010), and no studies were identified to investigate the perceptions of both EA practitioners and scholars and compare the differences (if any) between them.

1.2 RESEARCH OBJECTIVE AND QUESTIONS

This study aimed to gather data related to EA scholars' and practitioners' perspectives on the degree to which science in EA needs improvement, and the factors that have the potential for improving the state of scientific work within EA. This study provided a preliminary foundation for future comprehensive analysis of the quality of science in the context of EA. My research questions were focused on:

1. What are the levels of satisfaction of EA scholars and practitioners (i.e., government scientists, consultants, EA administrators, and non-governmental organizations (NGOs)) with the quality of science embedded in various aspects of an EA process?
2. What is the perceived status of science in the EA process by scholars and practitioners?
3. What factors have influenced the quality of scientific practices in EA?

1.3 SCOPE

This study investigated the perceptions of EA scholars and practitioners on the quality of science embedded in various stages of the EA process and also explored factors contributing to their perceptions. To understand better how EA scholars and practitioners feel about the quality of science in EA, their perceptions of the status of science in EA and the power of various EA stakeholders in an EA process were also covered in this study. How EA scholars and practitioners felt about the scientific support from the EA scientific community was also explored and compared because a mutual understanding of the expectations from the two groups is the foundation of creating a collaborative relationship between EA practitioners and scholars. Also, factors that were considered important by research participants in influencing the quality of science in EA were also discussed.

1.4 OUTLINE OF THE THESIS

Following the introduction in Chapter 1, the literature review in Chapter 2 includes the nature, purposes, effectiveness of EA, the three dimensions of EA (i.e., administrative/legislative, participatory, and scientific/technical), and the potential collaborative relationship between research scientists and EA practitioners. Chapter 3 includes the survey and interview methods used for data collection and also NVivo (QSR International Pty Ltd., 2018) and Minitab (Minitab Inc., 2018) used for data analysis. In Chapter 4 a journal paper is presented, including the main body of the results and discussion regarding EA scholar and practitioner views on science in EA. Chapter 5 includes an overall conclusion which synthesizes the entire thesis research. Finally, references and appendices including online survey questions, interview questions, and consent forms for both surveys and interviews are attached to form the entire thesis.

CHAPTER 2. LITERATURE REVIEW

The literature review starts with an overview of the nature and purposes of EA perceived by different EA stakeholders, and then an evaluation of EA effectiveness is discussed in four dimensions (i.e., procedural, substantive, transactive, and normative). The conceptualization of environmental and resource decision-making in three dimensions (i.e., administrative/legislative, participatory, and scientific/technical) and a discussion on the role of science and the relationship between research scientists and EA practitioners are presented and summarized.

2.1 NATURE AND PURPOSES OF EA

EA has political roots since it was invented initially as a political response to increasing public concerns towards the deteriorating natural environment and depleting natural resources in the late 1960s (Ortolano & Shepherd, 1995). During the early 1970s, EA was criticized as a political decision-making tool used by proponents and politicians to justify project decisions that had been made when the EA process was initiated (Noble, 2015). From the mid-1970s to the early 1980s, based on a great effort to collect baseline data about the environment, comprehensive and detailed descriptions of the biophysical environment in local project areas led to weighty EA documents and the resulting prolixity issue was also created (Noble, 2015). The project scoping process was first introduced in the USA as a solution for this prolixity issue by prioritizing problems identified from the EA process and then reducing the required volumes of baseline data (Noble, 2015).

EA is conceptualized as an environmental planning tool from a technocratic perspective, with the potential for objectively identifying, predicting, and evaluating the possible impacts of a proposed development and its alternatives (Ortolano & Shepherd, 1995). The rationalist theory in decision-making and planning emerged in the 1960s, which requires a technical rational model of evaluation for better decisions (Owens, Rayner, & Bina, 2004). In the rational model, the technocratic paradigm is the underlying theory, and natural scientists and experts play a dominant role in the decision-making process (Ortolano & Shepherd, 1995). However, the rationality theory embedded in many underlying approaches to EA has been criticized with respect to its impractical nature and the gaps between ecological rationality and political decision-making processes (Cashmore, Gwilliam, Morgan, Cobb, & Bond, 2004; Noble, 2015).

The political root of EA leads to the failure of EA decisions to meet requirements of rationalist models (Lee, Haworth, & Brunk, 1995; Ortolano & Shepherd, 1995). Political decisions include complicated trade-offs among various factors (e.g., economic benefits at the expense of environmental costs, and vested interests among different relevant parties and stakeholders); therefore, a rational EA decision would not be practically made in the political arena (Cashmore et al., 2004).

There is disagreement in the perspectives of the purposes of EA among the major EA stakeholders which result from the diversity of interests and objectives expressed by different participating groups (Fuller, 1999). Beanlands and Duinker (1983) used four major EA stakeholders in the Canadian context as an illustration of the vested conflicts of interests and objectives of different participating groups in the EA process. Government administrators considered EA as an administrative mechanism to guarantee the fulfilment of procedural requirements listed in EA regulation and legislation. Therefore, from the administrators' perspective, they tended to rank the adherence to EA guidelines and relevant policies, regulations, and legislation as the priority. Based on this intention, the resulting terms of references would be a checklist embracing the requirements of EA guidelines and regulations (Beanlands & Duinker, 1983). Proponents constituted the second participating stakeholder group in the example provided by Beanlands and Duinker (1983). Their intention in the EA process was very straightforward – to get the proposed development approved and licensed with the least financial and temporal resource budget and investments. They generally tended to rank the things that must be done for project approval as the priority during the EA process; therefore, they generally lacked an incentive to think about anything beyond that required scope for a better quality of EA (Beanlands & Duinker, 1983).

Consultants were the third participating group in the discussion of Beanlands and Duinker (1983). Consultants were employed by industrial proponents to conduct EA; therefore, their responsibilities in the EA process were to translate vague EA guidelines and terms of reference into a number of applicable research studies and then to prepare EA documents for project approval. Generally, consultants faced a dilemma in terms of the implementation of good scientific practices in the EA process. On the one hand, consultants liked to implement good scientific practices; however, on the other hand, they would also have to consider time and financial resource constraints imposed by their employer, the proponents, because good scientific practices often required more temporal and financial investments. Therefore, consultants would have to strike a compromise between the satisfaction of their employers in terms of temporal and financial budgets and technical standards that are generally accepted in their peer reviews (Beanlands & Duinker, 1983).

Beanlands and Duinker (1983) listed research scientists in governments and universities as the fourth participating stakeholder group in influencing the quality of science in EA practices during the EA process. Scientists were generally called upon in two conditions – the first was to help prepare assessment guidelines and the second was to help evaluate EA work conducted by consultants at the review phase. The EA guidelines were rarely written in a contractual format, but usually generalized and vaguely worded; therefore, the participation of scientists in the preparation of EA guideline documents did not really help ensure the quality of EA work as it was expected (Beanlands & Duinker, 1983). In most EA cases, scientists were brought into the EA process under the second condition and they conducted a peer review of the EA work based on their high standards of scientific practices which were not clearly specified in the early terms of reference and EA guidelines (Beanlands & Duinker, 1983).

Fuller (1999) echoed the specification of Beanlands and Duinker (1983) in terms of the conflicts of interests among various EA stakeholders, and admitted that the expectations of different EA stakeholders are not complementary and sometimes conflictive to some degree. There was an ultimate conflict embedded in the underlying purposes of EA from different stakeholders. The different objectives of stakeholders led to different perceived purposes of EA, and also the different expectations of the quality of EA and scientific practices implemented in the EA process. Finally, these different expectations were reflected in the different qualities of EIS documents, the product of the EA process (Fuller, 1999).

2.2 EFFECTIVENESS OF EA

An evaluation of and improvement in the quality and effectiveness of EA are important for delivering better EA outcomes (Loomis & Dziedzic, 2018). The rationale for EA is to properly predict possible impacts of proposed developments and then to inform decision-makers of those possible consequences before major decisions are made, thereby achieving sustainable development goals (Sadler, 1996; Loomis & Dziedzic, 2018). Since the 1970s, there have been abundant available EA theories and scientific guidance materials in the literature (e.g., Caldwell et al., 1982; Beanlands & Duinker, 1983). However, the quality of, and the effectiveness of EA are still contentious and unsatisfactory, and consequently improvements in various aspects are needed (e.g., Sadler, 1996; Cashmore et al., 2004; Ross et al., 2006; Shakil & Ananya, 2015; Hansen & Wood, 2016; Bond, Fischer, & Fothergill, 2017).

There are multiple ways of defining the evaluation criteria of the categories of EA effectiveness. Ortolano (1993) presented an early example of EA evaluation, and defined EA effectiveness in five dimensions: 1) procedural compliance: whether the EA process conforms to established regulations and rules; 2) completeness of EA documents: whether significant impacts are described in detail; 3) methods to assess impacts: whether methods for predicting and evaluating possible impacts of proposed developments are appropriate; 4) influence on project decisions: whether the conduct of EA influences decisions; and 5) weight given to environmental factors: whether environmental factors have been given appropriate weights. Sadler (1996) simplified the dimensions of EA effectiveness into three categories: 1) substantive: whether EA achieves its objectives and expectations; 2) procedural: whether the EA process complies with established procedures and principles; and 3) transactive: whether the EA process is efficient temporally and financially. Baker and McLelland (2003) added a fourth dimension, normative efficacy, on the basis of Sadler's effectiveness model. Normative effectiveness is defined as whether policy achieves its purposes or normative goals (Baker & McLelland, 2003). These four dimensions of effectiveness have been widely used in the evaluation of EA effectiveness

(Loomis & Dziedzic, 2018). Chanchitpricha and Bond (2013) brought these four categories of effectiveness together to devise a literature-based framework of evaluation criteria that is applicable to many impact assessment (IA) processes, such as EA, strategic environmental assessment (SEA), social impact assessment (SIA), and health impact assessment (HIA).

National case studies are the most discussed in the literature of EA effectiveness, including: Vietnam (Clausen, Vu, & Pedrono, 2011), Brazil (Fonseca, Sánchez, & Robeiro, 2017), Syria (Haydar & Pediaditi, 2010), Estonia (Heinma & Põder, 2010), the United Kingdom (Jha-Thakur & Fischer, 2016), Bangladesh (Shakil & Ananya, 2015), and Lithuania (Kruopienė, Židonienė, & Dvarionienė, 2009). Compared to a considerable number of national EA effectiveness evaluation studies, there were fewer analyses on regional EA systems, although they play a key role in implementing the majority of EA activities (Loomis & Dziedzic, 2018). The analysis of EA effectiveness in the procedural dimension has played a dominant role in all kinds of EA effectiveness evaluation case studies and analysis of the transactive dimension has received the least attention (Loomis & Dziedzic, 2018). Some shortcomings of the EA substantive effectiveness that were generalized from a national or regional case study can also be found in other studies. These include: poor performance of monitoring and follow-up, subjectivity in impact prediction, insufficient consideration of development alternatives, incompetence of EA practitioners, ineffective and insufficient public participation, limited scope of EA regulations, and inappropriate assessment of cumulative effects (Lawrence, 1997; Kruopienė et al., 2009; Toro, Requena, & Zamorano, 2010; Clausen et al., 2011; Jha-Thakur & Fischer, 2016; Almeida & Montaño, 2017). The ineffectiveness of these substantive aspects has contributed, to some degree, to the limitation of the influence of EA on decisions (Almeida & Montaño, 2017).

The effectiveness of EA depends on the implementation of several control mechanisms, such as procedural, judicial, evaluative, public and government agency, professional, and development-aid agency (Bond et al., 2017). In the countries or states with a developed EA system, procedural and judicial controls lead to procedural effectiveness, such as in São Paulo and Minas Gerais states, Brazil (Almeida & Montaño, 2017), and in the United Kingdom (UK) (Bond et al., 2017). The UK Institute of Environmental Management and Assessments' EIA Quality Mark was used as an example of evaluative and professional control mechanisms to complement the use of existing procedural and judicial control mechanisms in the UK. The results indicate that the combination of these control mechanisms leads to more effective EA outcomes, especially in terms of completeness of EA documents, development of knowledge and learning among stakeholders, and the involvement and coverage of different stakeholders beyond legal compliance (Bond et al., 2017).

Normative effectiveness is usually evaluated on the basis of the contribution of EA to wider policy goals, such as sustainable development (Baker & McLelland, 2003; Loomis & Dziedzic, 2018). The widespread EA frameworks and procedures have dramatically increased environmental awareness and considerations in political decision-making when compared with previous decades of development (Caldwell, 1993). EA has also contributed to improvement of the possibilities for high-quality environmental decisions in Finland (Pölönen, Hokkanen, & Jalava, 2011; Karjalainen, Marttunen, Sarkki, & Rytkönen, 2013). However, it is still far away from achieving sustainable development objectives. Bruhn-Tysk and Eklund (2002) criticize the contribution of EA to sustainability and demonstrate that EA plays a limited role in facilitating two pre-defined sustainability objectives in Sweden, that is, intra- and inter-generational equity. One explanation for the limited role of EA in promoting sustainability is that some sustainable outcomes attributed to EA are the by-products of EA procedures, such as the development of learning and attitudinal and value changes (Cashmore, Bond, & Cobb, 2007). These transformative potentialities of EA have been overlooked in the conventional EA theory (i.e., the rationalist theory) (Cashmore, Bond, & Cobb, 2008).

All the potential improvements in various dimensions of EA identified in the literature indicate that there is a need for a solution to improve EA performance, and this solution should not be considered based on only a single dimension of EA. For example, Sandham, van Heerden, Jones, Retief, and Morrison-Saunders (2013) indicate that there is no positive relationship between legislative reform and the quality of EISs; therefore, just improving legislation cannot be considered as a complete solution for improving EA performance.

2.3 ADMINISTRATIVE, POLITIC, AND SCIENTIFIC LENS OF EA

Sinclair, Doelle, and Duinker (2017) conceptualize the framework of cumulative effects assessment (CEA) in three dimensions: 1) administrative or regulatory; 2) participatory; and 3) scientific or technical. They indicate that this CEA mindset is applicable for all environmental and resource decision-making. The administrative or regulatory dimension is dominated by administrators and government responsibilities, and the established legislative EA framework for approving and licensing proposed developments. The political/public participatory dimension is dominated by civic sciences including the focuses on stakeholder involvement, relations, and power for mediating potential stakeholder conflicts and improving the relationship and communication among various stakeholders. The scientific dimension is dominated by mainstream scientific knowledge, and traditional and local ecological knowledge, covering scientific protocols for devising and testing impact prediction models (Sinclair et al., 2017).

