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Title: Risk as a Fundamental Barrier to Adoption of Low Impact Design Technologies

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RISK AS A FUNDAMENTAL BARRIER TO ADOPTION OF LOW IMPACT DESIGN TECHNOLOGIES

Abstract

Urbanization has resulted in a rapid transformation of the urban landscape resulting in an increased stormwater runoff and the subsequent degradation of waterways. The conventional stormwater management systems designed for peak flow management and end of the pipe treatment (e.g. detention pond and retention basins) are no longer sustainable. Hence, the needs for a paradigm shift towards the adoption of Low Impact Design (LID) technologies that uses distributed controls approaches throughout the landscape to manage frequently occurring storm events.

LID encompasses the use of structural devices (engineered systems) and non-structural approaches land use planning to maintain or restore the natural hydrologic functions on a site with the goal of minimizing the impact from urban stormwater runoff. Of particular concern are the rate and volume of stormwater runoff, the pollutants carried in the runoff, and recharge of water into the ground. LID has been proven to reduce development and infrastructure costs, minimize operations and maintenance costs, and improve the marketability of projects.

However, the adoption of LID technology by stakeholders has been discouraging due to perception of risk about the failure of LID devices. To substantiate this as part of an ongoing research study, interviews with stakeholders were conducted to ascertain the level of perception of risk, factors influencing perception of risk and its impacts on adoption of LID technologies for stormwater management. The findings from this study shows a high level of awareness about LID technologies among the stakeholders, but the slow rate of adoption was associated with perception of risk, high cost of adoption among others factors are presented in this paper.

Keywords: Urbanization, Stormwater Management, Runoff, Pilot Projects, LID, Risks, Risk-Sharing, Decision Making

Introduction

LID encompasses the use of structural devices (engineered systems) and non-structural approaches land use planning to maintain or restore the natural hydrologic functions on a site with the goal of minimizing the impact from urban stormwater runoff. It uses a combination of these technologies, or a "suite of technologies," to maintain or restore the natural hydrologic functions on a site with the goal of reducing the impact of development (Guillette, 2010). Of particular concern are the rate of storm water runoff, the pollutants in the water, and recharge of water into the ground. By reducing water pollution and increasing groundwater recharge, LID helps to improve the quality of receiving surface waters and to stabilize the flow rates of nearby streams. The integrated LID devices that are available allow the designer to restructure the built environment to control stormwater and capture rainwater in order to minimize the impact from stormwater runoff. The LID approach differs from conventional conveyance systems as it promotes the highest and best use of the intrinsic land form and built structure(s) to both distribute storm water and collect rainwater. It capitalizes on the integration of infrastructure, architecture, and landscape in order to create a balanced, hydrologically functional and sustainable site. The integration of LID devices permits the developer and designer to use an array of stormwater management devices that are both cost-effective and environmentally sound.

However, supporting the transitions for adoption of innovation like the LID requires demonstrations on a smaller scale or pilot. Pilot projects are important; providing onsite evaluations and assessment of the effectiveness and efficiency of new technology. In general, pilot projects are concerned with the spread of knowledge about innovation, not the rate of adoption of innovation itself. In spite of this, between technology awareness and adoption lies an element of uncertainty and risk which is deemed a fundamental barrier to adoption of innovation like LID. The findings presented in this paper was an outcome of interviews with stakeholders level of awareness about LID technologies, perception of risk of LID technologies , and mode of risk management in contemporary projects and how will this differ with LID technologies. The stakeholders interviewed include design/landscape architects, developers, stormwater consultants and building contractors.

Uncertainty and Risk

Uncertainty is certainty. Uncertainty can be defined as an absence of information about parts of a system under consideration. Uncertainty is always present, even when information is perceived as complete. A high level of uncertainty inhibits adoption because people are averse to risk and it can be fuzziness, randomness or incompleteness of information (Blockley & Godfrey, 2000). Innovation adoption uncertainties can be in two parts, the probability of occurrence and the consequences of occurrence. In the context of risk management, uncertain events are usually considered as hazards with the potential to have negative effects.

