Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/envsci

The split ladder of participation: A diagnostic, strategic, and evaluation tool to assess when participation is necessary

Margot Hurlbert [a,b,*], *Joyeeta Gupta* [b,c]

[a] *Department of Justice Studies and Sociology and Social Studies, University of Regina, Regina, Sk, Canada*
[b] *Governance and Inclusive Development, Amsterdam Institute for Social Science Research, University of Amsterdam, The Netherlands*
[c] *UNESCO-IHE Institute for Water Education, Delft, The Netherlands*

ARTICLE INFO

Keywords:
Public participation
Water governance
Social learning
Policy framing

ABSTRACT

The mainstream literature sees participation as critical to deepening democracy and solving complex environmental issues. An explosion of literature on public participation has occurred since Arnstein's ladder of participation in (1969). However, the literature does not address the conditions under which participation is likely to work and what it can achieve in different circumstances. In order to address these questions, this paper reviews the literature on participation, learning, trust, governance and management and conceptualizes the analysis through developing the split ladder of participation. It creates four ideal typical circumstances and explains what the nature and goal of stakeholder participation is for each circumstance. This model is then tested in four case studies in Mendoza, Argentina, Coquimbo, Chile, and Alberta and Saskatchewan, Canada. This split ladder is presented as both a diagnostic and evaluation tool and is supported through the use of examples.

1. Introduction

Environmental governance is challenged in responding to the complex environmental problems of the Anthropocene (Biermann et al., 2012; Gupta, 2014a). An emerging governance frame, adaptive governance, responds to this complexity (Folke et al., 2005) by stressing social learning, reflexivity, responsiveness, and accountability, operating in a system where the science is contextual, knowledge is incomplete and multiple ways of knowing and understanding are present (Brunner et al., 2005). Further, reflexive governance (Voß et al., 2006), deliberative democracy (Hajer and Wagenaar, 2003), and transition management (Loorbach, 2007; Rotmans et al., 2001) build on these themes. Congruently, global environmental change requires new ways of knowledge development and a new inclusive responsive science (Funtowicz and Ravetz, 1993, 2008; Gibbons et al., 1994; Jasanoff, 2004; Nowotny et al., 2001; Shiva and Bandyopadhyay, 1986).

Almost all proposals on improving global governance recommend stakeholder involvement (Norton, 2005; Pahl-Wostl et al., 2007b; Pahl-Wostl, 2009). This emerges from the literature on adaptive governance, development (Chambers, 1997; Hickey and Mohan, 2005), law (Razzaque, 2009) and

* *Corresponding author at*: Department of Justice Studies and Sociology and Social Studies, University of Regina, Regina, Sk, Canada. Tel.: +1 306 585 4232.
E-mail address: margot.hurlbert@uregina.ca (M. Hurlbert).
http://dx.doi.org/10.1016/j.envsci.2015.01.011
1462-9011/

particularly in relation to water governance (de Loe and Kreutzwiser, 2007; Plummer, 2006; Brooks, 2002; Hampton, 1999). The message is that the greater the participation, the better the chances for improving governance as first expressed in Arnstein's ladder of participation (1969).

The literature often romanticizes participation without examining when participation is challenging and/or implemented through inappropriate mechanisms, or where policy making is more appropriately technocratic and created or implemented by expert bureaucrats. Although the literature covers the contextual difficulties of participation (Allan and Wilson, 2009; Collins and Ison, 2009b), with modest impact (Akamani and Hall, 2015), it scarcely covers the conditions under which participation may work and the conditions which determine what level of participation should be used (Warren, 2009) for different policy problems. This paper hypothesizes that participation is not always necessary, not always useful, and may not always lead to consensus. It uses a methodological framework which links the nature of participation to the problem type, the nature of learning needed, and the type of adaptive governance or management required.

This paper first explores the nature of policy problems or problem structuring, the learning required in different types of problems, the concepts of trust, management, and governance. Based on these concepts and elaborating further on Arnstein's ladder, this paper creates a split ladder of participation to conceptualize the different relevance and impacts of participation to different problem types. This split ladder is presented, discussed, and analyzed in four case studies of water governance.

2. Elements relevant for assessing if and when participation is necessary

2.1. *Introduction*

Deciding on when and at what level participation is appropriate in which context is an inadequately developed puzzle (Hedelin and Lindh, 2008). Arnstein's hierarchical ladder system intimates that the highest rungs should be preferred over lower rungs (Arnstein, 1969; Johnson et al., 2004). This presumption is often replicated in the adaptive (water) management and governance literature. However, different levels of engagement are likely appropriate in different contexts depending on the objectives and the capacity of stakeholders (Richards et al., 2004; Michener, 1998; Tippett et al., 2007; Fung, 2006) and at differing levels of governance (local to international). This theme is explored below by analysing the nature of the problem, the role of learning and trust, or the degree to which stakeholders are willing to defer to the judgments of other stakeholders in the policy process (Tsaang et al., 2009: 103) which can reduce conflict (Mackenzie and Krogman, 2005: 517). Finally a distinction between management and governance of policy problems assists the analysis.

2.1.1. *The nature of the policy problem*

The structuring of the policy problem (a gap between a current situation and a more desirable future one; Hoppe, 2011, p. 23) is an important determinant of the appropriate mechanism of public participation. Adapting to anthropogenic climate change is a policy problem; responding to the increasing frequency and magnitude of extreme climate events such as floods and droughts is the same problem, structured differently. Further, problems can be unpackaged into smaller policy problems. For example, climate adaptation includes the policy problems of preparing municipal infrastructure and improving the adaptive capacity of rural producers for increasing frequency and intensity of floods and droughts. An issue typology, or how a policy problem is structured or framed and the resulting policy's form and content, determines how policy makers and the public construct meaning around the problem and how it is analyzed (Lebel et al., 2010; Collins and Ison, 2009a).

Although the framing of environmental and other social problems has been studied extensively (de Boer et al., 2010; Hisschemoller, 2005; Hoppe and Hisschemöller, 2001), in the context of integrating adaption into public policy it is only starting to be studied (Adger et al., 2009; Dupuis and Knoepfel, 2011; Dupuis, 2011; Moser and Ekstrom, 2010; Wolf, 2012). Policy design theories which analyze the form and content of a policy are highly relevant to explaining the deficit of implementing adaptation into policy processes (Dupuis, 2011; Hulme, 2005); they are independent variables determining the success of a particular policy (Ingram et al., 2007; Schneider, 2006; Schneider and Ingram, 1993).

Implicit in the definition of a policy problem is the social and political construct which articulates that a particular state of affairs is undesirable and that a more desirable future state (in accordance with science, values, norms, and goals) can be attained by governmental action (Hisschemöller and Hoppe, 1996). 'Reality' is linked to the 'perception' (Carroll, 1988: 1) of actors, and specifically those with the power to determine the policy agenda (Hisschemöller and Gupta, 1999). The relation between problem perception, definition, and policy framing between the citizenry and policy makers is important in democratic governance. Perspectives structure human observations and help people make sense of their environment and are constituted by people's underlying frames or belief systems (Vasileiadou et al., 2012). Structural disconnects between major groups and their 'perspectives' may result in a democratic deficit in which democratic systems lose viability (Hoppe, 2011: 5); for example, when the government frames a policy problem as 'responding to drought' or 'responding to flood' and the public frames the same problem as 'adapting to climate change' (Hurlbert, 2014). Examining public and government problem framing disconnects warrants expanding on the discussion of the structuring of policy problems.