Participatory and scientific dimensions are similar to the perspective of Cashmore (2004) in that the conceptualization of science in the EA process is through two lens – applied natural science and civic science. As for the former, EA is considered in the applied science paradigm as a process in which scientific knowledge and expertise are applied to EA practices, and by this way, a rational and objective impact evaluation process can be conducted (Cashmore, 2004). The methods of natural sciences play a dominant role in the applied science models (e.g., analytical science model) (Cashmore, 2004). As for the latter, stakeholder involvement and value judgments play a dominant role, and EA is considered as a tool for deliberative democracy regarding proposed developments (Cashmore, 2004). The civic science models include the environmental governance model, the participation model, and the information provision model, which all have assigned a more extensive role for social sciences than that for natural sciences (Cashmore, 2004).

According to Sinclair et al. (2017), the satisfactory implementation of all three dimensions of EA is needed to reach the ultimate purpose of EA, namely sustainable development. If only scientific and public participatory dimensions are well implemented, this means that government regulators and administrators are excluded from the EA process; therefore, the strong results from scientific analyses and participatory processes will not have any administrative power and influence to get development approval. If the scientific dimension is ignored, and only legislative and public participatory dimensions are well implemented, the resulting development decision may result in excessive undesirable environmental impacts and consequently lead to failure in fulfilling the established substantive EA objectives, as exemplified in the study of Dirschl, Novakowski, and Sadar (1993). Even though there is a combination of well-implemented scientific methodologies and a strong regulatory context, the neglect of the public participatory dimension may lead to the objections of the public to the proposed development due to the lack of civic engagement. EA is a legislative response to public concerns; therefore, these concerns must be fairly addressed by allowing sufficient public participation in the EA process (Dirschl et al., 1993).

2.4 SCIENCE IN EA

There should be no argument regarding the importance of science in achieving the effectiveness of EA (Morrison-Saunders & Sadler, 2010). Increased degrees of scientific rigour applied in the EA process would dramatically enhance the possibility of more accurate impact predictions regarding the developments, and consequently reduce the uncertainties embedded in the final decision (Robinson, 1989; Greig & Duinker, 2011). Therefore, support from EA scholars could help the EA process to achieve its established objectives, and the substantive criteria of the EA effectiveness would accordingly be met.

In the early development of EA, the most common participation of research scientists in the EA process is at the review phase in cases of controversy and conflicts (Beanlands & Duinker, 1983); that condition also continues today (P. Duinker, personal communication, March 29, 2018). In a public hearing, research scientists would be requested to conduct a peer review of EA documents regarding a proposed development based on their expertise. Consequently, due to their criticism, research scientists are often considered as development interveners, and an adversarial relationship between research scientists and development proponents would be created (Beanlands & Duinker, 1983).

However, there is another way of constructing a collaboratively interactive relationship between research scientists and development proponents if the EA process or framework encourages scientists to participate in the project design and the conduct of scientific studies at the early stage of EA. Greig and Duinker (2011) demonstrate a potential benign cycle between research scientists and proponents for improving the implementation of science in the EA process. Science is divided into two groups: science outside EA and science inside EA. Research scientists operating outside EA are responsible for creating robust and reliable ecological effects knowledge that is defined as science outside EA (e.g., Lester et al., 2010). EA practitioners operating inside EA, such as consultants working for proponents, are responsible for applying impact predictive models and then providing feedback regarding the predictive models for use outside EA processes for model refinements. The application of ecological knowledge in the EA process is defined as science inside EA (e.g., Beanlands & Duinker, 1983; Dipper, 1998; Arts et al., 2001). In addition, improved relationships between various key stakeholders involved in the EA process is also helpful for facilitating the achievement of EA effectiveness because it will create more opportunities for communication, and consequently result in an increased understanding and consensus of EA issues among stakeholders (Morrison-Saunders & Bailey, 2009). Therefore, there is a need to transform the adversarial relationship between scientists and EA practitioners into a more collaborative one. Moreover, Mackinnon et al. (2018) demonstrated a large gap between science inside EA and science outside EA by a thorough literature review on scientific developments associated with EA since the 1970s, which also needs to be addressed by a more collaborative arrangement among EA stakeholders.

The importance of a collaborative relationship between scientists and other stakeholders (e.g., policy-makers, citizens, and project proponents) has been identified in terms of generating a well-informed resource management decision and achieving a sustainable goal of natural resource management (Rogers, 2006; Roux, Rogers, Biggs, Ashton, & Sergeant, 2006; Gibbons et al., 2008; Ryder, Tomlinson, Gawne, & Likens, 2010). Barriers to achieving such a relationship have also been discussed in the literature, such as cultural differences, education background differences, lack of incentives for collaboration, and lack of opportunities for communication (Briggs, 2006; Roux et al., 2006; Ryder et al., 2010). These barriers lead to fundamentally conflicting values, beliefs, and understandings of science, and consequently generate difficulties for these stakeholders to mutually understand each other (Briggs, 2006; Ryder et al., 2010).

The terms ‘best available science’ or ‘best available scientific knowledge’, used interchangeably, have been introduced in many environmental and resource management decision-making processes. This is done to promote engagement of scientists in the policy arena and also to promote the communication, understanding, and transparency between scientists and other stakeholders in the policy and management arena (Sullivan et al., 2006; Ryder et al., 2010; Hanekamp & Bergkamp, 2016). Scientific contributions from scientists are expected to be standardized in political decision-making based on the use of ‘best available science’ (Glicksman, 2008). However, there is no explicit definition for ‘best available science’, and also no explicit explanation about how it can be applied in an environmental decision-making process (Bisbal, 2002; Sullivan et al., 2006; Green & Garmestani, 2012; Hanekamp & Bergkamp, 2016). This ambiguity in the definition of ‘best available science’ leads to the failure in fulfilling the role of best available science expected in the environmental decision-making policy arena (Bisbal, 2002; Green & Garmestani, 2012). In addition, there are some external factors, such as lack of human and financial resources, and adversarial relationships between stakeholders with conflicting values, that may exacerbate the difficulty of appropriately applying ‘best available science’ in environmental decision-making (Mills, Francis, Shandas, Whittaker, & Graybill, 2009; Murphy & Weiland, 2016).

In summary, science plays an important role in ensuring the quality and effectiveness of EA. However, the use of science is undermined in the environmental decision-making policy arena due to both internal and external factors, such as ambiguous definition of ‘best available science’ and adversarial political tensions among different EA stakeholders with conflicting values and interests. A collaborative relationship between scientists and other stakeholders is important to ensuring the scientific contributions to decision-making (Rogers, 2006; Roux et al., 2006; Gibbons et al., 2008; Ryder et al., 2010). There are still many barriers that need to be overcome for such a collaboration (Briggs, 2006; Roux et al., 2006; Ryder et al., 2010).

CHAPTER 3. METHODS

This section describes the study design including data collection procedures and methods used for data analysis. Both online surveys and interviews were used for collecting data. Microsoft Excel (MS Excel) (Microsoft, 2018), Minitab (Minitab Inc., 2018), and NVivo (QSR International Pty Ltd., 2018) were used for quantitative and qualitative data analyses, respectively.

3.1 DATA COLLECTION

3.1 1 Online Surveys

Online surveys were initially used to investigate the key EA stakeholders' perspectives on science in the context of EA due to the advantages of convenience and cost-savings. In addition, online surveys are also a frequently used instrument in other similar EA inquiries (e.g., Sadler, 1996; Morrison-Saunders & Bailey, 2003; Morrison-Saunders & Sadler, 2010). Opinio (ObjectPlanet, 2018), an online survey software, was selected for this study based on the considerations of cost and data security. Survey questions included eight demographic questions, such as EA-related working experience levels, EA-related teaching experience levels, self-identified roles played in EA, ages, education levels, and eight questions regarding the perceptions of survey respondents on: 1) the quality of science at the stages of the EA process; 2) factors influencing the quality of science in EA; 3) the power of various EA stakeholders; 4) the contributions of scientific support from the scholars' community to the EA process; and 5) the status of science in EA practices (Appendix A). The five-point Likert scale was used to investigate the respondents' satisfaction with the quality of science at the stages of the EA process (i.e., 'very dissatisfied', 'dissatisfied', 'neither satisfied nor dissatisfied', 'satisfied', and ‘very satisfied’). A three-point scale was used to investigate the respondents’ perception of the importance of factors influencing the quality of science in EA, and the power of various EA stakeholders in the EA process (i.e., ‘low importance/power/influence’, ‘medium importance/power/influence’, and ‘high importance/power/influence’). ‘I do not know’ was also provided as an additional option in the survey questions. The survey questions helped to contribute to the formulation of generalizations about the trends and themes regarding the perceived quality of science in the EA process among the key stakeholders in the EA community. Original survey questions are attached in Appendix A. A consent form for ethical considerations (see Appendix B) was also included with the online survey questions, and the survey respondents were required to read and check an acknowledgement of the consent form prior to proceeding to the survey questions. A practice survey was conducted with Peter N. Duinker and Tony R. Walker, before the survey went live. Both of them are experienced EA professionals.

Survey respondents were reached in two ways: 1) the International Association for Impact Assessment (IAIA) network; and 2) literature search in EA-related journals (i.e., Environmental Impact Assessment Review, and Impact Assessment and Project Appraisal). The reason for choosing IAIA as a way of distributing the survey is because IAIA is a well-known leading global network in the field of impact assessment. Moreover, the IAIA network was used by previous research studies to investigate EA professional perspectives on the effectiveness of EA (Sadler, 1996), and on the art and science of impact assessment (IA) (Morrison-Saunders & Sadler, 2010). The majority of IAIA network members are EA practitioners; therefore, in order to balance the ratio of EA scholars and practitioners in survey results, EA-related journal paper authors were also considered as potential target survey respondents.

Specifically, IAIA helped to distribute the survey link through its monthly e-news and the normal distribution list, which is called IAIA Connect, that connects the IAIA current/active members. At the same time, around 200 journal paper authors were selected from the EA-related journal papers that were published from 2014 to 2016 in Environmental Impact Assessment Review as potential survey respondents, and their email addresses were collected. Survey links were directly sent through the Opinio survey invitation distribution system to these identified EA journal paper authors. All surveys were anonymous, and the instrument was kept open from May 2016 to December 2016. By the end of 2016, 56 survey respondents completed the survey, including 35 EA scholars and 21 EA practitioners. Raw survey responses were downloaded from Opinio in MS Excel format and then were categorized based on their self-identified roles into two groups – 'EA scholars' and 'EA practitioners'.

3.1.2 Interviews

Due to the small sample size of online surveys, interviews were considered as a complementary instrument to enrich the results of this study. Interviews were used for collecting in-depth opinions of various EA professionals regarding the quality of science embedded in EA, and the factors contributing to the status of science in EA. Specifically, interviews included 14 questions – six demographic questions, which were similar to the demographic questions included in the online surveys, such as the inquiries about the interviewees' EA-related working experience levels, teaching experience levels, education levels, and ages, and eight questions regarding interviewee perspectives on the scientific practices in EA. Interview questions are attached in Appendix C. Thirty-six Canadian EA professionals were purposively selected for interviews based on the personal knowledge and recommendation of my supervisor, Peter N. Duinker, and my committee member, Tony R. Walker. Thirteen out of 36 EA professionals agreed to be interviewed. Practice interviews were conducted with my supervisor, Peter N. Duinker, and my committee member, Tony R. Walker (both experienced EA professionals) before interviews were conducted. One interviewee acted as both a scholar and a practitioner, and the others were purely practitioners. None of the potential interviewees acting purely as EA scholars agreed to be interviewed. A recruitment letter (see Appendix D) was sent via an invitation email to all selected participants, including a consent form for interviews (see Appendix E) and a copy of the interview questions (see Appendix C) as email attachments. All appendices are available at Dalspace. Due to the broad locations of purposively selected EA professionals in Canada, the interviews were conducted individually through either in-person or over-the-phone appointments in a location at interviewees' convenience. All interviews took between 40 and 120 min, depending on the interviewees' responses. The interviews were audio-recorded and then transcribed verbatim by myself. My supervisor, Peter N. Duinker, verified the accuracy of the transcripts based on the audio-records of the interviews.

3.2 DATA ANALYSIS

Both quantitative and qualitative data were generated from the online surveys and interviews. This sub-section describes how these data were categorized and analyzed separately.

3.2.1 Quantitative Data from Online Surveys

Survey respondents were categorized into two groups – EA scholars and EA practitioners. EA scholars include only research scientists, and EA practitioners include consultants, government scientists, government regulators, and NGOs. The survey quantitative data were from the Likert scale, which are ordinal, and the sample size was small (i.e., 35 EA scholars and 21 practitioners); therefore, the Mann-Whitney U test, a non-parametric statistical analysis method, was used to calculate the statistical significance values and to compare the difference between the satisfaction levels of EA scholars and practitioners with the quality of science at the stages of the EA process (De Winter & Dodou, 2010). The statistical p-value significance thresholds selected for this study was 0.1 and 0.05. Minitab was used as the statistical analysis software in this study. MS Excel was used to categorize survey data, and to create tables and figures to represent survey respondents' demographic information and also to compare the attitudes of EA scholars and practitioners to the quality of science in EA and the importance of the factors influencing the quality of science in EA.

As for the survey data regarding the attitudes of respondents to the quality of science in EA, 'satisfied' and 'very satisfied' were merged, and 'dissatisfied' and 'very dissatisfied' were also merged. The number of respondents who expressed 'I do not know' or did not respond to a specific survey question were subtracted from the calculation of the percentage of respondents' satisfaction levels.

3.2.2 Qualitative Data from Online Surveys and Interviews

Text data from the surveys and interview transcripts were coded, categorized, analyzed, and distilled using *a posteriori* coding scheme. NVivo (QSR International Pty Ltd., 2018) was used for the qualitative data analysis. The emerging trends identified in the survey text data and interview transcripts were used to enrich the patterns and findings identified in the quantitative survey data. Only one interviewee was identified as both a scholar and practitioner; therefore, this person was not distinguished from other practitioners, when interview data were analyzed.