Risk connotes different meaning as it primarily depends on specific application and contextual situations. Unlike uncertainties, risk can either be pure and speculative, foreseen and unforeseen and finally information and interpretation risk (Ali, 1999; AS/NZS, 2004). Risk has often been considered to be a major factor reducing the rate of adoption of a new technology (Lindner, 1987; Tsur, Sternberg, & Hochman, 1990). It is not the expected outcome that constitutes a risk but the degree to which that outcome would be disappointing to the stakeholders'. All risk concepts have one element in common; a distinction between reality and possibility. Hence, uncertainty is closely related to risk and in many theories of behaviour, psychological uncertainty is assumed to be an important mediator of human responses in situations with unknown outcomes.

The issue of risk in the adoption of LID technologies has not been given attention. The need for strong empirical evidence to test stakeholders' risk perception of LID technologies and its impacts on adoption needs critical evaluation. The importance of risk is not that it is happening, but that it might happen. Its existence is only in the mind. It is about thoughts and perceptions which can be individual, organisational or institutional (Dougherty, 1992; Storey, 2000). Risk perception of LID technologies by the stakeholders is simply due to a lack of knowledge about long term functionality. If a person's knowledge is complete, that person would have no uncertainty (Windschitl & Wells, 1996). But as pointed out earlier, uncertainty is always certainty as no one can adequately predicts with exactness the outcomes of emerging innovation.

Risk Perception

People's understanding and their interpretation of risk is vital for understanding risk related behaviour and adoption of innovation. The interaction between risk perception and adoption requires a fundamental understanding of risk by stakeholders. It has traditionally been conceived as a cognitive phenomenon, basically a question of information processing. The very term, perception, suggests that information is involved and is of crucial importance (Sjoberg, 1996). Perceptions are formed on the basis of information about the external world, ultimately based on sensory information, and they can be seen as the result of more or less rigid information processing. Risk perceptions are viewed as individual's personal considerations and private understandings based on their values, beliefs, education, experiences and stake in the outcome (Beecher et al., 2005; Covello & Sandman, 2001) .

Stakeholders' risk perceptions are further reinforced by continuous process of communication and interaction within a social culture. The perception of an expert will be different from someone less familiar with the technology in question, therefore, familiarity is a factor in risk perception (Beecher, et al., 2005). Three theories of risk perceptions as it affects innovation adoption can be inferred, they are Knowledge theory, Economic theory and Personality theory (Dake, 1990; Wildavsky & Dake, 1990). The knowledge theory explains people's perception about the risk inherent in a new technology that seems most directly to threaten their wellbeing. The perception is directly hinged but not limited to the level of education and expertise about the innovation in question. The economic theory shows the rich are more willing to take risks stemming from technology because they benefit more and are somehow shielded from adverse consequences while the poor feel just the opposite. The personality theory on the other hand describes individual risk-aversion or risk taking propensities: some individuals love risk taking so they take many risks, while others are risk averse and seek to avoid as many risks as they can. Risk perception is multi-dimensional implying that a particular hazard means different things to people with different contexts knowledge, affluence and personality.

Perception of risk may be visualized in three developmental stages (Fig. 1), and is shaped by various elements within the "explosion symbol" often called outrage. The outrage is influenced by who communicates the issues, form modes and channel of communication. For instance, gender influence has an impact on communication. Female communicators are perceived more trust worthy than their male counterpart (Keith, 1996). Add to this the fact that "men tend to judge risks as smaller and less problematic than do women" (Slovic, 1999). These factors have various degrees of influence on the personality of the individual depending on their education, experience and stake in the outcome, which is further reinforced by the interaction within the community where they find themselves. To change the perceived level of LID risk, risk communication must strive to change the number and intensity of outrage factors (Covello & Sandman, 2001). Positive risk communications over time brings about perception development which triggers innovation adoption by "Early Adopters"(Rogers, 1995). The early adopters are respectable people, opinion leaders who try out new ideas, but in a careful ways. Successes recorded by the early adopter bring about perception maintenance which promotes further adoption by the "Early Majority". These are thoughtful people, careful but accepting change more quickly having learned from the experiences and failures of the early adopters. The "Late Majority/Laggards" typifies the last stage in the innovation adoption life cycle. They consist of those who are traditional people, caring for "the old ways", are critical towards new ideas and will only accept it if the new idea has become mainstream or even tradition. The adoption curve tends to exhibit "S" shape over time as people develop confidence in the technology. Therefore, risk perception is not static, it changes over time, and positive perception maintenance ensures adoption while negative maintenance results in innovation rejection.