Structured problems are problems where there is substantive agreement on norms, principles, ends and goals surrounding a policy problem and agreement on the knowledge inherent in solving the problem. These problems are largely determined by technical/bureaucratic specialists who are guardians of the public interest. An example of a structured environmental/drought problem is identifying the cost effectiveness of different crop practices to reduce soil erosion or determining the costs and benefits of expanding an irrigation project (Batie, 2008: 1177). A moderately structured policy problem occurs when policy makers have either

some agreement on norms, principles, ends and goals in defining a future state, or some agreement on the relevant and required knowledge inherent in solving the problem, but not agreement on both norms as well as knowledge (Hoppe, 2011: 73–75).

Unstructured problems are those in which uncertainty exists in respect to the values and science (Hoppe, 2011: 73). These are akin to 'wicked problems', social messes, or untamed public problems. Their causes and effects are difficult to identify and model; they are intractable and elusive because they are influenced by many dynamic economic (e.g. the variable distribution of costs and benefits), social, political and biophysical factors (Rittel and Webber, 1973). They tend to be connected to, or are symptoms of, other problems (Carroll et al., 2007). Fig. 1 illustrates the relationship between structured and unstructured problems and agreement on values/norms and scientific certainty.

Responding to climate variability and change and the embedded problems of drought and flood (IPCC, 2014) impact water and its governance. This is an unstructured problem (at the top left of Fig. 1) as the state finds it difficult to adopt and compel domestic actors to make binding greenhouse gas (GHG) reduction commitments (Hisschemöller and Gupta, 1999: 167; see also Gupta, 2014b) and both a value consensus and a stable knowledge base at global and national level is required (Haas and Haas, 1995). Adaptation to climate change which also lacks consensus on science and values is an unstructured problem in the same top left corner of Fig. 1 (Adger et al., 2009: 342–342; Adger et al., 2006). However, components of this adaptation problem may become structured or moderately structured policy problems:

1. Preparing municipal infrastructure for increasing frequency and intensity of floods (where knowledge is sound, but who pays is tenuous) could be illustrated on the top right hand corner of Fig. 1;
2. Improving the adaptive capacity of rural producers to drought (where assisting this group of actors is agreed but the science of future climate scenarios is uncertain) (Li, 2005). This would situate this policy problem on the bottom left side of Fig. 1.

The study of problem structuring and the level of agreement on both the related science and values, allows analysis of the appropriate public participation mechanism for a particular policy problem. However, two more factors are important: learning and social trust.

2.1.2. *The nature of learning needed*

Solving problems requires actors to learn about how the problem can be addressed. Social learning is learning in and with social groups through interaction (Argyris and Schön, 1978,1996; Siebenhuner, 2008) or collaboration, organization, and learning which occurs in networks of interdependent stakeholders (Mostert et al., 2007). It is a process of iterative reflection that occurs through sharing experiences and ideas (Keen et al., 2005: 9) and reviewing experiential history and ways of knowing, to ascertain an emergent hybrid of theorizing and practice which isolates difference leading to new insights and innovations (Blackmore et al., 2007). It includes interdisciplinary learning involving social and natural scientists.

Social learning can be single, double, or triple loop learning (Argyris, 1999; Keen et al., 2005; Cundill and Fabricius, 2010).

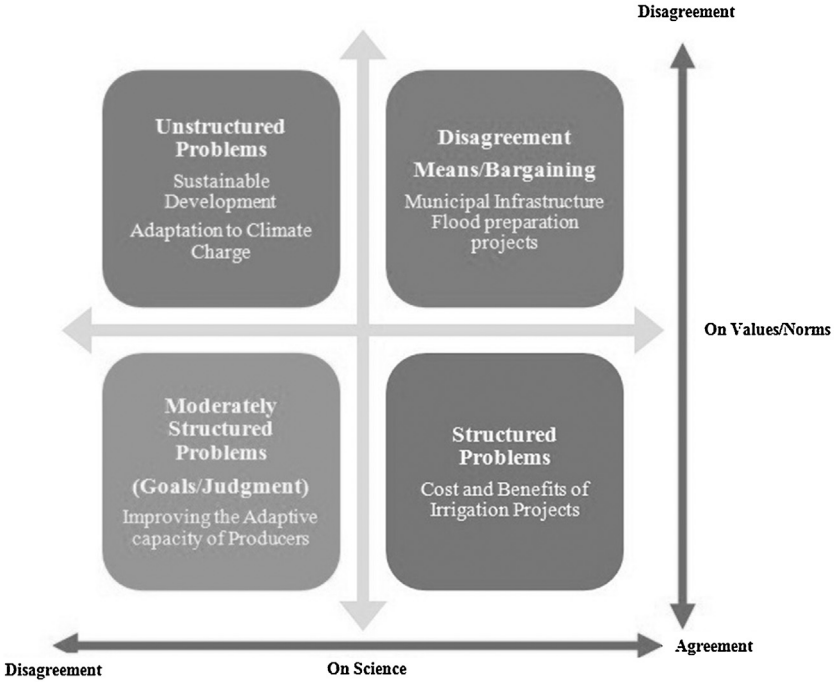

Fig. 1 – Four types of policy problems identified in policy analysis.
***Source*: Adapted from Hisschemöller (1993: 247); Hisschemöller and Hoppe (1996: 44); Hisschemöller and Gupta (1999: 157).**

Single loop learning refers to incremental changes, improving existing routines, and instrumental change in strategy within the existing normative framework. This learning is needed to improve the routines and policy approaches to address structured problems. Double loop learning involves questioning the assumptions and mental models underpinning strategies needed to solve moderately structured problems (when there is scientific certainty but no consensus on relevant norms and values, or where there is some scientific uncertainty, but not consensus on norms). Triple loop learning is needed when values and norms that underpin assumptions are questioned and reflected upon leading to a deeper understanding of the context, power dynamics and values influencing the management of natural resources such that underlying world views may be changed (Pahl-Wostl, 2009). Here analysis occurs in understanding how problems and solutions are related (even when separated widely by time and space) and learning goes beyond insight to context, leading to 'transformational' learning (Tschakert and Dietrich, 2010). Such learning is required to structure unstructured, wicked problems such as climate change and may be time consuming (Gupta, 2014a).

2.1.3. *The relevance of trust and information flow*

Learning requires mutual trust, trust that people have in those that they know, and 'social trust' or trust people have in those that they do not know, but there is confidence in the social structure within which people interact (Pretty and Ward, 2001). Social trust indicates whether people are willing to defer to the judgments of other stakeholders in the policy process. Even if people disagree, social trust can be high if people are willing to cooperate and work towards a common solution (Tsaang et al., 2009). This process of self-reflection recognizes individual mental frames and how they pertain to decision making which can occur with good facilitation (Pahl-Wost, 2006: 22). A clear link exists between trust and the levels of citizen involvement and quality of information flows (see Table 1).

Arnstein's (1969) ladder of participation is comparable to the concept of information flow with its bottom rungs of lowest participation showing manipulation and therapy to the highest rungs of delegated control and power. Dorcey et al.'s (1994) 'levels of public involvement' range from low levels of involvement aiming to inform or educate, to increasing levels of involvement (which are ongoing) aiming to build consensus. The congruence between participation, trust, and information flows is shown in Table 1. With high levels of trust there can be increased citizen involvement in iterative processes at the top of Table 1; although the methods of involvement of Dorcey in the left column can be used with any level of trust, Pahl-Wostl (2009) and Huntjens et al. (2011) conclude that to build trust, increasing information flows and iterative processes of involvement are required.