Chapter 4. JOURNAL PAPER: SCHOLAR AND PRACTITIONER VIEWS ON SCIENCE IN ENVIRONMENTAL ASSESSMENT

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Key Words

Environmental assessment, Science, Scholars, Practitioners, Satisfaction

Abstract

This study investigated the views of environmental assessment (EA) scholars and practitioners on science in EA. Fifty-six online survey responses were received, including 35 scholars and 21 practitioners; thirteen practitioners were interviewed. The study indicates that EA scholars were more dissatisfied with the quality of science in EA than the practitioners and their perceptions were found to be related to their understanding of science and underlying expectations of scientific practices in EA. This study confirms a gap between science inside and outside EA. Factors contributing to the barriers to filling this gap include EA stakeholders' different understandings of and expectations for the quality of science, the role of scholars in EA, and the purpose and objectives of EA. These disagreements imply insufficient and/or ineffective communications among EA stakeholders, which should be addressed if a more collaborative arrangement is to be developed for improvements in the quality of science in EA.

4.1 INTRODUCTION

Environmental assessment (EA) is a widely acknowledged formal political decision-making and environmental planning tool in many countries (Sadler, 1996; Noble, 2015). It can be traced back to the 1970s and was developed in the United States of America (USA) as a formal political response by the government to increasing public concerns about environmental impacts caused by human developments (Ortolano &

Shepherd, 1995; Sadler, 1996). Due to its political roots, EA was criticized as a political decision-making tool used by proponents and politicians to justify project decisions that had been made when the EA process was initiated (Noble, 2015). In addition, this history has led to the failure of EA decisions to meet requirements of rationalist models (Lee, Haworth, & Brunk, 1995; Ortolano & Shepherd, 1995). Political decisions include complicated trade-offs among various factors (e.g., economic benefits at the expense of environmental costs, and vested interests among different relevant parties and stakeholders). Therefore, a rational EA decision would not be practically made in the political arena (Cashmore, Gwilliam, Morgan, Cobb, & Bond, 2004).

There was a disagreement on the perspective of purposes of EA among major EA stakeholders which arise from the diversity of interests and objectives expressed by different participating groups (Fuller, 1999). Beanlands and Duinker (1983) used four major EA stakeholders (i.e., government administrators, proponents, consultants, and research scientists) in the Canadian context as an illustration of the vested interests and objectives of different participating groups in the EA process. Fuller (1999) echoed the specification of Beanlands and Duinker (1983) in terms of the interests among various EA stakeholders, and admitted that the expectations of different EA stakeholders are not complementary and sometimes in conflict to some degree. There was an ultimate conflict embedded in the underlying purposes of EA from different stakeholders. The different objectives of stakeholders led to different perceived purposes of EA, and also the different expectations of the quality of EA and scientific practices implemented in the EA process. Finally, these different expectations were reflected in the different quality of environmental impact statement (EIS) documents, a major product of the EA process (Fuller, 1999).

EA was developed over 40 years ago, and the earliest EA-related best practice guidelines and EIS handbooks were published in the 1970s (e.g., Cheremisinoff & Morresi, 1977). Strong scientific principles for EA practices have been established since the 1970s (e.g., Holling, 1978). As a result of more attention, these principles have been further strengthened since the 1980s (e.g., Caldwell, Bartlett, Parker, & Keys, 1982; Beanlands & Duinker, 1983). However, Mackinnon, Duinker, and Walker (2018) conducted a thorough literature review on scientific developments associated with EA since the 1970s and identified a large gap between science inside EA and science outside EA, which means that scientific quality in EA still requires improvement.

The concepts of science inside EA and outside EA were introduced by Greig and Duinker (2011) when they were trying to demonstrate a potential benign cycle between research scientists and proponents for improving the implementation of science in the EA process. Greig and Duinker (2011) categorized science into two groups: science outside EA refers to reliable ecological effects knowledge that is created by research scientists outside EA (e.g., Lester et al., 2010). Science inside EA refers to the ecological knowledge that is used and applied in EA impact predictive models by EA practitioners operating inside EA (e.g., Dipper, 1998; Arts, Caldwell, & Morrison-Saunders, 2001).

In the early 1980s, Beanlands and Duinker (1983) pointed out a necessary step to transform the adversarial relationship between scientists and EA practitioners into a more collaborative one for improving the overall quality of science in EA. In later studies, the importance of a collaborative relationship between scientists and other stakeholders (e.g., policy-makers, citizens, and project proponents) has been identified in terms of generating a well-informed resource management decision and achieving a goal of sustainable natural resource management (Rogers, 2006; Roux, Rogers, Biggs, Ashton, &

Sergeant, 2006; Gibbons et al., 2008; Ryder, Tomlinson, Gawne, & Likens, 2010). Barriers to achieving such a relationship have also been discussed in the literature, such as cultural differences, education background differences, lack of incentives for collaboration, and lack of opportunities for communication (Briggs, 2006; Roux et al., 2006; Ryder et al., 2010). These barriers lead to fundamentally conflicting values, beliefs, and understandings of science, and consequently generate difficulties for these stakeholders to mutually understand each other (Briggs, 2006; Ryder et al., 2010).

Greig and Duinker (2011) emphasized that an agreement among EA stakeholders as to the need for improved quality of science in EA as a necessary condition. However, EA stakeholders seem to have different perceptions on the quality of EA performance. On the one hand, the quality of EA practices is always dissatisfying to EA reviewers. The EIS is a key product of EA systems and it has been commonly used to reflect the quality of EA practices performed by EA practitioners (e.g., proponents and consultants hired by proponents). Reviews of EISs indicate that there were discrepancies between what should be done as described or guided in the literature and what had been done as stated in the EISs in European (Glasson, Therivel, Weston, Wilson, & Frost, 1997; Thompson, Treweek, & Thurling, 1997; Barker & Wood, 1999; Gray & Edwards-Jones, 2003; Canelas, Almansa, Merchan, & Cifuentes, 2005), in Canada (Duinker, 2013), in the USA (Tzoumis, 2007), and in Bangladesh (Kabir & Momtaz, 2012). EA practitioners, such as proponents and consultants, were generally satisfied with the quality of scientific work done in EA in an Australian survey (Morrison-Saunders & Bailey, 2003) and in a Finnish survey as well (Jalava, Pasanen, Saalasti, & Kuitunen, 2010). Even though these EA practitioners indicated that they were dissatisfied with the importance of science placed at different stages in an EA system, when they were asked to self-evaluate their performance, their satisfaction levels were generally very high (Morrison-Saunders & Bailey, 2003).

It is essential to understand the perception of various EA stakeholders on the quality of science embedded in EA practices. Effective EA decision-making needs scientific support (Morrison-Saunders & Sadler, 2010); effective scientific support needs a collaboratively harmonious relationship between EA scholars and practitioners and also a consensus towards the perceived satisfaction levels with scientific work in EA practices (Greig & Duinker, 2011). There is a lot of literature about theoretical studies and empirical studies regarding the role of science and the quality of scientific practices in EA. However, there have been only a few studies investigating the perceptions of EA practitioners on the scientific practices in EA (e.g., Caldwell et al., 1982; Sadler, 1996; Morrison-Saunders & Bailey, 2003; Jalava et al., 2010); and no literature has been found that investigate the perceptions of both EA practitioners and scholars and compare the differences (if any) between them.

This study aimed to provide data about EA scholars' and practitioners' perspectives on the degree to which science in EA needs improvement, and the factors that have the potential for improving the state of scientific work within EA. The study provides a preliminary foundation for future comprehensive analysis of the quality of science in the context of EA. Our research questions focused on:

1. What are the levels of satisfaction of EA scholars (i.e., research scientists) and practitioners (i.e., government scientists, consultants, EA administrators, and non-governmental organizations (NGOs)) with the quality of science embedded in various aspects included in an EA process?

2. What is the perceived status of science in the EA process by scholars and practitioners?
3. What factors have influenced the quality of scientific practices in EA?

4.2 METHODS

4.2.1 Online Surveys

Opinio (ObjectPlanet, 2018), online survey software, was selected for this study based on the consideration of cost-saving and data security. Also, online surveys are a frequently used instrument in other similar EA inquiries (e.g., Sadler, 1996; Morrison-Saunders, Annandale, & Cappelluti, 2001; Morrison-Saunders & Bailey, 2003; Morrison-Saunders & Sadler, 2010). Survey questions included eight demographic questions investigating respondents' EA-related working experience, teaching experience, roles played in EA, ages, education, genders, countries that they have most worked in, and contributions to EA-related literature, and eight other questions regarding the perceptions of survey respondents on 1) the quality of science at the stages of the EA process; 2) factors influencing the quality of science in EA; 3) the power of various EA stakeholders; 4) the contributions of scientific support from the scholars' community to the EA process; and 5) the status of science in EA practices. The five-point Likert scale was used to investigate the respondents' satisfaction with the quality of science at the stages of the EA process (i.e., 'very dissatisfied', 'dissatisfied', 'neither satisfied nor dissatisfied', 'satisfied', and 'very satisfied'). A three-point scale was used to investigate the respondents' perception of the importance of factors influencing the quality of science in EA, and the power of various EA stakeholders in the EA process (i.e., low, medium, and high importance/power/influence). 'I do not know' was also provided as an additional option in the survey questions. These survey questions helped to contribute to the formulation of generalizations about the trends and themes regarding the perceived quality of science applied in the EA process among the key stakeholders in the EA community.

Online surveys were distributed in two ways: 1) the International Association for Impact Assessment (IAIA) network via its monthly e-news and the normal distribution list (i.e., IAIA Connect); and 2) literature search for EA-related journal paper authors (i.e., Environmental Impact Assessment Review, and Impact Assessment and Project Appraisal). IAIA is a well-known leading global network in the field of impact assessment, and the IAIA network was used by previous research studies to investigate EA professional perspectives on EA inquiries (e.g., Sadler, 1996; Morrison-Saunders et al., 2001). Because the majority of IAIA network members are EA practitioners, in order to balance the ratio of EA scholars and practitioners in survey results, around 200 journal paper authors were selected from the journal papers that were published from 2014 to 2016 in Environmental Impact Assessment Review as potential survey respondents. All surveys were anonymous, and the instrument was kept open from May 2016 to December 2016. By the end of 2016, 56 survey respondents completed the survey, including 35 EA scholars and 21 EA practitioners. Raw survey responses were downloaded from Opinio in the format of Microsoft Excel (MS Excel) (Microsoft, 2018) and then were categorized based on their self-identified roles into two groups – ‘EA scholars’ and ‘EA practitioners’.

Minitab (Minitab Inc., 2018) was used for doing the Mann-Whitney U test, a non-parametric statistical analysis method, to deal with the ordinal data generated from Likert-scale questions (De Winter & Dodou, 2010). Statistical significance values were calculated and the difference between the satisfaction levels of EA scholars and practitioners with the quality of science in EA was identified. The statistical p-value significance thresholds selected for this study was 0.1 and 0.05. As for the survey data regarding the attitudes of respondents to the quality of science in EA, ‘satisfied’ and ‘very satisfied’ were merged, and ‘dissatisfied’ and ‘very dissatisfied’ were also merged. The number of respondents who expressed ‘I do not know’ or did not respond to a specific survey question were subtracted from the calculation of the percentage of respondents’ satisfaction levels. NVivo (QSR International Pty Ltd., 2018) was used for dealing with qualitative data from open-ended survey questions and also additional comments provided by respondents to explain their answers to Likert-scale questions. These qualitative data were coded, categorized, analyzed, and distilled using *a posteriori* coding scheme.

4.2.2 Interviews

Due to the small sample size of survey responses received, interviews were considered as a complementary instrument to enrich the survey results. Interview questions included six demographic questions which were highly similar to the demographic questions included in the online surveys, and eight other questions regarding the interviewee perspectives on the scientific practices in EA. Thirty-six Canadian EA professionals were purposively selected for interviews based on the personal knowledge of all authors. Thirteen out of thirty-six EA professionals agreed to be interviewed. One interviewee acts as both a scholar and a practitioner, and the others act purely as practitioners. None of the potential interviewees acting purely as EA scholars agreed to be interviewed. Therefore, interview data were not categorized into two groups as had been done for survey results.

Due to the diverse locations of purposively selected EA professionals in Canada, the interviews were conducted individually either over the phone or in person at a location of the interviewees' convenience. All interviews took between 40 and 120 minutes, depending on the interviewees' responses. The interviews were audio-recorded and then transcribed verbatim by myself. PND verified the accuracy of the transcripts based on the audio-records of the interviews. Similarly, MS Excel (Microsoft, 2018) was used to create figures to represent interviewees' demographic information. NVivo (QSR International Pty Ltd., 2018) was used for dealing with qualitative data from interview questions. An inductive coding method was used for interview data first, and then the resulting coding nodes were compared with the coding nodes generated from survey results to identify whether interview data and survey results are complementary and consistent or conflicting.

4.3 RESULTS

4.3.1 Survey Demographic Data

Thirty-five survey respondents were identified as EA scholars. Most of them had a medium to high level of teaching experience (83%) and a medium to high level of contribution to the EA-related literature (80%). Twenty-one survey respondents were identified as EA practitioners, and they generally had a comparatively lower level of teaching experience and literature-writing experience than the scholars. The roles of the EA practitioners included consultants (71%), EA regulators (19%), NGOs (5%), and other (5%). Both pools of survey respondents had a generally high level of EA experience: 67% of scholars and 84% of practitioners had more than five years of EA experience. Most scholars had doctorate degrees or had even worked as post-doctoral fellows (73%). However, most practitioners had Master's degrees (57%) and some had doctorate degrees (29%).The countries and/or continents that the survey respondents mostly work in on EA projects are varied (Figure 1). Interestingly, 35% of EA scholars answered survey questions from a biophysical science point of view, and 65% from a social science point of view; however, 81% of EA practitioners answered from a biophysical science point of view, and only 19% from a social science point of view.