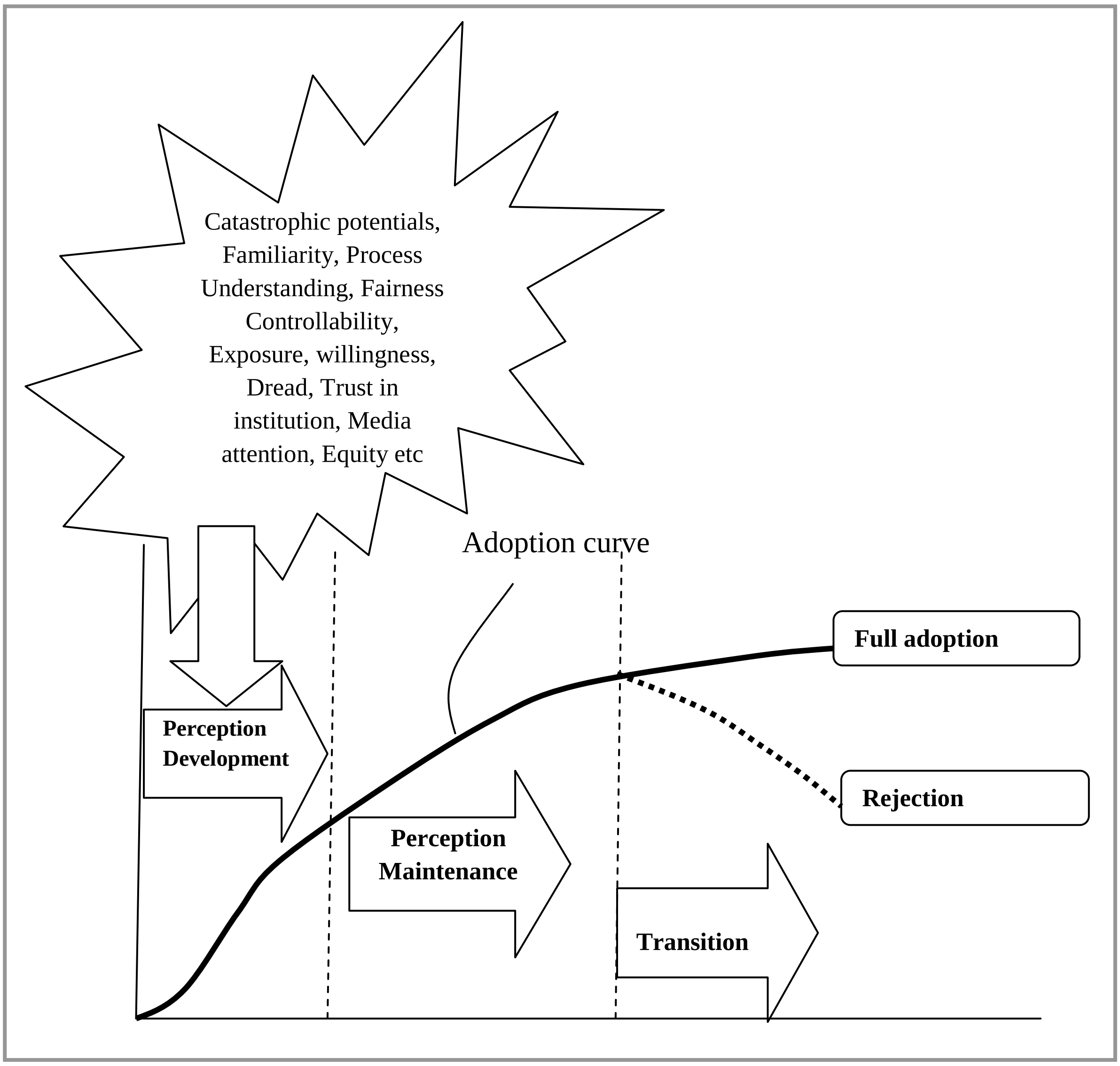

Figure 1: Risk perception development stages and innovation adoption life cycle

Methodology

The objectives of the ongoing research study are:

- To identify and develop a contract structure which ensures proper construction of LID technologies through contractual risk sharing mechanism and ,
- The development of incentive mechanism to contribute to the adoption of LID technologies.