In relation to climate adaptation, trust building results from early communication of uncertainties, joint and participative knowledge production, open access to, and shared, information sources, transparent decision making process and sharing of responsibilities (Huntjens et al., 2011). This would entail climbing higher on Arnstein's ladder, or closer to the top of Table 1. Transparency and trust-building are closely related (Abrams et al., 2003), often requiring a leader to build trust by making sense of things, compiling and generating knowledge, managing conflict, linking actors, and mobilizing support for change (Folke et al., 2005). Hence, the concepts of management and governance also align with information flow and trust.

2.1.4. *Management versus governance*

Conceptually management and governance are distinct and yet overlapping processes. Management refers to the processes of decision making, coordination and resource deployment within a given normative and regulatory setting (Hatfield-Dodds and Cook, 2007: 3). Governance entails the interactions among formal and informal norms, rules, structures and processes, that determine how people make decisions and share power, exercise responsibility and ensure accountability (Lebel et al., 2006; Raik and Decker, 2007; Cundill and Fabricius, 2010: 14). The management process is a subset of the governance processes, being a narrower inquiry.

This relationship can also be seen in the environmental policy literature. Adaptive management is a process of developing goals and a hypothesis concerning mechanisms for achieving goals, implementing the goals through policy design, and then continuously monitoring, assessing and revising a regulatory environment to ensure goals are actually achieved (making necessary revisions to design as required) (Foxon et al., 2009; Swanson and Bhadual, 2009; Bruch, 2009; Pahl-Wostl et al., 2007a). Adaptive governance refers to

Table 1 – Citizen power and degrees of involvement.

Spectrum of public involvement Dorcey et al. (1994)	Information flows	Trust
Increasing levels of involvement	Information emerging primarily from citizens but in an iterative process	High levels of trust
Ongoing involvement Seek consensus	Ongoing, iterative information flow	Existence of social trust in citizens participating in decisions
Test ideas Seek advice Define Issues Consult on relationships	Two way information flow	Trust building activities
Gather information and perspectives Educate Inform	One way information flow	Low levels of trust

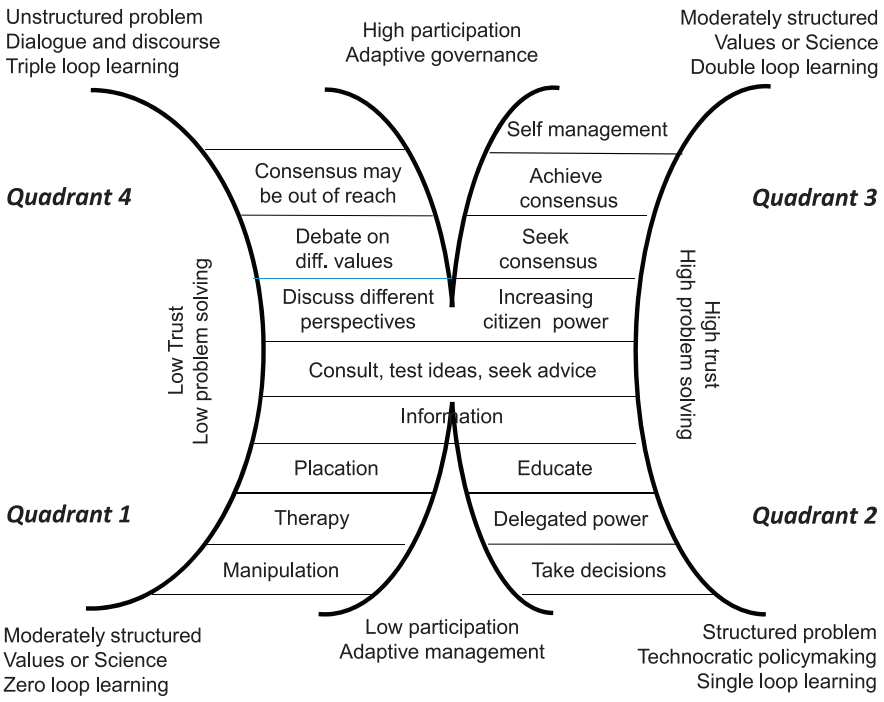

Fig. 2 – The split ladder of participation.

political, social, economic, and administrative systems that develop, manage and distribute a resource in a manner that promotes resilience through collaborative, flexible, and learning across different scales (Olsson et al., 2006; Folke et al., 2005; Gunderson and Holling, 2002; Berkes and Folke, 1998). Adaptive governance is broader than adaptive management setting the social and human context for applying adaptive management (Dietz et al., 2003) or the networks, leadership, and institutional structures that determine the success or failure of adaptive management (Carpenter et al., 2006).[1]

2.2. *Towards a split ladder of stakeholder participation*

2.2.1. *A diagnostic, evaluation, and strategic tool*

Although models for engaging the public in policy making have been proposed (Fung, 2006; Jackson, 2001; Davidson, 1998), none combine problem structuring, social learning, trust, management, and governance. These concepts are necessary for the choice of participatory mechanisms for unstructured policy problems such as climate change (see Huntjens et al., 2011; Pahl-Wostl, 2009; Gupta, 2014b). We propose a split ladder of participation that synthesizes these concepts (see Fig. 2). We first explain the purpose of this split ladder, then explain our model and differentiate it from Arnstein's.

The split ladder of participation is a diagnostic, evaluation and strategic tool for tackling policy problems. The ladder is a diagnostic tool that helps to assess when participation is likely to work (based on factors of trust, values, uncertainty), under what conditions participation is needed (not being required in all structured policy problems at all times), and posits that sometimes stakeholder participation may not quickly lead to consensus outcomes especially where triple loop learning is needed. In other words, to use the ladder requires an understanding of the nature of the policy problem and the dynamics of the disagreements surrounding the problem. Problems can be diagnosed and situated within the split ladder. Depending on the desired policy learning outcome, policy makers, academics, and stakeholders can assess what sort of participation is needed.

The ladder is an evaluation tool as it can be used to study policy problems with a history and where participatory mechanisms have been applied. In this way past policy problems can offer insights and be compared across places, contexts and times. In such situations, the split ladder of participation is an evaluation tool that can be used to assess how stakeholder participation was developed in specific situations and whether the modalities of participation were in line with the nature of the problem and desired results.

The ladder can be a strategic tool in that policymakers can decide, based on an understanding of the tool, at what level they wish to engage in stakeholder participation and in order to achieve which sorts of goals. The model requires policy makers to consider and acknowledge the importance of what learning is required and/or desired in order to make public participation count.

Having explained the purpose of our split ladder, we now elaborate on it. Our model takes Arnstein's model and splits it

[1] Of course the literature contains considerable diversity in opinion on definitions of adaptive governance and adaptive management (Dewulf et al., 2007). Often the terms are used interchangeably (see Eakin et al., 2011: 319; Booher and Innes, 2010: 35; Manning and Pearsall, 2006).

at the bottom and at the top. The model overlaps with the four quadrants in Fig. 1. The bottom half corresponds with low levels of participation; the top half with high levels of participation and low levels of certainty in science. The rungs of the ladder are both activities (e.g. seeking consensus) initiated by the state and outcomes in relation to stakeholder participation (e.g. achieving consensus). There are four main quadrants associated with policy problems (see Fig. 2) explained below.

2.2.2. *Explaining quadrant 1: Moderately structured leading to zero loop learning*

Quadrant one is populated by moderately structured problems where there is disagreement on knowledge, norms or values, low levels of trust, and methods of participation have resulted not in learning, but in manipulation, therapy or placation as Arnstein's ladder (1969) indicated. Examples of problems in this quadrant include resource development issues with uncertain cumulative impacts, involving or resulting in marginalized people and interests (intensifying distrust).