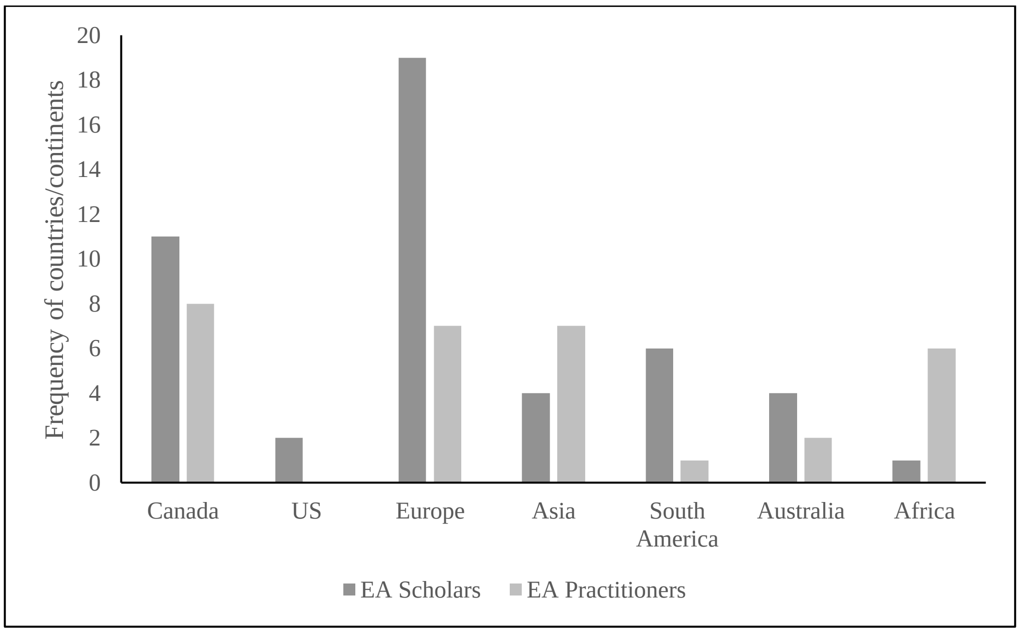

Figure 1: Countries/continents that survey respondents work in on EA projects.

4.3.2 Survey Results

Both scholars and practitioners were highly dissatisfied with cumulative effects assessment (CEA) (82% and 80%, respectively) (Table 1). Perceived satisfaction levels for other EA components were highly variable for both scholars and practitioners. For example, regarding species at risk, EA scholars generally expressed higher satisfaction than EA practitioners. However, this observation was not statistically significant (p=0.1443, alpha=0.1). Scholars were significantly more unsatisfied with the quality of science used in the identification of valued ecosystem components (VECs) compared to practitioners (p=0.0299, alpha=0.05). Scholars were slightly more unsatisfied with approaches used for impact prediction compared to practitioners (p=0.0974, alpha=0.1). No other statistically significant differences were observed in other individual EA components (Table 2), indicating there was no difference in perceived satisfaction levels with these individual EA components.

Generally, at an aggregated level, EA scholars expressed greater dissatisfaction with the quality of science used in most EA components compared to EA practitioners (Table 1), which was confirmed using a Mann-Whitney U test (p=0.0092, alpha=0.05) (Table 2). Additionally, the two pools of survey respondents had stronger differences on perceived satisfaction with the quality of science in the first six EA components in group 1 (p=0.0015, alpha=0.05) than the other six components in group 2 (p=0.7308, alpha=0.05) (Table 2). Six components in group 1 are the most common ones included in an EA process, because they can be found in almost all EA systems, and the six components in group 2 are less common than those in group 1. Specifically, EA scholars were significantly more unsatisfied with those most common six EA components than practitioners (p=0.0008, alpha=0.05) (Table 2).

Table 1: Satisfaction levels (%) expressed by EA scholars and practitioners (i.e., *satisfied*, *neither satisfied nor dissatisfied*, and *dissatisfied*) with EA components.

Topic	**Scholars (%)**				**Practitioners (%)**		
Group 1	Satisfied	Neither	Dissatisfied		Satisfied	Neither	Dissatisfied
VECs	39	35	26		62	28	10
Time and Space Bounds	39	22	39		57	10	33
Baseline Data	38	24	38		60	10	30
Impact Prediction	36	21	43		60	10	30
Impact Significance	29	24	47		55	5	40
Monitoring and Follow-up	15	20	**65**		33	19	**48**
Group 2	Satisfied	Neither	Dissatisfied		Satisfied	Neither	Dissatisfied
Species at Risk	55	16	29		35	30	35
Cumulative Effects Assessment	6	12	**82**		10	10	**80**
Sustainability Assessment	27	27	46		10	32	58
Public Participatory Processes	29	34	37		38	19	43
Social Impact Assessment	23	23	54		35	10	55
Human Health Impact Assessment	20	30	50		35	20	45

Table 2: Statistical significance in the differences between the satisfaction levels expressed by EA scholars and practitioners with EA components. The selected confidence level is 90% and 95% (alpha=*0.1* & ***0.05***).

EA components	**Statistical significance (p-value)**	**EA components**	**Statistical significance (p-value)**
Group 1	***P=0.0008***	**Group 2**	P=0.3654
VECs	***P=0.0299***	Species at Risk	P=0.8600
Time and Space Bounds	P=0.1423	Cumulative Effects Assessment	P=0.2330
Baseline Data	P=0.1188	Sustainability Assessment	P=0.7253
Impact Prediction	*P=0.0974*	Public Participatory Processes	P=0.3187
Impact Significance	P=0.1336	Social Impact Assessment	P=0.4254
Monitoring and Follow-up	P=0.1215	Human Health Impact Assessment	P=0.1945
P-value = 0.0092			

Reasons for the satisfaction with these EA components can be categorized into two groups. First, survey respondents were satisfied with what had been done, such as simple cause-effect approaches which were used to identify VECs. Second, their satisfaction was based on the current level of proponents' capacity and availability of analytical tools.

Reasons for the dissatisfaction with EA components can be summarized into 11 groups:

1) non-existent EA components;

2) inadequate implementation;

3) very weak scientific foundation;

4) a too narrow scope and focus;

5) unclearly or incorrectly defined scope;

6) ignored consideration of uncertainties;

7) big gaps between what should be done based on scientific literature and what has been done in real EA practices;

8) insufficient baseline data collection;

9) ambiguous decision-making processes;

10) political barriers; and

11) limited resource investments (e.g., time, human, and financial resources).

Appendix G presents details of these qualitative responses, which are notably diverse across the entire pool of respondents.

Fourteen factors were included in the survey to investigate the perceived importance levels ascribed by the EA scholars and practitioners; these were categorized into three groups based on survey responses (Table 3). The first group includes seven factors that were considered highly important to both scholars and practitioners, and the importance of factors in the second group were considered to be of medium importance by most EA scholars and practitioners. The third group consists of five factors that were considered more important by EA scholars than practitioners. Using a Mann-Whitney U test on single factors, EA practitioners rated the importance of time availability slightly higher than scholars ($p=0.0507$, $alpha=0.1$), and EA scholars rated the importance of the first four factors in group 3 higher than practitioners ($p=0.0725$, $p=0.0970$, $p=0.0902$, and $p=0.0833$, $alpha=0.1$, respectively) (Table 3). Responses for the first three factors in group 3 reflect different attitudes of scholars and practitioners towards the importance of scientific community participation in the EA process, and statistical analysis on the grouped responses on these three factors indicates that scholars felt their participation in EA was more important than how EA practitioners thought about it ($p=0.0071$, alpha=0.05). Scholars explained that their participation could bring more scientific considerations into project decisions; however, practitioners considered that EA is not scientific research and indicated that cooperation between scholars and practitioners can be helpful only when scholars can allow/accept different value systems to be freely discussed. Interestingly, compared with scholars, a higher proportion of practitioners expressed a dissatisfaction with the contribution of the scientific community to EA (Figure 2).

Additional factors were reported by scholars and practitioners. For example, scholars emphasized that a clear definition of science and a clear guideline directed by regulators in terms of the methods for conducting scientific analysis are also highly important in influencing the quality of science. Practitioners also listed the following factors:

1) integration of science and traditional, local cultural, and indigenous knowledge;

2) independence of EA practitioners;

3) effectiveness of communication;

4) community engagement;

5) political interference;

6) methodological guidelines;

7) opportunities for practitioners to learn the theoretical foundation of EA;

8) scientific understanding of cause-effect; and

9) accordance with dominant value systems.

Both scholars and practitioners indicated that the contribution of science is weakened by other factors such as traditional knowledge and public interest in the project decision-making process. Weak synergy between scholars and government regulators/decision-makers also results in limited scientific insights embedded in EA regulations and government guidance documents. Referring to the ways that science should be strengthened so that it can improve the effectiveness and efficiency of the contribution to project decision-making, the scholars proposed the following priorities:

1) more consideration of uncertainty;

2) better training of EA practitioners;

3) better understanding of the gap between scientific problems in academics and real EA problems in practice;

4) increased funding;

5) improved participatory processes;

6) higher scientific standards required by permitting authorities to practitioners;

7) independence of scientists and science;

8) better collaboration between scholars and practitioners;

9) improved involvement of scholars in the EA process; and

10) better adaptive learning from the EA process.

The practitioners suggested the following ways:

1) a better application of precautionary principles in decision-making processes;

2) more time and funding availability;

3) more consideration of uncertainty;

4) stronger partnerships between stakeholders;

5) strengthened scientific standards by regulators;

6) more-transparent decision-making processes;

7) earlier participation of scholars in the EA process;

8) scientists with more field experience and more collaborative and humble attitudes; and

9) continuous refining of the best available science.

For most stakeholders, EA scholars and practitioners expressed the same level of power and influence on their role in influencing the EA process (Table 4), and confirmed using a Mann-Whitney U test (p=0.8957, alpha=0.1), which indicates that there was no statistical difference between merged responses to perceived power and influence of all stakeholders by both pools. For observations on single stakeholders, those in group 1 were considered highly powerful by both pools of EA scholars and practitioners, and the power and influence of stakeholders in group 2 were considered in the medium level by both pools of respondents (Table 4). Scholars ascribed a higher level of power to proponents than did practitioners (p=0.0113, alpha=0.05), and there was no statistical significance found in the difference of the two pools of respondents' attitudes about other stakeholders. For group 3, practitioners considered scholars and aboriginal groups to have a more powerful role in EA than what scholars believed they had, and the difference between the attitudes of the scholars and practitioners towards the importance of scholars was confirmed by statistical analysis (p=0.0875, alpha=0.1).

Table 3: Importance levels (%) and statistical significance in the differences between the importance levels expressed by EA scholars and practitioners (i.e., *low*, *medium*, and *high importance*) with influential factors in influencing the quality of science in EA. The selected confidence level is 90% and 95% (alpha=*0.1* & ***0.05***).

Factors	Scholars (%)			Practitioners (%)			P-values
Group 1	Low	Medium	High	Low	Medium	High	
Time availability	3	31	66	0	14	86	*P=0.0507*
Funds availability	6	28	66	5	24	71	P=0.6420
Training levels of practitioners	6	28	66	0	24	76	P=0.7718
Proponents' attitudes towards social responsibility beyond regulatory requirements	6	26	68	10	33	57	P=0.2125
The expectations of regulators regarding the quality of science in EA	2	49	49	5	38	57	P=0.6792
Structure of the regulatory process for EA	11	29	60	15	20	65	P=0.5763
EA practitioners' opinions about the importance of science in EA	11	40	49	21	32	47	P=0.3495
Group 2	Low	Medium	High	Low	Medium	High	
Public discourse in EA	9	57	34	15	50	35	P=0.4069
Support level for EA practitioners from the general scientific community	26	48	26	30	45	25	P=0.4067
Group 3	Low	Medium	High	Low	Medium	High	
The participation of the scientific community in EA	14	37	49	35	30	35	*P=0.0725*
Opportunities for the scientific community to participate in EA	14	43	43	15	65	20	*P=0.0902*
Cooperation between EA scholars and practitioners	11	40	49	20	50	30	*P=0.0833*
Stakeholders' concern for the quality of science in EA	6	43	51	19	43	38	*P=0.0970*
The availability of scientific literature	11	46	43	28	24	48	P=0.3570

Table 4: Power and influence levels (%) perceived by EA scholars and practitioners (i.e., *low*, *medium*, and *high power and influence*) in the generic EA process.

Stakeholders	Scholars (%)				Practitioners (%)		
Group 1	Low	Medium	High		Low	Medium	High
Politicians	11	20	69		19	10	71
Regulators	3	28	69		0	29	71
Proponents	3	14	83		15	30	55
Group 2	Low	Medium	High		Low	Medium	High
NGOs	17	72	11		24	52	24
Consultants	6	51	43		14	57	29
The public	26	54	20		14	57	29
Group 3	Low	Medium	High		Low	Medium	High
Scholars/Scientists	57	37	6		38	52	10
Aboriginal groups	27	43	30		32	26	42

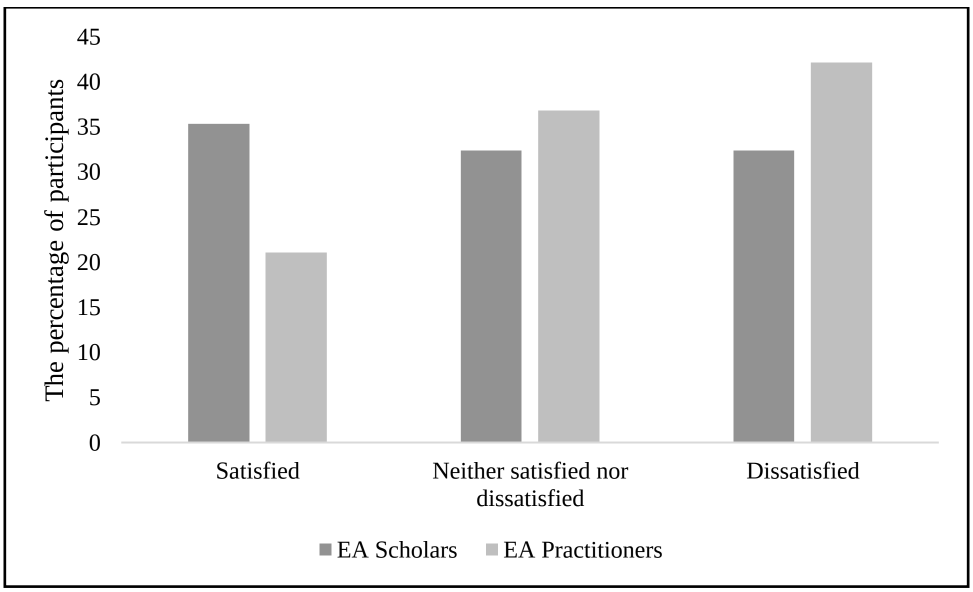

Figure 2: Satisfaction levels (%) by scholars and practitioners with the contribution to the scholarly scientific community to the EA process. Statistical differences indicated that EA scholars and practitioners have essentially the same satisfaction levels (p=0.278, alpha=0.1).