To accomplish these objectives, a qualitative research approach was chosen because of limited information availability on the topic of research, unknown variables and inadequacy of the theory base. Under this scenario, a qualitative study helps define what is important-that is what needs to be studied (Leedy & Ormrod, 2010; Neuman, 1997). A preliminary literature review conducted on the implementation of LID for stormwater management identified risk and uncertainty associated with the suite of technologies as a barrier to adoption (Earles, Rapp, Clary, & Lopitz, 2008). To further explore this as part of an ongoing research study, interview session was held with the individual LID stakeholder selected. The interview focussed on obtaining stakeholders general knowledge of LID, risk perception of LID technologies, impacts of incentive provisions on the adoption of LID among others. The stakeholders consisted of design/landscape architects, developers, stormwater experts, council officials and building contractors. Personnel interviewed were all senior executives of their respective organisations (Keith, 1996; Morgan, 1996; Slovic, 1999). Contact details of selected participants were obtained through an internet search limited to Auckland region which were later followed by an email request for thirty (30) minutes one-on-one interview. Interviews conversations were digitally and manually recorded and probing questions asked whenever more clarifications were required.

In addition to the digitally recorded interview conversations, respondents were asked to respond to a table that identified barriers to LID adoption according to group classification. The group classifications were Technical (T), Economic (E), Risk (R), Institutional (I) and Social (S) factors. The TERIS template provided definitions and brief explanation of what constituted each of the TERIS components. The following were the identified barriers for respondents' categorical classification:

- Fear of liability (engineers, owners, reviewers approving design)
- Reluctance to try something new
- Lack of education and training
- Limited design examples
- Costs-design, construction, operation and maintenance-life cycle
- Public perception
- Compatibility with existing requirements
- No clear economic incentive for using LID
- Semi-arid area hydrology/poorly drained soil
- Maintenance and durability
- Standing water nuisance
- Fear of lengthening review process
- Conflicts with municipal code requirements
- Expansive soils and construction defects lawsuit
- High groundwater table
- Other alternatives are easier

Results

There was an overwhelming positive response from the email requests on one-on-one thirty minutes interviews sent to fifteen participants identified through the internet search. This positive response was as a result of high level of awareness about LID technologies among the stakeholders interest. The level of interest by stakeholders was displayed on every interview sessions where further useful information and contacts were provided at will. Overall, twelve (12) participants responded within a week of request, giving a success rate of 75%. The 25% shortfall was compensated for by three (3) people who were brought in on two occasions to participate in the interview session. On these two scenarios, group focus approach was adopted thereby providing insights and contribution from various perspectives (Morgan, 1995, 1996; Morgan & Krueger, 1993). In all, design/landscape consultant, stormwater experts, contractors, developers and council officials participated in completing the TERIS template. Figures 2 and 3 below provide the summary of positive responses and categorical classifications of identified barriers by stakeholders. Figure 2 details the respondents' perception of LID adoption barriers based on the TERIS classification and figure 3 provides supplemental information on the percentage of comparative significance of each categorical classification as obtained. The digitally recorded interview was focussed on the projects the stakeholders considered to be LID, how risk is dealt with in their contemporary projects and how would this differ from LID projects?, what impacts will contractual risk sharing and the provisions of incentives have on the adoption of LID?, who among the stakeholders should be at the forefront of promoting LID technologies among others?. From the interview conversations, there was a high level of awareness about LID technologies among stakeholders. However, the low level of adoption was linked with high cost of adoption, risk of design and construction failure, limited design examples, maintenance and durability of LID technologies and the public perception about failures of pilot projects.