2.2.3. *Explaining quadrant 2: Structured problems, technocratic policymaking and single loop learning*

Quadrant two is populated by structured problems where there is agreement on science and values. These problems can be tackled by technocrats/bureaucrats who take decisions in the public interest leading to single loop learning in policy making and implementation; technocrats occasionally interact with the public to educate or be educated (as well as ensure that the location of the problem in quadrant 2 is still appropriate). Policy makers may use traditional adaptive management to test, hypothesize and learn (Bruch, 2009: 103; Pahl-Wostl et al., 2007a). Note that adaptive governance exists in another quadrant of the split ladder.

2.2.4. *Explaining quadrant 3: Moderately structured problems and aiming for double loop learning*

Quadrant three is populated by moderately structured problems with high trust, but some disagreement on either values or science. Such problems require a high level of citizen engagement, iterative information flows, and should lead to double loop learning to address the uncertainty. Once double loop learning has been achieved, the problem may be treated as structured requiring technocratic decision-making (see Section 2.2.3). These problems normally require adaptive governance to deal with multi-level, multi-actor systems with cross-scale interactions (Huntjens et al., 2011). Once consensus occurs and self-management processes begin, adaptive co-management (a dynamic process with continuous change involving heterogeneous actors (Plummer, 2009; Adger, 2003) might be employed as in community based systems of hybrid resource management (Plummer, 2009; Ruitenbeek and Cartier, 2001; Folke et al., 2003; Ruitenbeek and Cartier, 2001: 8). As multiple institutional links with user groups, communities, government agencies and non-governmental organizations are involved (Armitage et al., 2007; Olsson et al., 2007) these arrangements are part of a wider envisioned governance network.

2.2.5. *Explaining quadrant 4: Wicked problems requiring triple loop learning*

Quadrant four is where unstructured problems reside; great uncertainty in knowledge (Rittel and Webber, 1973) and values combine and connect into symptoms of other problems (Carroll et al., 2007). These intractable, elusive problems are influenced by dynamic social and political factors together with low trust and high debate. Examples include 'safe use of nuclear power' (Laes et al., 2004), 'storage of used uranium' (Batie 2008), the tension between development and growth versus sustainability, and climate change. Such problems require triple loop learning through high participation, dialogue, trust building and discourse by exposing context, power dynamics and underlying values (Blackmore et al., 2007). Some problems such as sustainable development and climate change can occupy this quadrant indefinitely as it is difficult to achieve triple loop learning (Gupta, 2014a).

2.3. *Strategizing participation with the split model*

Not only can the model be used to locate problems, trust issues, and participatory mechanisms, the model can be used by policy makers and stakeholders to strategize the movement of policy problems. The centre of the split ladder provides for the exercise of policy problem scoping, identifying issue typologies, problem structures, perceptions, and frames. In this way the goals and exercises of consulting, testing ideas and gathering information occur. For a given policy problem, the reality of the diverse framing by social actors can be situated on the split ladder of participation. The given policy problem can be located as part of an issue typology or as sub-policy problems dispersed on the split ladder.

Where problems are structured, a limited participatory approach may be sufficient for first order learning and problem solving. Where problems are moderately structured in terms of science or values, participatory approaches may be necessary to allow for greater second order learning. Here, participatory approaches may lead to developing appropriate consensus values which leads to problem resolution. This will bring us to the top-right hand side of our model. However, there is an equal and opposite process possible – where those in power wish to see the problem as structured and placate or manipulate social actors into accepting their position and views on how the problem can be addressed arriving at the bottom left hand corner of the ladder. This leads to zero order learning.

This brings us to the top left hand corner of the split ladder. Where a problem is unstructured, there is need for extensive dialogue and discourse, triple loop learning, and approaches to manage the low trust context. Collins and Ison (2009b) called for 'jumping off' Arnstein's ladder into a new policy paradigm, a suggestion enhanced herein. The writers propose that these debates start in the top left hand corner in respect of wicked problems, and if managed well can be transformed into moderately structured problems, perhaps through dialogue, building on consensus, and the framing of sub-problems (Hoppe, 2011).

The hypothesis of the split ladder is that through cyclical and active engagement with the public, triple loop learning to

respond to a wicked problem would allow a deep understanding beyond insight and patterns of context, in order for a shift in understanding to occur, but this may take time. However, the inherent danger of adding the concepts of participation and social learning is the romanticization of these added procedures. The split ladder of participation acknowledges that negative outcomes might occur.

3. Applicability

3.1. *The split ladder tested*

The split ladder of participation is tested here through four case studies of water governance in Alberta (Canada), Saskatchewan (Canada), Coquimbo Region (Chile), and Mendoza (Argentina), selected because of their common features: river basins with irrigated and some dryland agriculture together with projected increasing future droughts and flood events (IPCC, 2014). The study areas have diverse governance structures and context. Chile operates predominantly via a water market; Canada through government licensing of water (with Alberta having a limited water market); Mendoza's water is tied to land ownership.

The case study research between 2012 and 2014 consisted of reviewing the literature and policy documents on water governance (including all embedded problems identified in Section 2.1.1.) and conducting 25 interviews with key policy and water governance people (see Table 2). Themes of policy framing, activities, and outcomes in relation to climate change, drought, flood, and water governance, mechanisms of participation employed, and contextual factors including trust and perceived social learning were pursued to test the correlation between policy problems and experiences and the split ladder model.

3.2. *Alberta, Canada case study area*

Alberta's water governance is composed primarily of a government licensed and managed regime but makes provision for a water market for water short areas (Hurlbert, 2009). The study area is a dryland river basin with small communities, farming, ranching, irrigated agriculture, and some oil and gas activity. The Alberta Water Act, 2000 aims to promote water conservation, sustain a healthy environment and support economic growth and prosperity. The complex web of water governance institutions include local watershed groups, irrigation associations, and industry associations. When probing policy problems and public participation in this regime, examples were discovered within quadrants one, two, and three.

The Oldman River dam, completed in 1991 after decades of dialogue with local First Nations, is an example of a quadrant one problem categorized as sustainable, equitable development. The provincial government selected the dam site to avoid co-management of the project with the First Nation (Daschuck and Marchildon, 2006). It chose a participatory approach that excluded the First Nations and the concerns of the federal government resulting in court challenges, acts of civil unrest by the First Nations, and protests by displaced farmers. This process institutionalizes resource development without participation of First Nations (Glenn, 1999). Placation, manipulation, and mistrust resulted.

Examples of quadrant two include ongoing government regulatory activities which are managed in a technocratic, policymaking style in relation to drinking water quality standards adopted both federally and provincially, and implemented through legislation, monitoring and reporting (Environment Canada, 2012). Local governments then operate the water treatment systems (Boyd, 2003: 24). Another example pertains to how the Pest Control Products Act of Canada regulates toxic chemicals, banning certain ones, monitoring and testing, and setting limits of usage. Legislation requires that pesticides are re-evaluated as many once believed safe are discovered not to be, or new ones must be added to the list (Boyd, 2003: 121). In both these cases there is technocratic policy making with little stakeholder participation, new information is assessed and single loop learning occurs (with one way communication flows) when regulations are updated and revised.