4.3.3 Interview Demographic Data

Twelve interviewees were identified as EA practitioners, including consultants, proponents, NGOs, EA regulators, government reviewers and NGOs, and one interviewee was identified as both EA practitioner and scholar. Most of the interviewees were not experienced EA-related teachers or professors or experienced literature contributors but were experienced EA professionals due to their very high level of EA-related work experience (Figure 3). All had a Canadian EA background. Interestingly, no interviewee answered questions from a social science perspective. Most indicated that they answered from a mixed perspective (Figure 3).

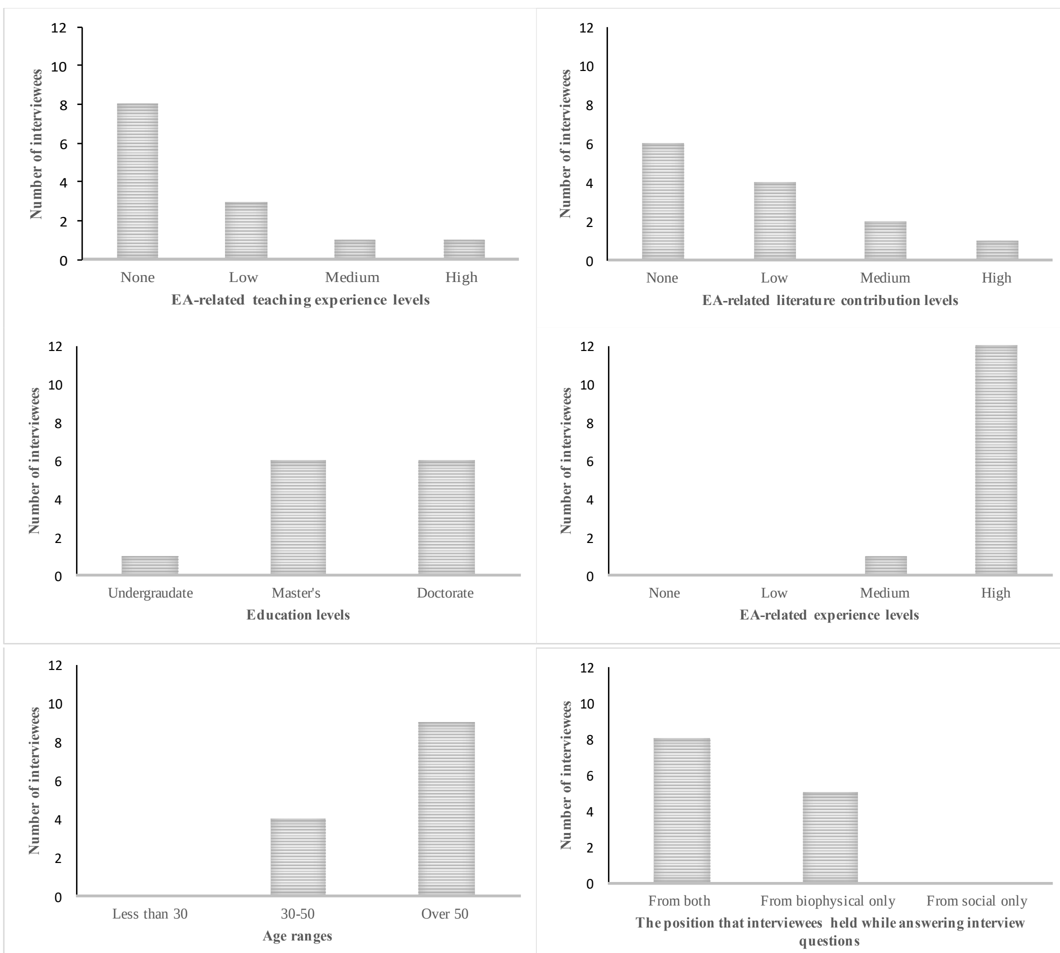

Figure 3: Demographic information about 13 interviewees.

4.3.4 Interview Results

The factors behind interviewee satisfaction with the quality of science in EA echoed the factors offered by survey respondents, and the reasons why interviewees were dissatisfied can also be categorized into the same 11 groups as those presented in survey responses. Appendix H presents a detailed summary of those reasons explaining their dissatisfaction.

For the status of EA, interviewees indicated that current EA is about mitigating undesirable outcomes and has become standardized about moving a project through a regulatory process rather than a scientific process. They said this standardized process leads to a lack of creativity in finding solutions for EA issues, and inefficient use of proponents' time and money. In addition, some important stakeholders are marginalized in this kind of standardized regulatory process due to their low political power. EA is considered as a consulting and negotiating process among various stakeholders rather than an evaluation process based on scientific evidence. There has been disagreement on the purpose of EA by various stakeholders; therefore, they would use EA as a tool for their own purposes. For example, proponents want to get their projects approved, so they want to understand the concerns of stakeholders about their projects to make sure their projects can be approved. Indigenous groups and land owners want to protect their properties; therefore, they would treat EA as a way of opposing proposed projects. Some people who are concerned about climate change would treat EA as a way of reminding the government of the importance of climate change and how a proposed project would contribute to an increase in emissions of GHGs. And these different stories brought to any public hearings by stakeholders make EA complicated.

For the status of science in EA, some interviewees indicated that there is a generally weak scientific foundation for EA, which results in a low-quality discourse. The main factors contributing to a weak scientific foundation for preparing EISs include: unqualified EA practitioners, time and cost constraints on consultants by proponents, a low expectation of regulators about the quality of science, and low participation of scholars and government scientists in the EIS preparation phase. There are two other scientific issues flagged by interviewees. First, science is misused when scientific data are purposively selected to support stakeholders' arguments. For example, on one hand, scientific uncertainty is used by intervenors to block the project, and this is not an appropriate way of helping a project to be improved. Academic scientists often reveal support for the positions of specific intervenors. If so doing, they often engage in a narrow selection of evidence for those positions. On the other hand, proponents have been brought incomplete information and have been selective in the analysis in the EA report to get their projects approved. Second, there is a lack of independent science. Governments do not have sufficient budgets to hire scientists to do EA. Scientific work is generally done by professional people hired by proponents, and these professionals consequently are not independent to speak freely about negative project impacts. In addition, the current EA structure does not demand and encourage independent science.

Some adverse tensions were identified in the relationships of various EA stakeholders. Consultants expressed satisfaction with the general quality of science because they believe that the level of science expected by government reviewers is reached. However, government reviewers indicated that they are not allowed to speak freely on scientific issues and negative environmental issues under political pressure. Regulators expressed satisfaction with the amount and quality of scientific information they receive and post to the public record. However, a low acceptance level of science by regulators was criticized by other stakeholders as a reason why scientific quality in EA was unsatisfactory. Negative impacts that are flagged by government reviewers and NGOs cannot sway the decision of politicians and the Ministers in charge because political will makes the weight of economic benefits and concerns embedded in EA decisions higher than that of environmental concerns.

4.4 DISCUSSION

The survey results indicate that the EA practitioners were generally satisfied with the quality of science in EA. This finding is consistent with the results of two other surveys with respect to the practitioner perspective on the quality of science in EA - one was at an international scale (Sadler, 1996), and the other was in Western Australia (Morrison-Saunders et al., 2001; Morrison-Saunders & Bailey, 2003).

The EA practitioners expressed a higher satisfaction level in the current survey responses regarding the quality of science in EA than the EA scholars. Satisfaction reasons given by survey respondents can be generally summarized as that the survey respondents expressed satisfaction based on what they have experienced as achievements in the scientific practices in EA. It needs to be noted that when the EA practitioners expressed satisfaction levels with the quality of scientific practices in EA, they were self-evaluating themselves. EA practitioners are the persons doing EA; therefore, in this survey, they were self-evaluators. In contrast, the EA scholars acted as external evaluators for scientific practices in EA; therefore, the EA scholars may be more critical about the evaluation of the scientific practices in EA than the EA practitioners. Based on this logic, it would not be surprising that the EA practitioners showed a higher satisfaction level than the EA scholars. The same logic was also used by Greig and Duinker (2011) to explain their understanding of the survey results presented in Morrison-Saunders and Bailey (2003) regarding a high satisfaction level with the quality of science by EA practitioners in Western Australia.

Another explanation for the difference between the satisfaction levels of the EA scholars and practitioners is that the EA scholars and practitioners have different understandings of science and this distinction results in their different expectations of the quality of science implemented in EA. Non-scientists consider science as a process of data collection; therefore, when they talked about the quality of science, they generally thought about how many data they have collected, and how good the quality of data collection is (Bisbal, 2002; Briggs, 2006; Sullivan et al., 2006; Ryder et al., 2010; Green & Garmestani, 2012). However, scientists consider science as a more completely rigorous analysis process, starting with an identified research problem, and then based on the defined scope of the research question to determine the scope of data collection and to select an appropriate research method to collect and analyze data. A thorough data analysis would be applied after data collection and finally a conclusion would be drawn based on a logic flow embedded in the analysis (Bisbal, 2002; Briggs, 2006; Sullivan et al., 2006; Ryder et al., 2010; Green & Garmestani, 2012). These different understandings of science embrace different values and beliefs, and sometimes these values are in conflict in the environmental decision-making policy arena (Briggs, 2006; Ryder et al., 2010).

Science is not easily practiced in EA and the following factors have contributed to the difficulties of scientific implementation in EA: 1) a low expectation or an unclear direction from regulators as to the quality of science; 2) limitations in human, time, and financial resources' support; and 3) adversarial political tensions between stakeholders. A low expectation or unclear direction from regulators may be understood from two perspectives. First, regulators have a solid understanding of science, but they put a low quality threshold on the requirements on the scientific practices in EIS guidelines due to some reality constraints such as staff shortages, loss of experienced staff, and financial insufficiency (Morrison-Saunders & Bailey, 2009). Second, regulators may not have a deep understanding of science, so they have no idea about what an appropriate quality threshold on the scientific practices in EIS guidelines should be like. As a result, they use vague and ambiguous language to write EIS guidelines. A low expectation or unclear direction from regulators can also reflect a root of most of the dissatisfaction reasons explained by survey respondents, such as non-existent EA components, inadequate implementation, a too narrow scope and focus, unclearly or incorrectly defined scope, big gaps between what should be done based on scientific literature and what has been done in real EA practices, and insufficient baseline data collection. Because regulators do not specify explicit requirements as to what should be done in the scientific dimensions of EA, consultants cannot get a clear understanding about the expectations from regulators regarding the quality of science. At the same time, there are also time and financial constraints from the proponents' side, so it would not be surprising that some scientific quality issues as listed above would be identified and would generate dissatisfaction among EA stakeholders.

The power of regulators has been demonstrated in influencing the environmental performance of proponents in the literature, and proponents also have an incentive to be proactive and/or interactive towards environmental approvals regulation. Specifically, Morrison-Saunder et al. (2001) identified that the expectations of EA regulators were one of the main influencing drivers to the improving quality of science in EA, and regulator pressure was the main incentive and stress on proponents to improve the quality of EISs. In addition, an administrative control mechanism operated by regulators was identified as one of the main drivers to the positive changes in the Brazilian EISs in the period between 1987 and 2010 (Landim & Sánchez, 2012). The results of these two studies echoed the study of Annandale (2000), which indicated the power of regulators in influencing the response of the companies dealing with mines to environmental approvals regulations. In a later study, Annandale, Morrison-Saunders, and Bouma (2004) identified regulator pressure as a determinant of the environmental performance of development companies. Additionally, Annandale and Taplin (2003) found that development companies treat environmental approvals regulation as an important opportunity to improve their project designs so as to avoid possible environmental negative outcomes caused by poor project designs. Therefore, the expectations of regulators may be considered by proponents as the ceiling of the scientific quality in EA. If the quality of science in EA is expected to be improved, then improving regulators' requirements or expectations would be one of the direct ways.

The importance of resources (i.e., human, temporal, and financial) was frequently linked with the improvement in the scientific dimension of EA by the survey and interview participants, and these links can be interpreted from the following four perspectives. First, in the EIS preparation phase, well-qualified practitioners with a high level of expertise and sufficient temporal and financial resources are needed for collecting sufficient baseline data and applying appropriate scientific methods in predicting possible impacts and determining impact significance. Second, at the public participatory stage, sufficient staff, temporal, and financial resources are also important to support the participation of the public and other stakeholders (e.g., NGOs and aboriginal groups) in the EA discourse. Third, in the post-EA phase, sufficient resources are important for governments to conduct monitoring and follow-up and to post the monitoring and follow-up reports to the public record for adaptive learning purposes. Fourth, independent and sufficient research funds are an important factor for creating independent science.

These results overlap with the results of Morrison-Saunders et al. (2001) who pointed out that sufficient time and financial resources were an important determinant to the level of science in EA, and the insufficiency of research funds provided by proponents was considered as a major factor influencing the level of science applied in EA. Additionally, Morrison-Saunders and Bailey (2009) demonstrated that sufficient human resources play an important role in influencing the quality and effectiveness of EA practices. Staff shortages in regulatory agencies caused by a recent resource boom in Australia would reduce the capacity of regulators, so as to hardly meet the requirements and expectations of other stakeholders. The relationships between regulators and other stakeholders may also be strained (Morrison-Saunders & Bailey, 2009). Therefore, sufficient human, temporal, and financial resources are needed to improve scientific practices and effectiveness of EA.

Based on the survey respondents and interviewees, adversarial political tensions were identified among EA stakeholders, which reflect weaknesses in effective communication between stakeholders in terms of their different expectations and challenges encountered in their different roles. And these communication gaps among stakeholders generate different perceived satisfaction levels with the quality of science in EA. That being said, an improvement in effective communications among stakeholders can promote their mutual understandings, thereby relieving adversarial political tensions and creating a foundation for a collaborative relationship between EA stakeholders.