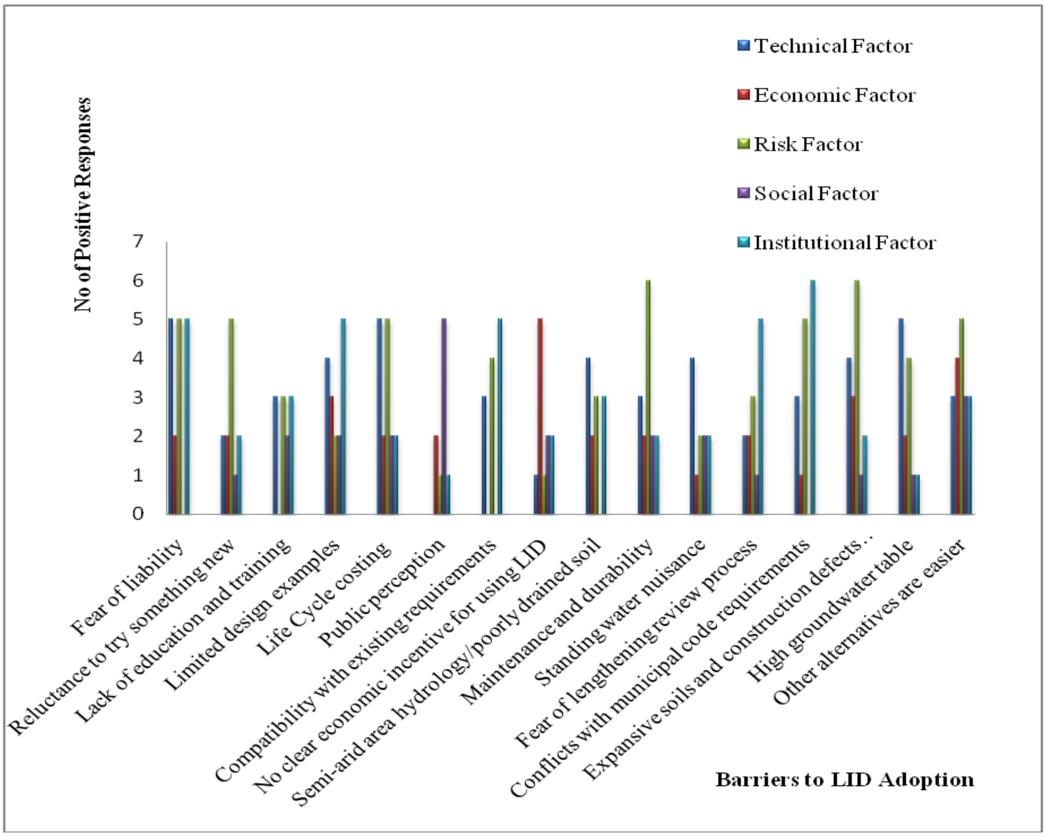

Figure 2: Respondents' perception of LID adoption barriers

Figure 3: Categorical barriers to LID adoption

Discussions

The stakeholders' categorical groupings and the emergence of risk with a weighting of 28% confirms perception of risk as the fundamental barriers to the adoption of LID. Prior to the findings of this study, institutional barrier was believed to be a major barrier to adoption and had since been the focus of scholars. As a result of this finding, institutional factor was subject to a critical examination which revealed that risk factor is inherent in the institutional settings and decisions. This is shown by ensuring compatibility with existing requirements and codes, and the general lengthening review process to ensure that statutory regulations are fully complied to avoid litigation for negligence in term of LID failure. Therefore, perception of risk is a fundamental barrier to adoption and not the institutional factor as earlier claimed. This finding supports stakeholders' risk perception and the innovation adoption life cycle (Rogers, 1995; Wildavsky & Dake, 1990) .

Furthermore, the fear of professional liability was responsible for high cost associated with LID design due to contingency cost to cover professional liability which may result from design failure as a result of lack of design standard and the limited design examples. On the other hand, the developers were generally unwilling to adopt LID due to high cost, insufficient knowledge about functionality and durability of LID, and the public perception of failed LID pilot projects. To enhance rapid adoption of LID, there is a need to change stakeholders' perception of risk about LID projects. This could be achieved through provisions of incentives and risk sharing mechanism that promotes learning -by- doing which will provide the platform for incorporating lesson learnt in future LID projects. Moreover, there is the need for proper implementation and construction of pilots projects to change negative perception of failure as experienced in failed pilot projects. Leadership commitment through implementation of LID on publicly funded government project like schools, government offices and public parks will facilitates greater awareness and positive perception maintenance which transits to individual LID adoption. In addition, provision of incentives like subsidies, stormwater charge waiver, fast track approval process, free technical services and other forms of incentives will build trust and confidence in the technology and motivates individual developers to adopt LID on a major scale.

Conclusion

This paper is a preliminary result on identifying stakeholder perceptions of risk in adopting LID technologies for stormwater management. To actualise this feat, interviews with pre-selected stakeholders limited to Auckland region through an online search was conducted. The interview was focussed on stakeholder general understanding of LID, mode of risk management in their contemporary day to day projects and how would this differ with innovative technology like LID among others.