Examples of quadrant three issues include water management in irrigation districts. Alberta's laws establish irrigation districts to allow for self-management of their water allocation (Hurlbert et al., 2009). These districts link with other irrigation districts and municipalities to co-manage water via processes that are influenced by exogenous (government mandates, social and political context including culture, knowledge systems, power) and endogenous variables (leadership, human capital, and social capital). The interaction between these variables requires a flexible process and involves multiple feedback loops and double loop learning (Plummer, 2009: 24). An example of this double loop learning occurred during the drought of 2001–2002. Irrigators, municipalities, and industrial water users waived legal priority claims (first in time – first in right) responding quickly to a shortage of

Table 2 – Interviews in case study areas.

study area	Number of interviewees	Institutions
Alberta, Canada	6	Environment Canada, Ag Canada, Alta Agriculture, Alta Environment and Sustainable Resource Development
Saskatchewan, Canada	6	Environment Canada, Ag Canada, Water Security Agency, Inter-Governmental Ministry
Mendoza, Argentina	6	Inter-American Institute, Conicet, Government Official, Irrigator Association, Water Law Specialists
Coquimbo, Chile	7	Politicians, Water Law Specialists

stream flow, by entering into less formal 'sharing' agreements allowing one irrigator to produce a crop and leaving another's land fallow (Morito, 2008).

3.3. *Saskatchewan, Canada, case study area*

Saskatchewan's water governance is composed primarily of a government licensed and managed regime through the crown corporation, the Saskatchewan Water Security Agency (SWSA) (Hurlbert, 2009). The study area is a dryland river basin with few small communities, farming, ranching, irrigated agriculture, and some oil and gas activity. The Water Security Agency Act envisions water as a common property resource; the SWSA strategy envisions it as a finite resource important for economic growth, quality of life, and environmental well-being. A smaller group of organizations than in Alberta participate in water governance. Examples of policy problems in quadrant two, three, and four as well as movement between quadrants was found.

The same examples of quadrant two technocratic policy making exist in Saskatchewan as in Alberta. An example of movement into quadrant two from quadrant three is the Farm Ranch Water Infrastructure Programme. This grassroots led programme assisted rural agricultural producers with building water infrastructure on farms in response to extreme drought. In 2008 local producers in south-west Saskatchewan approached the government for a financial contribution and developed and implemented the programme in their area (Hurlbert, 2014). For the first two years this programme was a quadrant three programme being co-managed by producers and government. After successful development and retooling of the programme based on producer input and participation, the program's term and geographical scope was expanded and the provincial government employees took over the administration in late 2009 (Hurlbert, 2014). Since then the government administers the programme, without producer participation, calibrating the programme based on ecological and financial indicators situating it in quadrant two. This research confirmed that structured policy problems require minimal public participation and can be responded to in a technocratic manner.

Similar examples of quadrant three exist in Saskatchewan as in Alberta. Irrigation districts and watershed advisory groups manage water resources in Saskatchewan. However, local watershed advisory groups have played a central role in Saskatchewan in relation to double loop learning. These have been tasked with the preparation of source water protection plans for selected watersheds (Hurlbert and Diaz, 2013). Often these groups operate in quadrant three, dealing with moderately structured problems as the science is somewhat clear – current water resources, corresponding demands, and activities impeding quality – and decisions require value determinations. These groups have also participated in a quadrant four wicked problem: planned adaptation to climate change (East et al., 2012; Espeseth et al., 2012). Through collaborative participation of local citizens as envisioned by Green (1999) these groups tackled climate change adaptation by developing concrete actions for government (educating the public or updating zoning bylaws – in quadrant 2) and people (shipping livestock to be pastured in areas not suffering drought or enhancing communication with downstream water users – in quadrant three) (Hurlbert and Diaz, 2013). Although the wicked problem of climate adaptation was tamed into concrete actions it by no means was solved and no triple loop learning occurred; as a result it remains a quadrant four issue.

3.4. *Coquimbo, Chile, case study area*

Coquimbo's water governance is influenced by the federal Chilean constitutional privatization of water and creation of a water market (Hurlbert and Diaz, 2013; Hill, 2013) which results in low institutional capital. Permanent water rights are bought and sold without restriction on type of use and without recognition of the human right to water (ibid.). The study area is a desert with an Andean river stream providing water for irrigation and mining and is populated by small communities, dryland cattle, goat farmers and traditional fishing (Salas et al., 2012). The Chilean government is mandated to manage water but local governments and civil society organizations also participate in water governance (Reyes et al., 2009). Examples of all quadrants were found in Chile.

An example of Quadrant two is drinking water and sanitation regulation in Chile implemented by the Superintendency of Sanitary Services (SISS, n.d.) and provided by some municipal governments. However, if communities do not have drinking water access, bottled water is trucked in by the community which is often expensive and of poor quality (Reyes et al., 2009; Salas et al., 2012). As a result, this structured problem and technocratic policymaking, didn't cover the entire case study area. If the policy problem of the human right to water were raised in relation to these communities without water access, a moderately structured problem would exist with value decisions on reallocation of water.

Quadrant three examples include irrigation groups, the Associacion de Canalistas, tasked with allocating, distributing, and monitoring water quantity as well as making irrigation infrastructure decisions (Morales and Espinoza, 2005). Local watershed advisory committees tasked with the preparation of source water protection plans for selected watersheds and basin water management initiatives with public involvement have been unsuccessful so no longer occupy quadrant three or potentially quadrant four in Chile (Hurlbert and Diaz, 2013; Reyes et al., 2009).

Quadrant one problems include dam projects in Coquimbo. The Pulcaro dam, built in 1995, led to relocating five communities (Rojas et al., 2007). The people impacted were profoundly disappointed with state communications which promised to resolve conflicts with communities but didn't fulfil them (ibid.). One community, Villa Nueva Puclaro, ended up with no access to water or lands for irrigation and without even a small garden around their houses. Further up into the Andes, the Pascua Lama dam project was forced through by the Canadian mining company Barrick Gold and Argentinian and Chilean government institutions ignored opposition from regional environmental groups worried about the impact on glaciers (Rojas et al., 2007). The participation of people in the environmental reviews of the projects was only done in, "a

general and superficial manner since it was perceived that the inclusion of stakeholders in formal meetings was sufficient'' (Rojas et al., 2007: 64). Local water groups operate in the communities in a space of little power and effectiveness contributing little to these types of development issues (Reyes et al., 2009).

Two issues were identified in quadrant four. First, there is debate occurring on whether the private system of water interests should be nationalized (Donoso, 2014). Pessimistic interviewees were afraid that this process would result in zero order learning and a shift into quadrant one, placation; optimistic interviewees hoped that recognition of the human right to water would lead to third order learning and related consensus and a shift to quadrant three. Second, Emergency Declarations because of drought in central Chile have promoted discussion on adaptation. One option is piping water from southern Chile. These discussions may continue to occupy quadrant four until triple loop learning is achieved.

3.5. *Mendoza, Argentina, case study area*

Mendoza's water, is governed by the Departamento General de Irrigacion (DGI), a government appointed, but autonomous institution. The study area is a desert oasis fed by glacier river water supporting a large urban community (Mendoza) and irrigated agriculture with some oil and gas activity. In Mendoza, water is tied to land as traditional rights within irrigation cooperatives, overseen by inspectors. Because land is valueless without water, and because of a long oasis tradition, a robust water governance system exists. Water-related policy problems exist/existed in quadrants two, three and four.

Quadrant two examples include technocratic water sanitation and drinking services provided by the Provincial Centre of Water and Sanitation) (Diaz and Bertranou, 2004). Although the private company of Obras Sanitarias de Mendoza provides water and sanitation service to much of the area, many small water cooperatives formed in small communities by residents manage their own water resources, an example of a self-managed system in quadrant three. Quadrant three examples also include small and larger irrigation cooperatives formed to provide information, marketing and distribution services to irrigators; Riverbed Inspectorates Associations that distribute, ration, and manage water resources; a general users assembly that represents all water users and oversees water management; and campesinas or groups of indigenous people raising goats communally (Mussetta, 2013). Basin Councils were formed by DGI in 2000 for source water protection and integrated basin management, but have had little impact (Mussetta, 2013).