The literature emphasizing the importance of changing from adversarial relationships among EA stakeholders to a collaborative way in improving the quality of science can be traced back to the 1980s (i.e., Caldwell et al., 1982; Beanlands & Duinker, 1983). The importance of creating interdisciplinary teams in an adaptive learning management system is elaborated by Ryder et al. (2010). Mackinnon et al. (2018) demonstrated the gaps between science inside EA and science outside EA, and emphasized that the improvement in science inside EA would depend on more collaborative relationships and arrangements among EA stakeholders. However, how to develop and/or improve this kind of collaborative arrangement among EA stakeholders has not drawn enough attention.

Morrison-Saunders and Bailey (2009) shared a positive initiative, the *Partnering Agreement* between regulators and consultants in Western Australia, and demonstrated benefits generated from the resulting cooperative relationship between these two EA stakeholders. However, it may be easier to promote collaborative relationships between two EA stakeholders than more than three stakeholders, especially when these stakeholders have conflicting values and expectations about the quality of science and effectiveness of EA. Even though regulators and consultants play a totally different role in the EA process, they generally have similar EA-related training background (Morrison-Saunders & Bailey, 2009). Therefore, it may be more challenging to motivate two stakeholders with different EA-related training background to cooperate and collaborate.

The level of willingness by EA stakeholders to cooperate and collaborate to improve their working relationships and EA performance is a keystone for initiating such a collaborative arrangement (Morrison-Saunders & Bailey, 2009). However, based on the survey responses of this study, the EA practitioners gave the participation of scientific communities in the EA process less importance than did the EA scholars, which reflects, to some degree, that EA practitioners are not willing to work together with scholars. And some survey comments even explained that in reality, EA scholars and practitioners mutually avoid each other due to their different value systems. This obviously should be addressed for developing more collaborative and participatory working relationships among stakeholders so as to improve the quality of science in EA.

Greig and Duinker (2011) showed a potential collaborative relationship between EA practitioners and scholars for improving the quality of science in EA, and pointed out that one condition must be reached to make this kind of collaborative arrangement work – all stakeholders should reach a consensus about the status of science in EA, and agree that the quality of science needs to be improved for delivering better EA outcomes. However, based on survey responses, EA scholars and practitioners have different perceptions on the quality of science in EA, and these different satisfaction levels also indicate that at least EA scholars and practitioners do not reach a consensus about the status of science in EA; consequently, their willingness to change the current EA situation would be different.

4.5 CONCLUSIONS

This study indicates that EA scholars were more dissatisfied with the quality of science in EA than EA practitioners. When survey respondents and interviewees explained their satisfaction levels, their perceptions were generally related to their underlying expectations on the scientific practices in EA and their understanding of science in EA. This study implies that EA practitioners play an influential role in determining the quality of science in EA and EA scholars play a limited role in influencing the quality of science in EA. However, the EA practitioners did not show a willingness to change this situation. Also, this study implies that EA scholars and practitioners did not reach a consensus about the status of science in EA. This disagreement may be a barrier to creating mutual understandings and effective communications among EA stakeholders, thereby hindering the building of a collaborative relationship between EA scholars and practitioners for improving the quality of science in EA (Grieg & Duinker, 2011).

This study aligns with the conclusion made by Mackinnon et al. (2018), that there are large gaps between science inside EA and science outside EA. Factors contributing to the barriers to filling the gap include EA stakeholders' different understandings of and expectations on the quality of science, the role of scholars in EA, and the purpose and objectives of EA. These disagreements imply insufficient and/or ineffective communications among EA stakeholders, which should be addressed if a more collaborative arrangement is to be built for a better quality of science in EA.

As for the limitations, due to time constraints, this study collected 56 online survey responses (35 EA scholars and 21 EA practitioners), and interviewed 13 EA professionals. Therefore, the small sample size of online surveys is not enough to statistically represent all EA scholars and practitioners throughout the world. In addition, the countries and/or continents that the survey respondents mostly work in on EA projects are different (Figure 1), which may also contribute to their different perceptions of the quality of science in EA due to different EA conditions in these countries and/or continents. All interviewees were selected from Canada, and the EA-related working background of all interviewees is mostly in Canada. These factors may generate bias in our findings.

Future research on diverse views about science in EA is suggested to focus on 1) how to promote mutual understandings and effective communications among EA stakeholders so as to create a solid foundation for their potential collaborative working relationships; 2) how to promote the participation of EA scholars in the EA process in order to improve the scientific foundation for EA and generate a high-quality EA discourse; 3) how to improve the expectations of regulators on the quality of science in EA; and 4) how to mediate adverse tensions in the relationships of various EA stakeholders, especially when they have conflictive values, beliefs, and purposes.

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CHAPTER 5. CONCLUSIONS

5.1 IMPLICATIONS OF THE STUDY

This study aimed to investigate the EA scholar and practitioner views on science in EA including their satisfaction levels with the various aspects in the EA process, perceived status of science in EA, and factors contributing to the state of science in EA. Both on-line surveys and interviews were used for data collection. Minitab was used for statistical data analysis and NVivo was used for qualitative data analysis. Fifty-six survey responses were received, including 35 scholars and 21 practitioners; thirteen interviewees agreed to be interviewed.

Based on the pre-determined p-value thresholds (i.e., p=0.1 & 0.05), survey results indicated that the EA scholars were generally more dissatisfied with the quality of science in EA than the practitioners (p=0.0092, alpha=0.05). Specifically, the EA scholars were more unsatisfied with the quality of science used in two specific EA aspects than the practitioners, that is, the identification of VECs (p=0.0299, alpha=0.05), and impact prediction approaches (p=0.0974, alpha=0.1). These results indicate that EA scholars and practitioners did not reach a consensus about the status of science in EA. This disagreement may be a barrier to creating mutual understandings and effective communications among EA stakeholders, thereby hindering the building of a collaborative relationship between EA scholars and practitioners for improving the quality of science in EA (Grieg & Duinker, 2011).

When survey respondents and interviewees explained their satisfaction levels, their perceptions were generally related to their underlying expectations to the scientific practices in EA and their understanding of science in EA. The reasons explaining their satisfaction would be summarized as that they were satisfied with what had been done in EA, and similarly, the reasons explaining their dissatisfaction would be summarized as that they were dissatisfied with what had not been done in EA, such as, monitoring and follow-up were almost non-existent in EA. Therefore, different perceptions of the EA scholars and practitioners indicate that their underlying expectations to the quality of science in EA are varied.

Both EA scholars and practitioners rated a high level of importance to the factors: time and funds availabilities, and the opinions of proponents, regulators, and other EA practitioners about the importance of science in EA (Table 3). This finding implies that EA practitioners play an influential role in determining the quality of science in EA. However, the different attitudes of the EA scholars and practitioners towards the importance of the participation of scientific communities in the EA process reflect a fact that these two groups have different expectations to the participation of EA scholars in the EA process. EA scholars play a limited role in influencing the quality of science in EA, and the EA practitioners did not show a willingness to change this situation in this study. This implication obviously hinders the fulfilment of a benign cycle between EA scholars and practitioners to collaborate with each other for improving the quality of science in EA as described by Grieg and Duinker (2011).

This study confirms the conclusion made by Mackinnon et al. (2018), that there are large gaps between science inside EA and science outside EA. Factors contributing to the barriers to filling the gap include EA stakeholders' different understandings of and expectations on the quality of science, the role of scholars in EA, and the purpose and objectives of EA. These disagreements imply insufficient and/or ineffective communications among EA stakeholders, which should be addressed if a more collaborative arrangement is to be built for a better quality of science in EA.

5.2 LIMITATIONS

As for the limitations, due to time constraints, this study only collected 56 online survey responses (35 EA scholars and 21 EA practitioners), and only interviewed 13 EA professionals. The small sample size of online surveys is not enough to statistically represent all EA scholars and practitioners throughout the world. In addition, the countries and/or continents that the survey respondents mostly work in on EA projects are different (Figure 1), which may also contribute to their different perceptions of the quality of science in EA due to different EA conditions in these countries and/or continents. All interviewees were selected from Canada, and the EA-related working background of all interviewees is mostly in Canada. These factors may generate bias in our findings.

5.3 FUTURE RESEARCH

Future research on diverse views about science in EA is suggested to focus on 1) how to promote mutual understandings and effective communications among EA stakeholders so as to create a solid foundation for their potential collaborative working relationships; 2) how to promote the participation of EA scholars in the EA process in order to improve the scientific foundation for EA and generate a high-quality EA discourse; 3) how to improve the expectations of regulators on the quality of science in EA; and 4) how to mediate adverse tensions in the relationships of various EA stakeholders, especially when they have conflictive values, beliefs, and purposes.

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APPENDIX A: Online Survey Questions

DALHOUSIE UNIVERSITY

Scholar and practitioner perspectives on the quality of science in EIA

Part One: Demographic Questions

1. What is the level of your experience and involvement in teaching EIA courses?

- ☐ High
- ☐ Medium
- ☐ Low
- ☐ None

2. Which sector do you work in or on most? Please check only one that is the most appropriate.

- ☐ Academia
- ☐ Consulting
- ☐ Government department scientist
- ☐ Government department regulator
- ☐ NGO
- ☐ Proponents/Developers
- ☐ Aboriginal group
- ☐ Other ________

3. To what degree have you contributed to the EIA-related literature (e.g., journal papers, book chapters, and conference proceedings)?

- ☐ High
- ☐ Medium
- ☐ Low
- ☐ None

4. What is your sex?

- ☐ Male
- ☐ Female
- ☐ Other ________

5. What is your highest education level?

- ☐ Secondary education
- ☐ College diploma
- ☐ Undergraduate degree
- ☐ Continuing education certificate
- ☐ Masters
- ☐ Doctorate
- ☐ Post-doctorate

6. What is your level of experience in contributing to EIA?

☐ High
☐ Medium
☐ Low
☐ None

7. What is your age?

☐ 15-24
☐ 25-34
☐ 35-44
☐ 45-54
☐ 55-64
☐ 65+

8. Which countries do you work in on EIA projects? Please list up to three main ones.

____

Part Two:

9.In your answers to the following questions, please indicate whether you are doing so from a social science point of view or a biophysical science point of view.

☐ Social science
☐ Biophysical science

10. How satisfied are you with the current quality of science in each of the following main steps of the EIA process? Please check only one box that best describes your satisfaction level, and we invite you to explain your answer in the open box below each question. In your explanation, please identify relevant case examples we might consult to enrich our understanding of your answers.

10.1 The identification of valued ecosystem components (VECs)

☐ Very dissatisfied
☐ Dissatisfied
☐ Neither satisfied nor dissatisfied
☐ Satisfied
☐ Very satisfied
☐ I do not know

Explanation: ____

10.2 Time and space boundaries

☐ Very dissatisfied
☐ Dissatisfied
☐ Neither satisfied nor dissatisfied
☐ Satisfied
☐ Very satisfied
☐ I do not know

Explanation: ____

10.3 Baseline data collection

☐ Very dissatisfied
☐ Dissatisfied
☐ Neither satisfied nor dissatisfied
☐ Satisfied
☐ Very satisfied
☐ I do not know

Explanation: ____

10.4 Approaches to impact prediction

☐ Very dissatisfied
☐ Dissatisfied
☐ Neither satisfied nor dissatisfied
☐ Satisfied
☐ Very satisfied
☐ I do not know

Explanation: ____

10.5 Determination of impact significance

☐ Very dissatisfied
☐ Dissatisfied
☐ Neither satisfied nor dissatisfied
☐ Satisfied
☐ Very satisfied
☐ I do not know

Explanation:

10.6 Monitoring and follow-up

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Satisfied
- ☐ Very satisfied
- ☐ I do not know

Explanation:

11. How satisfied are you with the current quality of science in each of the following other relevant aspects of the EIA process? Please check the box that best describes your satisfaction level, and we invite you to explain your answer in the open box below each question. In your explanation, please identify relevant case examples we might consult to enrich our understanding of your answers.

11.1 Approaches to species at risk

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Satisfied
- ☐ Very satisfied
- ☐ I do not know

Explanation:

11.2 Cumulative effects assessment

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Satisfied
- ☐ Very satisfied
- ☐ I do not know

Explanation:

11.3 Incorporating sustainability assessment to EIA

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Satisfied
- ☐ Very satisfied
- ☐ I do not know

Explanation:

11.4 Public participatory processes

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Satisfied
- ☐ Very satisfied
- ☐ I do not know

Explanation:

11.5 Social impact assessment

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Satisfied
- ☐ Very satisfied
- ☐ I do not know

Explanation:

11.6 Human health impact assessment

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neither satisfied nor dissatisfied

☐ Satisfied
☐ Very satisfied
☐ I do not know

Explanation:
____
______

Part Three

12. How important are the following factors in influencing the quality of science implemented in EIA? If there are any factors that are not on the list, please feel free to add them in the three open slots at the end of the list. We also invite you to explain your answer in the comment box beside each factor.

Factor numbers	Factors	The Level of Importance			Comments
		Low importance	Medium importance	High importance	
12.1	Time available				
12.2	Funds available				
12.3	Training levels of practitioners				
12.4	Proponent's attitudes towards social responsibility beyond regulatory requirements				
12.5	The expectations of regulators regarding the quality of science in EIA activities and products				
12.6	The participation of the scientific community in the EIA process				
12.7	Structure of the regulatory process for EIA				
12.8	Level of public discourse in the EIA process				
12.9	The availability of scientific literature				
12.10	Support level for EIA practitioners from the general scientific community				

12.11	EIA practitioners' opinions about the importance of science in the EIA process				
12.12	Level of stakeholders' concern for the quality of science in the EIA process				
12.13	Opportunities for the scientific community to participate in the EIA process				
12.14	Cooperation between the EIA scholars contributing to the EIA-related literature and EIA practitioners including regulators, consultants, developers, etc.				
12.15					
12.16					
12.17					

Additional comments about question 12

____

Part Four

13. In your view, how satisfactory is the contribution of the scholarly scientific community (e.g., academics, and government researchers) to the EIA process?