The findings show risk is a factor responsible for high cost of LID adoption as a result of contingency to cover for professional and general liability for risk associated with the implementation and adoption of LID. It shows that, risk perception is not profession specific; it is a fundamental fact of life for individuals as reflected in the interview conversations with stakeholders. Leadership examples through implementation of LID on publicly funded projects will change public perception and enhance familiarity. Familiarity is a factor in risk perception and this will bring about positive perception maintenance and ultimate transition to LID adoption for sustainable urban environment. Following this findings, the development of an incentive and risk sharing framework to promote the adoption of LID technologies through learning-by-doing is currently underway.

References

Ali, J. (1999). Management of risks, uncertainties and opportunities on projects: time for a fundamental shift. *International Journal of Project Management, 19*, 89-101.

AS/NZS. (2004). *Risk Management Guidelines, Companion to AS/NZS 4360:2004*.

Beecher, N., Harrison, E., Goldstein, N., Mcdaniel, M., Field, P., & Sussking, L. (2005). Risk Perception, Risk communication, and Stakeholder Involvement for Biosolids management and Research. *Journal of Environmental quality*(34), 122-128.

Blockley, D. I., & Godfrey, P. S. (2000). *Doing it Differently*. London: Thomas Telford.

Covello, V., & Sandman, P. (2001). *Risk Communication: Evolution and revolution.* : John Hopkins University Press.

Dake, K. (1990). *Technology on Trial: Orienting dispositions toward environmental and health hazards.*, University of California, Berkeley.

Dougherty, D. (1992). Interpretive barriers to successful product innovation in large firms. *Organisation Science, 3*(2), 179-202.

Earles, A., Rapp, D., Clary, J., & Lopitz, J. (2008). Breaking Down the Barriers to Low impact Development in Colorado. Wright Water Engineers, Inc.

Guillette, A. (2010). Achieving Sustainable Site Design through Low Impact Development Practices. from http://www.wbdg.org/resources/lidsitedesign.php

Keith, S. (1996). Credibility in risky business: An interview with Vincent T . Covello,PhD: Community World.

Leedy, P., & Ormrod, J. (2010). *Practical Research- Planning and Design* (Ninth ed.). New Jersey: Pearson Education.

Lindner, R. K. (1987). *Adoption and diffusion of technology:an overview.* Paper presented at the technological Change in Postharvest Handling and Transportation of Grains in the Humid Tropics. ACIAR Proceeding Series, Australia

Morgan, D. (1995). Why things(sometimes) go wrong in focus groups. *Qualitative Health Research, 5*(4), 516-523.

Morgan, D. (1996). Focus groups. *Annual Review of Sociology, 22*, 129-152.

Morgan, D., & Krueger, R. (1993). *When to use focus groups and why. In D. Morgan(Ed.), Successful focus groups: Advancing the state of the art(pp3-19).* Newsbury Park,CA: SAGE.

Neuman, W. L. (1997). *Social Research methods: Qualitative and quantitative approaches* (3rd ed.). Boston: Allyn & Bacon.

Rogers, E. (1995). *Diffusions of Innovation* (4th ed.). New York: The Free Press.

Sjoberg, L. (1996). A Discussion of the Limitations of the Psychometric and Cultural Theory approaches to Risk Perception. *Radiation Protection Dosimetry, 68*(3/4), 219-225.

Slovic, P. (1999). Trust,emotion,politics, and science: Surveying the risk-assessment battlefields. *Risk Anal, 19*, 689-701.

Storey, J. (2000). The Management of innovation problem. *International Journal of Innovation Management, 4*(3), 347-369.

Tsur, Y., Sternberg, M., & Hochman, E. (1990). Dynamic modeling of innovation process adoption with risk aversion and learning. *Oxford Economic Papers*(42), 336-355.

Wildavsky, A., & Dake, K. (1990). Theories of Risk Perception; Who Fears What and Why? *Deadalus, 119*(4), 41-60.

Windschitl, P. D., & Wells, G. L. (1996). Measuring psychological uncertainty: verbal versus numeric methods. *journal of Experimental Psychology, 2*(4), 343-364.