A quadrant four problem where triple loop learning has occurred is that of a proposed mine, which would have further constrained water resources, in the Andes outside Mendoza. Local social movements (e.g. the Popular Water Assembly) held public meetings and effectively prevented mining development at the headwaters by lobbying government and preserving water for traditional viticulture and people. A Glacier Preservation Law was passed and has been upheld in court (CEPHDA, 2012). Climate change and adaptation are still quadrant four issues occasionally entering the foray of public debate.

3.6. *Discussion*

The case studies confirm the appropriate characterization of the quadrants of the split ladder. Examples of quadrant two type structured problems managed in a technocratic policy-making style with single loop learning by trusted bureaucrats exists in each case study area. Also, quadrant three was confirmed: moderately structured policy problems (where there is a disagreement on values or uncertainty surrounding science) can be tackled effectively with differing degrees of participation. In this research, quadrant three issues of water management, distribution, and refurbishing of local irrigation infrastructure are successfully self-managed in all study areas. Further local watershed groups exist in all study areas seeking to increase citizen power and achieve consensus on water issues, albeit with differing levels of success. More research determining contextual variables contributing to success is required.

In Alberta and Chile dam building was a quadrant one issue marginalizing less powerful actors (Berkes, 2009) and promoting local elite control over resources (Cinner et al., 2012). Although participation was attempted, in the process trust eroded, issues of values, norms and science remained unresolved and participants were excluded.

Movement along the split ladder of participation was confirmed. Examples of tackling quadrant four issues (climate adaptation) exist and in Saskatchewan evolved into either quadrant two technocratic activities (to be effected by government) or collaborative initiatives in quadrant three (tackled through further self-management). The Argentinian Glacier Law and Saskatchewan watershed planning examples illustrated that trust can be developed, the institutional context of governance can be expanded, the power of decision making diffused, and all benefits of public participation in decision making can be realized (Fischer, 2000). The hypothesis of the split ladder, that quadrant four is the ideal place to expand public participation and utilize adaptive governance and encourage social learning received some support. It is unclear why the Argentinian case resulted in triple loop learning and the Saskatchewan did not. More research is needed to uncover further examples and perhaps more government initiatives to tackle wicked problems with this level of participation.

Other than in Argentina, no examples of sustained iterative problems occupying quadrant four were discovered. Canada has withdrawn from the Kyoto Protocol in 2011 (CBC, 2011); has no coherent climate change policy and critiques IPCC science as ''Spin doctors, spun science'' (Fraser Institute, 2013: 22). In Chile, water issues exacerbated by climate variability and change are increasingly responded to with technical solutions and reduced citizen participation in policymaking (Carruthers, 2001; Reyes et al., 2009). Having said this, the potential exists with Chile's initiatives on changing its constitutional water laws and tackling climate change adaptation to truly engage with people and tackle these wicked problems aiming for triple loop learning.

4. Conclusions

This paper has addressed the question of when public participation in decision making is needed and under what conditions it is likely to work. This exercise has de-romanticized public participation. A split ladder of participation was developed and tested in four water governance cases in Alberta (Canada), Saskatchewan (Canada), Coquimbo Region (Chile), and Mendoza (Argentina). Although congruent to Arnstein's ladder with increased participation at the top of the ladder and decreased participation at the bottom, each end of the ladder has been split. The bottom right end of the ladder allows for the inclusion of structured policy problems, where little disagreement exists on science, values and norms, and decisions are largely made and implemented by technocrats. This adds to Arnstein's ladder. The bottom left quadrant of the split ladder coincides more closely with Arnstein's lower rungs depicted by low levels of trust, participation, one way communication flows, placation and manipulation. Projects impacting water and steamrolled through with significant disharmony (such as dams) reside here. The top end of the ladder is split to provide for highly collaborative co-governance mechanisms in regards to moderately structured problems (as envisioned by Arnstein) where delegated water governance resides in the forms of local watershed advisory groups or irrigation districts. However the top left quadrant allows for iterative communication flows facilitating triple loop learning in respect of unstructured problems (climate change and adaptation), an addition to Arnstein's ladder.

The case studies shows that the split ladder model can be used to evaluate stakeholder participatory processes in policy problems. They confirmed that:

- Structured policy problems require minimal public participation and can be responded to in a technocratic manner as depicted in quadrant one.
- Moderately structured policy problems (where there is a disagreement on values or uncertainty surrounding science) can entail differing degrees of participation depending on levels of trust and delegation of power as depicted in quadrants three and may be inappropriately used in quadrant two.
- One example (the Argentinian glacier law) was found of continuous tackling of wicked, unstructured problems with public participation as depicted in quadrant four, which allowed for change in assumptions and triple loop learning. Given imminent climate change, the sparse number of examples leading to successful triple loop learning found in this quadrant is disconcerting.

This research did not disclose examples in which the elements of problem structure, trust, social learning, and participation were contrary to the model with its four quadrants. Examples of moving along the ladder over time and between quadrants were also discovered. However, more research is required to confirm if the quadrants are always mutually exclusive, how movement along the ladder occurs, and how issues which currently exist in quadrant one can be moved into quadrant four ultimately resolved with triple loop learning. Further, the split ladder of participation was used as an evaluation tool herein, but its usefulness as a strategic or diagnostic tool in policy making requires proof.

Although quadrants three and four involve higher degrees of participation and shared power, which presumes certain methods of public engagement, the split ladder does not detail how, or by which methods, public participation is to occur. Linking methods and costs of participation (participatory mapping, consensus conference, or deliberative dialogues etc.) with the split ladder of participation requires further study and research especially in the context of other policy realms in addition to water governance.

The split ladder of participation requires policy makers to consider and acknowledge the importance of what learning is required, what learning is desired, and how to promote such learning, when considering the policy problem. Using the split ladder of participation can deepen democracy and can enhance good governance by showing when participation is effective and efficient. It also explains that third order learning is difficult and takes time and policy processes engaging the public in this quadrant are not necessarily a failure. Diagnosing policy problems correctly can help to make public participation count.

Acknowledgements

This research was funded by International Research Initiative on Adaptation to Climate Change, a joint initiative between IDRC, NSERC, and SSHRCC.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2015.01.011.

REFERENCES

Abrams, L.C., Cross, R., Lesser, E., Levin, D.Z., 2003. Nurturing interpersonal trust in knowledge-sharing networks. Acad. Manage. 17 (4) 64–77.

Adger, W.N., Paavola, J., Huq, S., 2006. Toward justice in adaptation to climate change. In: Adger, W.N., Paavola, J.S., Huq, M.J., Mace, (Eds.), Fairness in Adaptation to Climate Change. Massachusetts Institute of Technology Press, Cambridge.

Adger, W.N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D.R., Naess, L.O., Wolf, J., Wreford, A., 2009. Are there social limits to adaptation to climate change? Clim. Change 93 (3) 335–354.

Adger, N., 2003. Social capital, collective action, and adaptation to climate change. Econ. Geogr. 79 (4) 387–404.

Akamani, K., Hall, T.E., 2015. Determinants of the process and outcomes of household participation in collaborative forest management in Ghana: a quantitative test of a community resilience model. J. Environ. Manage. 147, 1–11.