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Satisfied
- ☐ Very satisfied
- ☐ I do not know

Explanation:

____

13.1 If the contribution is NOT satisfactory, what are the EIA communities' top three priorities for action during the next decade?

1) ____

2) ____

3) ____

14. In your view, does science as practiced in the context of contemporary EIA make the contributions it should to project decision-making?

14.1 If NOT, what are the main ways that science should be strengthened so that it can contribute effectively to project decision-making?

15. What do you think about the power/influence of various stakeholders included in the EIA process? If there are any key stakeholders that are not on the list, please feel free to add them in the three open slots at the end of the list. We also invite you to explain your answer in the comment box beside each stakeholder.

Stakeholder numbers	Stakeholders	The Level of Power/Influence			Comments
		Low power/ influence	Medium power/ influence	High power/ influence	
15.1	Politicians				
15.2	Regulators				
15.3	Scholars/Scientists				
15.4	Developers				

15.5	The public				
15.6	NGOs				
15.7	Consultants				
15.8	Aboriginal groups				
15.9					
15.10					
15.11					

Additional comments about question 15

____

16. If you have any additional comments about this survey or about the use of science in EIA, please write in the box below.

____

Thank you very much for your time and assistance in filling out this survey.

APPENDIX B: Consent Form for Online Surveys

DALHOUSIE UNIVERSITY

Before reading this consent form, please read the introduction thoroughly. You are invited to take part in a research study being conducted by me, Jie Ma, a graduate student in School of Resource and Environmental Studies (SRES), as part of my Master's degree at Dalhousie University. As a participant in the research, you will be asked to answer 16 questions in a survey conducted over the Internet using ??. All responses will be saved on a secure server at Dalhousie University. The survey does not ask for your name, and no grouping with less than ten responses will be reported.

Your participation in this research is entirely your choice. You do not have to answer questions that you do not want to answer, and you are welcome to stop the survey at any time if you no longer want to participate. All you need to do is close your browser. I will not include any incomplete surveys in my analyses. However, if you do complete your survey, if you change your mind later, I will not be able to remove the information you provided because the surveys are completed anonymously, so I would not know which one is yours.

Information that you provide to me will be collected anonymously, which means that there will be no questions asked in the survey that call for you to identify details such as your name or email address. Only my supervisor and I will have access to the survey results. Please note that, because quotes are a powerful means to portray results of a study such as this, I may be putting quotes from the survey responses into my thesis and papers. Your consent for me to do this is assumed if you complete the survey. Because of the way the survey is being conducted, the quotes will be anonymous.

The risks associated with this study are no greater than those you encounter in your everyday life. There will be no direct benefit to you in participating in this research and you will not receive compensation. The research, however, might provide insight into the scientific dimension in the EIA process in the context of Canada, as well as the comparison of the opinions between EIA scholars and EIA practitioners.

If you would like to see the results of the study, please feel free to contact me or my supervisor, Dr. Duinker, and we will ensure that you get an electronic copy of my master's thesis when it is finalized.

You should discuss any questions you have about this study with me or my supervisor. If you have any ethical concerns about your participation in this research, you may contact Research Ethics, Dalhousie University at (902) 494-1462, or email ethics@dal.ca (and reference REB file # 2016-3816).

Do you consent to participate in this survey?

- ☐ Yes
- ☐ No

APPENDIX C: Interview Questions

DALHOUSIE UNIVERSITY

Part One: Demographic Questions

1. How would you describe the level of your experience and involvement in teaching EIA courses?

   Prompts: None, low, medium, or high; the types and number of EIA courses.

2. How would you describe the level of your contribution to the EIA-literature such as journal papers, book chapters, and conference proceedings?

   Prompts: None, low, medium, or high; the frequency of publishing EIA-literature; the number of EIA literature you have contributed to.

3. What is your highest education level?

   Prompts:
   - ☐ Secondary education
   - ☐ College diploma
   - ☐ Undergraduate degree
   - ☐ Continuing education certificate
   - ☐ Masters
   - ☐ Doctorate
   - ☐ Post-doctorate

4. How would you describe the level of your experience in contributing to EIA?

   Prompts: The amount of time; the number of EIA projects you have worked; the frequency of participating in EIA activities.

5. Which countries do you most work in on EIA projects?

6. My final demographic question, you do not need to answer, but I would like to ask. Are you aged less than 30, 30-50, or over 50 years?

Part Two

7. How would you describe the status of science used in the EIA practices? Is it satisfactory or unsatisfactory? And what factors have contributed to this situation?
8. There are 12 aspects included in an EIA process below:

1) the identification of valued ecosystem components (VECs);
2) time and space boundaries;
3) baseline data collection;
4) impact prediction;
5) determination of impact significance;
6) monitoring and follow-up;
7) public participatory processes;
8) approaches for species at risk;
9) cumulative effects assessment;
10) incorporating sustainability principles into EIA;
11) social impact assessment; and
12) human health impact assessment.

Could you please pick up **3-5** aspects that you are the most interested in/ the most familiar with and describe your satisfaction levels with the quality of science used in these selected aspects?

9. What are the factors influencing the quality of science implemented in EIA from your perspective?
10. Do you see any potential for improving the quality of science used in the EIA practices and how these expectations can be achieved? Are there any barriers/challenges to fulfill this potential?
11. How can different stakeholders help to improve the quality of science used in EIA practices, such as EIA regulators, consultants, academia, government scientists, NGOs, the public, and aboriginal people?
12. How satisfactory is the contribution of academics and government scientists to the EIA process in terms of the scientific support? If the contribution is not satisfactory, is there any perceived potential for improving the scientific support to the EIA process and how this potential can be achieved by the EIA communities?
13. Could you please indicate whether you were answering the interview questions from a social science point of view or a biophysical science point of view?
14. Do you have any additional comments/suggestions on this topic that have not been included in the previous questions?

APPENDIX D: Recruitment Letter for Interviews

Dear ___________,

My name is Jie Ma, and I am a Master's student at Dalhousie University in Canada working under the supervision of Peter Duinker whom you may know specializes in scholarly work on environmental impact assessment (EIA). We are undertaking a study regarding EIA professionals' satisfaction with the quality of scientific work done in the EIA process and the factors contributing to the level of satisfaction.

You are being invited to complete an interview aiming to investigate EIA professionals' satisfaction with the quality of scientific work done in the EIA process and the factors contributing to the level of satisfaction. This interview will take between 60 and 90 minutes. The interview will be audio-recorded and transcribed verbatim by myself and my supervisor, Peter Duinker. You will have the option to review it for verification. If you do not reply with any feedback with respect to the transcription within 72 hours, we will assume that it is accurate. Should you choose to participate you will be given a random participant number to guarantee your confidentiality and anonymity. This study is a Master's thesis research project; therefore, I will seek to have results published in an academic journal. Any identifying information from the interview will be removed prior to being reported so as to protect your confidentiality and anonymity. You may find more details about this project in the attached consent form. I also attach a copy of interview questions in this email.

Scientific support plays an essential role in effective EIA decision-making, and EIA professionals, including both EIA scholars and practitioners, are important for guaranteeing a high quality of science in EIA. As an EIA professional, your valuable insights and experience with EIA work will be very essential inputs to this study. Your time and kind help will be highly appreciated.

If you are interested in participating, please reply to this letter so that we may schedule a meeting time and place at your earliest convenience. If you are not interested in participating, please respond to this email regardless so that all attempts at recruitment would cease. You will receive a follow-up email in the coming weeks to guarantee your willingness to take an interview for this study.

Thank you very much again for your time and consideration.

Sincerely,
Jie Ma

APPENDIX E: Consent Form for Interviews

DALHOUSIE UNIVERSITY

Project title: Scholar and Practitioner Perspectives on the Quality of Science in Environmental Impact Assessment

Lead researcher: Jie Ma, School for Resource and Environmental Studies, Dalhousie University, Jie.Ma@dal.ca

Other researchers

Peter Duinker, School for Resource and Environmental Studies, Dalhousie University, Peter.Duinker@Dal.Ca (Project Supervisor)

Tony Walker, School for Resource and Environmental Studies, Dalhousie University, trwalker@dal.ca (The Committee Member)

Introduction

We invite you to take part in a research study being conducted by me (Jie Ma), a Master's student at Dalhousie University as part of my Master of Environmental Studies degree program. Choosing whether or not to take part in this research is entirely your choice. Even if you do take part, you may leave the study at any time for any reason. The information below tells you about what is involved in the research, what you will be asked to do and about any benefits, risk, inconvenience or discomfort that you might experience.

Please ask as many questions as you like. If you have any questions later, please do not hesitate contact the lead researcher (Jie Ma).

Purpose and Outline of the Research Study

This study aims to provide preliminary data about all relevant EIA stakeholders' views (e.g., EIA scholars, regulators, consultants, NGOs, and EIA proponents) on whether science in EIA needs improvement, and which factors could improve the state of scientific work within EIA. This pilot study will provide a preliminary foundation for future comprehensive analysis of the quality of science in the context of EIA. There are two main objectives of this study: 1) to survey the level of satisfaction of key stakeholders involved in EIA with the quality of the science within the process; and 2) to identify the factors that have influenced that quality.

To address these objectives, both online survey and interviews will be used for complementing their data each other. Specifically, online surveys will be used for capturing the general trends of various EIA stakeholders' satisfaction with the quality of science used in EIA; interviews will be used for collecting the in-depth thoughtful opinions of key EIA stakeholders related to the quality of science used in EIA, and the contributing factors to the status of science used in EIA. The targeted population for the online survey mainly include the International Association for Impact Assessment (IAIA) members, and also the EIA scholars who published their papers in a key EIA journal (e.g., Impact Assessment and Project Appraisal, and Environmental Impact Assessment Review). The potential participants for interviews will be screened based on their activities conducted in the EIA process. 15 participants will be purposively selected from various key EIA stakeholders according to the personal knowledge and recommendation of the project supervisor, Peter Duinker, and the lead researcher's committee member, Tony Walker. Both of them are experienced EIA professionals. The interviews will be conducted individually and will be transcribed by the lead researcher (Jie Ma) and the project supervisor (Peter Duinker). And then, the interview transcripts will be coded using Nvivo. Analysis will focus on the satisfaction level of key EIA stakeholders with the quality of science used in EIA and contributing factors to the current status of science in EIA. Potential opportunities and/or challenges for the improvement of science used in EIA will also be identified in the analysis of interview transcripts.

Who Can Take Part in the Research Study

You may participate in this study if you are a relevant EIA stakeholder (e.g., EIA scholars, regulators, consultants, NGOs, and EIA proponents). All relevant EIA stakeholders are welcome to participate in the online survey, while only EIA stakeholders who are experienced EIA professionals and also know the matter of science used in the EIA process will be qualified as an interviewee for this study.

What You Will Be Asked to Do

You will be asked to participate in an interview. You will answer a list of prepared questions, but also be assigned the opportunity to add the points you consider as being relevant to the overall study. The interview will be conducted either over-the-phone or in-person based on the locations of interviewees. Before starting the interview, participants will be asked to sign a signature page which indicates that they have already read the explanation about the study, and agree to participate in the study; but they also understand that their participation is voluntary and they are free to withdraw from the study at any time.

The interview will be audio-recorded and will take between 60 and 90 minutes. Following a few demographic questions, the interview will focus on the perceived quality of science used in EIA and contributing factors to the status of science practiced in EIA. The perceived potential for improving the science in EIA practices, the perceived satisfaction level with the contribution of EIA scholar community to the quality of science used in EIA, and the expectations to other stakeholders' contributions to the improvement of science in EIA will also be asked.

Possible Benefits, Risks and Discomforts

Benefits:

You may not experience any direct benefits from participating in this study, but you may benefit from the final results, which could provide insight to the scientific dimension in the EIA process in the context of Canada, as well as the comparison of the opinions between EIA scholars and EIA practitioners.

Risks and Discomforts:

It is anticipated that this study poses minimal risk to participants. The issues arising in the interviews will be based on your direct experience as a key EIA stakeholder. However, your identity will not be made known by being assigned a random participant number in the interviews, and will be provided the opportunity to withdraw at any time up to one week following the interview, making the probability of causing psychological discomfort to be low.

Compensation / Reimbursement

You will not receive any compensation for participating in the study.

How your information will be protected:

Privacy:

As for the interview part, in order to protect your privacy, the following steps will be taken to ensure others (i.e., third parties) do not know your participation in this study. The list of potential interviewees will only be shared in the lead researcher's committee including the lead researcher herself (Jie Ma), the project supervisor (Peter Duinker), and the committee member (Tony Walker). Also, only the lead researcher and her thesis committee will have access to the data files. The potential interviewees located in Halifax Regional Municipality will be allowed to choose a location for an in-person interview at their convenience on purpose for guaranteeing that they will have the highest level of comfort possible to speak openly about their opinions. As for those who can only take an over-the-phone interview, the lead researcher will stay in a soundproofing room alone for the interview in order to protect the privacy of the participants from third parties. The interview invitations will be sent to potential participants via emails individually. All interview records will be transcribed by the lead researcher and the project supervisor. No third party will participate in the transcription process.

Anonymity:

All interviews will be audio recorded. These audio files will be destroyed immediately after transcription. Only the lead researcher and the project supervisor will participate in the transcription. One week after the interview the lead researcher will assign the transcript an anonymous participant number so that all interview data will be anonymized. Any identifying information from interviews will be removed prior to being reported.

Confidentiality:
All data and information provided by you will be kept strictly confidential. The lead researcher will not release any personal data. Only the lead researcher and her thesis committee will have access to the data files.

Quotes will not be directly attributed, and any quotes that would give away your identity will be avoided. Your specific role (e.g., government scientist, EIA regulator, and consultant) within the two sectors (i.e., EIA practitioners, and EIA scholars) will not be included in quotes because all participants are categorized into “EIA scholars” and “EIA practitioners” groups. Specifically, a quote may indicate “a quote from an EIA scholar” or “a quote from an EIA practitioner”.

Data retention:
Information that you provide to us will be kept private. Only the research team at Dalhousie University will have access to this information. We will describe and share our findings in the lead researcher’s Master thesis, Thesis Defense, and also journal papers. We will be very careful to only talk about group results so that no one will be identified. This means that you will not be identified in any way in our reports. The people who work with us have an obligation to keep all research information private. Also, we will use a participant number (not your name) in our written and computer records so that the information we have about you contains no names. All electronic records will be kept secure in an encrypted file on the researcher’s password-protected computer for a period of three years before being deleted.