Allan, C., Wilson, B.P., 2009. Meeting in the middle – desirable but not easy. Environ. Policy Gov. 19, 388–399.
Arnstein, S.R., 1969. A ladder of citizen participation. J. Am. Inst. Plan. 35 (4) 216–224.
Argyris, C., Schön, D., 1978. Organizational Learning: A Theory of Action Perspective. Addison-Wesley, Reading, UK.
Argyris, C., Schön, D., 1996. Organizational Learning II: Theory, Method, and Practice. Addison-Wesley, Reading, UK.
Argyris, C., 1999. On Organizational Learning. Blackwell, Oxford.
Armitage, N., Berkes, F., Doubleday, N., 2007. Adaptive Co-Management. Collaboration, Learning and Multilevel Governance. University of British Columbia Press, Vancouver, British Columbia, Canada.
Batie, S.S., 2008. Wicked Problems and Applied Economics. Am. J. Agric. Econ. 90 (f) 1176–1191.
Berkes, F., Folke, C. (Eds.), 1998. Linking Sociological and Ecological Systems: Management Practices and Social Mechanisms For Building Resilience. Cambridge University Press, New York, NY, USA.
Berkes, F., 2009. Evolution of co-management: role of knowledge generation, bridging organizations and social learning. J. Environ. Manage. 90, 1892–1902.
Biermann, F., Abbott, K., Andresen, S., Backstrand, K., Bernstein, S., Betsill, M.M., Bulkeley, H., Cashore, B., Clapp, J., Folke, C., Gupta, A., Gupta, J., Haas, P.M., Jordan, A., Kanie, N., Kluvankova-Oravska, N., Lebel, L., Liverman, D., Meadowcroft, J., Mitchell, R.B., Newell, P., Oberthur, S., Olsson, L., Pattvberg, P., Sanchez-Roriguez, R., Schooeder, H., Underfal, A., Camargo, V., Vogel, C., Young, O.R., Brock, A., Zondervan, R., 2012. Navigating the antrhopocene: improving earth system governance. Science 335 (March) 1306–1307.
Blackmore, C., Ison, R.L., Jiggns, J., 2007. Social learning: an alternative policy instrument for managing in the context of Europe's water. Environ. Sci. Policy 10 (6) 493–498.
Booher, D.E., Innes, J.E., 2010. Governance for resilience: CALFED as a complex adaptive network for resource management. Ecol. Soc. 15 (3) 35.
Boyd, N., 2003. Unnatural Law. UBC Press, Vancouver.
Brooks, D.B., 2002. Water, Local-Level Management. International Development Research Centre, Ottawa.
Bruch, C., 2009. Adaptive water management: strengthening laws and institutions to cope with uncertainty. In: Biswas, A.K., et al. (Eds.), Water Management in 2020 and Beyond, Water Resources Development and Management. Springer, Berlin.
Brunner, R.D., Steelman, T.A., Coe-Juell, L., Cromley, C.M., Edwards, C.M., Tucker, D.W., 2005. Adaptive Governance: Integrating Science, Policy, and Decision Making. Columbia University Press, New York.
Carpenter, S.R., Bennett, E.M., Peterson, G.D., 2006. Scenarios for Ecosystem Services: An Overview. Ecol. Soc. 11 (1) 29–44.
Carroll, J.E., 1988. Introduction. In: Carroll, J.E. (Ed.), International Environmental Diplomacy. Cambridge University Press, Cambridge, pp. 1–10.
Carroll, M.S., Blatner, K.A., Cohn, P.J., Morgan, T., 2007. Managing fire danger in the forest of the us inland northwest: a classic 'Wicked Problem' in public land policy. J. For. 105 (5) 239–244.
Carruthers, D., 2001. Environmental politics in Chile: legacies of dictatorship and democracy. Third World Q. 22 (3) 343–358.
CBC, 2011. Canada Pulls out of Kyoto Protocol. Available at: http://www.cbc.ca/news/politics/canada-pulls-out-of-kyoto-protocol-1.999072 (accessed 15.09.14).
CEPHDA (Centrde Derechos Humanos y Ambiente), 2012. Barrick Gold Suffers Legal Defeat in Argentine Supreme Court Glacier Protection Law Holds and Mining Companies Must Reveal Impacts. Available at: http://wp.cedha.net/?p=10828&lang=en.
Chambers, R., 1997. Whose Reality Counts? Putting the First Last. Intermediate Technology Publications, London.
Cinner, E.J., McClanahan, T.R., MacNiel, M.A., Graham, N.A., Daw, T.M., Mukminin, A., et al., 2012. Comanagement of coral reef social-ecological systems. Proc. Natl. Acad. Sci. U. S. A. 109, 5219–5222.
Collins, K., Ison, R., 2009a. Living with environmental change: adaptation as social learning. Environ. Policy Gov. 19, 351–357.
Collins, K., Ison, R., 2009b. Jumping off Arnstein's ladder: social learning as a new policy paradigm for climate change adaptation. Environ. Policy Gov. 19, 358–373.
Cundill, G., Fabricius, C., 2010. Monitoring the governance dimension of natural resource co-management. Ecol. Soc. 15 (1) Available at: http://www.ecologyandsociety.org/vol15/iss1/art15/main.html.
Daschuck, J., Marchildon, G., 2006. Historical Chronology of the Oldman River Dam Conflict. Research Report. IACC Project. Available at: http://www.parc.ca/mcri/pdfs/papers/iacc036.pdf.
Davidson, S., 1998. Spinning the Wheel. Planning. Available at: http://kitchentablesustainability.com/wp-content/uploads/2009/06/Davidson-Spinning-wheel-article1998.pdf.
de Boer, J., Wardekker, J.A., van der Sluijs, J.P., 2010. Frame-based guide to situated decision-making on climate change. Glob. Environ. Change 20 (3) 502–510.
de Loe, R., Kreutzwiser, R., 2007. Challenging the Status Quo: The Evolution of Water Governance in Canada. In: Bakker, K. (Ed.), Equ Canada, The Future of Canada's Water. UBC, Press, Vancouver.
Dewulf, A., Francois, G., Pahl-Wostl, C., Taillieu, T., 2007. A framing approach to cross-disciplinary research collaboration: experiences from a large-scale research project on adaptive water management. Ecol. Soc. 12 (2) 14–36.
Dietz, R., Ostrom, E., Stern, P.C., 2003. The struggle to Govern the commons. Science 302 (5652) 1907–1912.
Diaz, A.E., Bertranou, A., 2004. Systemic Study of Water Management Regimes Global Water Partnership, South America. Available at: http://www.eclac.cl/samtac/noticias/documentosdetrabajo/8/23418/InAr00404.pdf.
Donoso, G., 2014, May. Presentation of Los desafios de la institucionalidad del agua en Chile to Seminario Internacional. Governanza del Agua: Desde lo global a lo local, Universidad Catolica de Chile, Santiago Chile.
Dorcey, A., Doney, L., Rueggeberg, H., 1994. Public Involvement in Government Decision-Making: Choosing the Right Model (Victoria, Round Table on the Environment and the Economy). .
Dupuis, J., Knoepfel, P., 2011. Les barrières à la mise en oeuvre des politiques d'adaptation au changement climatique: le cas de la Suisse. Revue Suisse de Science Politique 17 (1) .
Dupuis, J., 2011. Political barriers to the implementation of climate change adaptation policies: the case of Switzerland. In: IGS-SENCE Conference Resilient Societies – Governing Risk And Vulnerability For Water, Energy And Climate Change. University Of Twente, Enschede, The Netherlands.
Eakin, H., Eriksen, S., Eikeland, P.-O., Oyen, C., 2011. Public Sector Reform and Governance for Adaptation: Implications of New Public Management for Adaptive Capacity in Mexico and Norway, vol. 47. pp. 338–351.
East, V., Pittman, J., McRae, K., Soulodre, E., 2012. Drought and Excessive Moisture Preparedness Plan. Upper Souris River Watershed. Available at: http://www.parc.ca/rac/fileManagement/upload/Upper_Souris_DEM_plan_July%209_2012.pdf.