If You Decide to Stop Participating
You are free to leave the study at any time. If you decide to stop participating at any point in the study, you can also decide whether you want any of the information that you have contributed up to that point to be removed or if you will allow us to use that information. You can also decide for up to one week following the interview if you want us to remove your data. After that time, it will become impossible for us to remove it because it will already be anonymized.

How to Obtain Results
The final results of the survey will be shared through scientific journals, presentations, and the Master’s thesis of the lead researcher.

Questions

We are happy to talk with you about any questions or concerns you may have about your participation in this research study. Please contact Jie Ma (at 902-9992367/ jie.ma@dal.ca) [or Peter Duinker (at 902-494-7100, Peter.Duinker@Dal.Ca)] at any time with questions, comments, or concerns about the research study. We will also tell you if any new information comes up that could affect your decision to participate.

If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca (and reference REB file # 2016-3816)."

APPENDIX F: Signature Page for Interviews

DALHOUSIE UNIVERSITY

Project Title: Scholar and Practitioner Perspectives on the Quality of Science in Environmental Impact Assessment

Lead Researcher: Jie Ma, School for Resource and Environmental Studies, Dalhousie University, Jie.Ma@dal.ca

Other Researchers

Peter Duinker, School for Resource and Environmental Studies, Dalhousie University, Peter.Duinker@Dal.Ca (Project Supervisor)

Tony Walker, School for Resource and Environmental Studies, Dalhousie University, trwalker@dal.ca (The Committee Member)

I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I understand direct quotes of things I say may be used without identifying me. I agree to take part in this study and I agree that the researcher will audio-record the interview with me. My participation is voluntary and I understand that I am free to withdraw from the study at any time, until one week after my interview is completed.

Name	Signature	Date
____________________	________________________	________________________

APPENDIX G: Detailed Summary of The Reasons Why EA Scholars and Practitioners Were Dissatisfied with The Quality of Science Used in 12 EA Components.

1. Non-existent EA components

Scholars	Practitioners
CEA	
Incorporating SA into EA	
HHIA	HHIA
	Monitoring and follow-up
	SIA

2. Inadequate implementation [purpose issues]

EA components	Scholars	Practitioners
Baseline data collection		- Baseline data should be defined as forecasting the conditions of VECs without a project; however, most of the EA practitioners do not realize this.
Monitoring and follow-up	- Follow-up activities are still oriented for compliance purposes rather than adaptive learning purposes.	
Approaches to species at risk		- The purpose of designing approaches to species at risk is considered by regulators as an opportunity for forcing their own agenda.
Public participatory processes	- Public participation occurs in the late review stages of an EA process when most design decisions have already made, which weakens the effects of public comments and power on project decisions.	- Public participation is a controlled consultation process and does not provide the public opportunities to engage the discussion of decision-making process.

3. Very weak scientific foundation

EA components	Scholars	Practitioners
Time and space boundaries	□ Insufficient understanding of how to determine spatial boundaries for migratory species and cumulative effects	
Baseline data collection	□ Insufficient understanding of natural ecosystem functions	
Approaches to impact prediction		□ Lack scientific methods to evaluate baseline data for impact prediction
Cumulative Effects Assessment (CEA)	□ There is no specific robust scientific method used for CEA.	□ CEA has a very weak scientific foundation; □ There is no specific robust scientific method for CEA.
Incorporating SA into EA	□ There is no well-structured robust scientific method for incorporating sustainability into EA.	
Social Impact Assessment (SIA)	□ Lack of consistently systematic methods for SIA	

4. Too narrow scope and focus

EA components	Scholars	Practitioners
Valued Ecosystem Components (VECs)	□ The focus on single components rather than ecological systems, landscape, and communities	□ Ignored social components in the consideration of VECs
Time and space boundaries	□ Lack of consideration of the dynamics of spatial variability for different VECs; □ Lack of consideration of long-term impacts	□ Ignored downstream greenhouse gases (GHGs) when deciding spatial boundaries;
Baseline data collection	□ Insufficient baseline data collection; □ Excluded consideration of natural heterogeneity	
Species at risk	□ A lack of holistic thinking of an entire ecosystem and its functions, but too much attention paid to single species	
Cumulative Effects Assessment (CEA)	□ The consideration of CEA is limited to only the overlapping of impacts in time and space boundaries between projects	
Social Impact Assessment (SIA)	□ The scope is too narrow; □ The focus is mainly on economic benefits.	□ SIA mainly focuses on demographic descriptions;

		□ There is too much attention to positive impacts on social VECs and negative impacts are ignored.

5. Unclearly or incorrectly defined scope

EA components	Scholars	Practitioners
Baseline data collection	□ Too broad coverage of baseline data collection	
Determination of impact significance	□ The definition of impact significance is vague.	□ Impact significance thresholds are poorly defined.
Cumulative Effects Assessment (CEA)	□ The definition of CEA in EA regulations is not clear.	
Incorporating Sustainability Assessment (SA) into EA	□ The definition of sustainability is poorly defined in EA.	□ The definition of sustainability is poorly defined in EA.
Social Impact Assessment (SIA)	□ SIA is not clearly defined and the coverage is also not clear.	

6. Ignored consideration of uncertainties

EA components	Scholars	Practitioners
Impact prediction	□ Uncertainties are ignored.	
Determination of impact significance	□ Uncertainties are ignored.	
Monitoring and follow-up		□ Uncertainties are ignored in the design of monitoring and follow-up activities.
SIA	□ Uncertainties are ignored.	

7. Big gaps between what should be done and what has been done [methodology issue]

EA components	Scholars	Practitioners
Valued Ecosystem Components (VECs)	□ Lack of a scientific rationale □ The fundamentally simplistic and biased methods to select VECs by proponents, consultants and regulators	□ Biased methods to select VECs □ VECs are selected based on the regulators' preference/request rather than the actual necessity □ A standardized process of VEC selection
Baseline data collection		□ A big gap between how it should be done and what has been done
Impact prediction	□ Impact prediction modelling is inadequately used	□ The comparison of alternative scenarios is ignored

	Models are oversimplified The comparison of alternative scenarios is ignored	
Determination of impact significance	Subjective professional judgements are often used as methods rather than scientific methods	Determination process is not consistently systematic based on facts
Monitoring and follow-up	Monitoring data are rarely collected for public access	
Species at risk	Approaches to species at risk are standardized, which are usually to propose a buffer zone, rather than are designed based on the species' ecological characteristics	
Public participatory processes		Many people are ill-informed, which makes their comments useless to project decisions
Social Impact Assessment (SIA)	Lack of consistently systematic methods for SIA	

8. Insufficient baseline data collection

EA components	Scholars	Practitioners
Time and space boundaries	Boundaries limited by existing available data	Boundaries limited by existing available data
Impact prediction	Insufficient baseline data results in a poor quality of impact prediction	
Social Impact Assessment (SIA)		Insufficient baseline data for SIA

9. Ambiguous decision-making processes

EA components	Scholars	Practitioners
Time and space boundaries	Unclear rationale	
Impact prediction	Underlying assumptions behind impact predictions are unclear and ambiguous	
Determination of impact significance	Determining impact significance is not consistently systematic and also the process is not transparent.	The process is not transparent.

10. Political barriers

EA components	Scholars	Practitioners
Time and space boundaries		Impractical expectations of regulators
Baseline data collection		Unwillingness of proponents to release their field data
Determination of impact significance		Political barriers restrict the judgements of practitioners

11. Limited resource investments (e.g., time, human and financial resources, etc.)

EA components	Scholars	Practitioners
Public participatory processes	There is a lack of resources used to support public participation. Time provided for the public to comment EA is too short.	

APPENDIX H: Detailed Summary of The Reasons Why The Interviewees Were Unsatisfied with the Quality of Science Used in 12 EA Components.

1. Non-existent EA components

EA Stages	EA components	Interviewees
Post-EA Phase	Monitoring and Follow-up	- Lack of monitoring and follow-up after project approval

2. Inadequate implementation

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Valued Ecosystem Components (VECs) selection	- Disagreement on the appropriateness of selecting VECs;
	Cumulative Effects Assessment (CEA)	- Poorly defined CEA
	Public Participation Processes	- Public participation should be fact-based; however, it has usually been oriented by opinions and feelings, which is not helpful to improve the overall quality of EA.
Post-EA Phase	Monitoring and Follow-up	- Lack of a build-in adaptive learning process in EA results in ignored potential learning opportunities

3. Very weak scientific foundation

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Impact Prediction	- Not enough scientific literature for impact prediction
	Impact Significance Determination	- Lack of understanding of the trade-offs and benefits of various options in impact significance determination
	Cumulative Effects Assessment (CEA)	- Lack of a good understanding of how human activities have already accumulatively stressed ecosystems

4. A too narrow scope and focus

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Baseline Data Collection	- In general, the temporal and spatial breadth of baseline data collection is too narrow.
	Approaches to Species at Risk	- Too much attention to individual species at risk makes people overlook ecosystem functions and the main species and drivers of ecosystem functions which are not on the list of species at risk.
	Cumulative Effects Assessment (CEA)	- Indirect effects of the overall development on a place over time are ignored in CEA.

5. Unclearly or incorrectly defined scope

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Baseline Data Collection	- Unclear extent of expected primary field data collection - No consensus on how to collect baseline data
	Impact Significance Determination	- Lack of legal definition of significance - Some proponents and consultants use different definitions of the significance of effects, which results in disputes over what should be the proper criteria for determining impact significance.
	Cumulative Effects Assessment (CEA)	- The scope of CEA is poorly defined
	Public Participation Processes	- Unclear understanding of the role of public participation in EA

6. Ignored consideration of uncertainties

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Impact Prediction	- Inappropriately dealing with uncertainty in impact prediction
	Impact Significance Determination	- Inappropriately dealing with uncertainty in impact significance determination

7. Big gaps between what should be done based on scientific literature and what has been done in real EA practices

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Valued Ecosystem Components (VECs) selection	- Lack of consistency in selecting VECs - Lack of scientific rationale for selecting VECs - Low level of science used in selecting VECs - VECs are pre-determined and negotiated by regulators. - VECs are selected based on the experience of practitioners rather than ecological realities.

The EIS Preparation Phase	Baseline Data Collection	- Lack of rigorous scientific practices on baseline data collection - Consultants use subjective judgements to decide how to collect baseline data. - Baseline data has been collected in an inappropriate way with a scientific flaw. Baseline data should be purposively selected to be collected based on an understanding of how natural systems work, and then the baseline data should be capable of being used to predict the impacts on the natural systems with and without a proposed project. - Practitioners use a lot of desktop information as baseline data for impact assessment.
	Time and Space Boundaries	- How proponents currently scope their projects' impacts does not align with ecological reality. Specifically, a proposed project may bring some negative impacts on some animals over their whole lives; however, proponents usually only include some certain negative impacts during a few years rather than all footprints on the animals. The real impacts created by the project should be considered based on the ecosystem function, and then determine the scope of impacts based on ecological realities.
	Impact Prediction	- Disagreement on using existing data for impact prediction - Consultants sometimes predict what would happen on selected VECs with a proposed project and then compare that with the condition of the VECs before the project; however, this is a wrong way to predict impacts caused by the project because two predictions about the VECs with and without a project should be done and then the difference between two predictions of the impacts are the real impacts caused by the project.
	Impact Significance Determination	- Subjective value judgements embedded in determining impact significance - Statistical significance is rarely used as a part of the evaluation of impact significance - In an absence of a proven statistically sound threshold for effects in a cause-effect chain, the level of impact significance totally depends on subjective expert opinions and these opinions may be changed due to their different roles in EA.
The EIS Preparation Phase	Cumulative Effects Assessment (CEA)	- Lack of a consistent thinking of the assimilative capacity of entire ecosystems
	Public Participation Processes	- Lack of continuity in public participation - Lack of public education

		- Current structure of a semi-traditional public hearing does not efficiently deal with many public comments on very broad issues, such as climate change, and the high volume of opinions on these irrelevant issues partially result in the low efficiency of EA hearing.
Post-EA Phase	Monitoring and Follow-up	- Low level of science in monitoring and follow-up - Very little monitoring and follow-up information is published for public access - Cookie-cutter approaches for follow-up and monitoring - Some conditions in follow-up and monitoring that require proponents to adhere to are too vague - Monitoring programs usually do not include affected people so that adjustments cannot be made to focus on the important issues that should be discussed and recorded in monitoring records.

8. Insufficient baseline data collection

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Baseline Data Collection	- Inadequate baseline data collection - Lack of long-term baseline data collection
	Impact Prediction	- Poor baseline data collection weakens the quality of impact prediction.
	Cumulative Effects Assessment (CEA)	- Lack of baseline data results in the inability of proponents to do CEA

9. Ambiguous decision-making process

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Valued Ecosystem Components (VECs) selection	- Lack of justification of selecting single species and further extrapolation - Lack of transparency in the discussion and determination of VECs
	Baseline Data Collection	- Disconnect between project designs and required baseline data collection

10. Political barriers

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Baseline Data Collection	- Lack of a legislated provision of adequate baseline information
	Cumulative Effects Assessment (CEA)	- CEA is the part of EA that proponents and governments seem to find an excuse not to do.
	Public Participation Processes	- It is hard to get aboriginal groups involved and to exchange information with them - Legislation makes unframed public comments unacceptable even though some of the comments include some valuable observation data
Post-EA Phase	Monitoring and Follow-up	- Not publicly available baseline data makes it hard to long-term track after project approval. - Proponents lack awareness of the importance of monitoring and follow-up - Disconnect between different stakeholders' understanding of the value of monitoring and follow-up - Governments pay more attention to new EA application than after-approved EA.

11. Limited resource investments (e.g., time, human, and financial resources, etc.)

EA Stages	EA components	Interviewees
The EIS Preparation Phase	Baseline Data Collection	- Financial barriers for proponents to collect baseline data - Time constraints from the proponent side are a barrier to collecting enough appropriate baseline data
Post-EA Phase	Monitoring and Follow-up	- Lack of human resources and financial support for regulators to monitoring and follow-up with proponents, which makes it sound like follow-up is nothing more than meetings or phone calls.