Environment Canada, 2012. Federal Sustainable Development Strategy – 2012 Progress Report, 3. Maintaining Water Quality and Availability, OttawaAvailable at: http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=8B7C79BE-1.

Espeseth, D., Pittman, J., Wittrock, V., Thomson, L., 2012. Drought and Excessive Moisture Preparedness Plan, Old Wives Lake Watershed. Available at: www.parc.ca/rac/fileManagement/upload/Old%20Wives%20Lake%20Watershed%20DEM%20Plan.pdf.

Fischer, F., 2000. Citizens, experts, and the environment. In: The Politics of Local Knowledge. Duke University Press, Durham/London.

Folke, C., Colding, J., Berkes, F., 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. In: Berkes, F., Colding, J., Folke, C. (Eds.), Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, Cambridge, UK, pp. 352–387.

Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annu. Rev. Environ. Resour. 30, 441–473.

Foxon, R., Reed, M.S., Stringer, L.C., 2009. Governing long-term social-ecological change: what can the adaptive management and transition management approaches learn from each other? Environ. Policy Gov. 19, 3–20.

Fraser Institute, 2013, November/December. Saving the Euro Fraser Forum. A Fraser Institute review of public policy in Canada, Vancouver, BC.

Fung, A., 2006. Varieties of participation in complex governance. Public Adm. Rev. 66.

Funtowicz, S., Ravetz, J., (Lead Authors); International Society for Ecological Economics (Content Partner); Costanza, R., (Topic Editor), 2008. Post-Normal Science. In: Cleveland, C.J. (Eds), Encyclopedia of Earth. Washington, D.C.

Funtowicz, S.O., Ravetz, J.R., 1993. Science for the post-normal age. Futures 25 (7) 739–755.

Gibbons, M., et al., 1994. The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies. Sage, London.

Glenn, J., 1999. Once Upon An Oldman, Special Interest Politics and the Oldman River Dam. UBC Press, Vancouver.

Green, J.M., 1999. Deep Democracy, Community, Diversity, and Transformation. Rowman & Littlefield Publishers, Inc., Oxford, England.

Gunderson, L.H., Holling, C.S., 2002. Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, Washington.

Gupta, J., 2014, June. *Sharing Our Earth*, Inaugural Address as Professor of Environment and Development in the Global South. University of Amsterdam. http://www.oratiereeks.nl/upload/pdf/PDF-3450weboratie_Gupta.pdf.

Gupta, J., 2014b. The History of Global Climate Governance. Cambridge University Press, Cambridge.

Haas, P.M., Haas, E.B., 1995. Learning to Learn: Improving International Governance. Glob. Gov. 1 (September–December (3)) 255–284.

Hajer, M.A., Wagenaar, H. (Eds.), 2003. Deliberative Policy Analysis: Understanding Governance in the Network Society. Cambridge University Press, Cambridge.

Hampton, G., 1999. Environmental Equity and Public Participation. Policy Sci. 32 (1) .

Hatfield-Dodds, S.N.R., Cook, D.C., 2007. Adaptive governance: an introduction, and implications for public policy. In: A paper presented at the ANZSEE Conference, July 4,5, Noosa, Australia.

Hedelin, B., Lindh, M., 2008. Implementing the EU Water Framework Directive – prospects for sustainable water planning in Sweden. Eur. Environ. 18, 327–344.

Hickey, S., Mohan, G., 2005. Relocating participation within a radical politics of development. Dev. Change 36 (2) 237–262.

Hill, M., 2013. Climate Change and Water Governance. Adaptive Capacity in Chile and Switzerland. Springer, Dordrecht/Heidelberg/New York/London.

Hisschemoller, M., 2005. Participation as knowledge production and the limits of democracy. In: Maassen, S., Weingart, P. (Eds.), Democratization of Expertise? Exploring Novel Forms of Scientific Advice in Political Decision-Making. pp. 189–208.

Hisschemöller, M., Hoppe, R., 1996. Coping with Intractable Controversies: The Case for Problem Structuring in Policy Design and Analysis. Knowl. Policy 8 (4) 40–61.

Hisschemöller, M., Gupta, J., 1999. Problem-solving through international environmental agreements: the issue of regime effectiveness. Int. Polit. Sci. Rev. 20 (2) 151–174.

Hisschemöller, M., 1993. De democratie van problemen. De relatie tussen de inhoud van beleidsproblemen en methoden van politieke besluitvorming. VU, Amsterdam.

Hoppe, R., 2011. The Governance of Problems, Puzzling, Powering and Participation. The Policy Press, University of Bristol, Bristol.

Hoppe, R., Hisschemöller, M., 2001. Coping with intractable controversies: the case for problem structuring in policy design and analysis. In: Hisschemöller, M., Hoppe, R., Dunn, W., Ravetz, J. (Eds.), Knowledge, Power and Participation in Environmental Policy Analysis. Transaction Publishers, New Brunswick, Canada, pp. 47–72.

Hulme, P.E., 2005. Adapting to climate change: is there scope for ecological management in the face of a global threat? J. Appl. Ecol. 42, 784–794.

Huntjens, P., Pahl-Wostl, C., Rihoux, B., Schlüter, M., Flachner, Z., Neto, S., Koskova, R., Dickens, C., Kiti, I.N., 2011. Adaptive water management and policy learning in a changing climate: a formal comparative analysis of eight water management regimes in Europe, Africa and Asia. Environ. Policy Gov. 21, 145–163.

Hurlbert, M., 2014. Adaptive institutional design in agri-environmental programs. Int. J. Clim. Change Strateg. Manage. 6 (2) 145–165.

Hurlbert, M., Diaz, H., 2013. Water governance in Chile and Canada – a comparison of adaptive characteristics. Ecol. Soc. 18 (4) 61–76.

Hurlbert, M., Corkal, D., Diaz, H., 2009. Government and civil society: adaptive water management in the South Saskatchewan river basin. In: Marchildon, G. (Ed.), Dry Oasis. Institutional Adaptations to Climate Change. CPRC Press, Regina.

Hurlbert, M., 2009. Comparative water governance in the four western provinces. Prairie Forum 34 (1) 45–77 (a special edition on climate change).

Ingram, H., Schneider, A.L., DeLeon, P., 2007. Social construction and policy design. In: Sabatier, P. (Ed.), Theories of the Policy Process. Westview Press, Boulder, CO.

IPCC, 2014. Summary for Policymakers. In: Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, V., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, V., Schlömer, S., von Stechow, C., Zwickel, T., Minx, J.C. (Eds.), Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom/New York, NY, USA.

Jackson, L.S., 2001. Contemporary public involvement: toward a strategic approach. Local Environ. 6 (2) 135–147.

Jasanoff, S. (Ed.), 2004. States of Knowledge: The Co-Production of Science and Social Order. Routledge, London.

Johnson, N., Lilja, N., Ashby, J.A., Garcia, J.A., 2004. Practice of participatory research and gender analysis in natural resource management. Nat. Resour. Forum 28, 189–200.
Keen, M., Brown, V.A., Dyball, R., 2005. Social learning: a new approach to environmental management. In: Keen, M., Brown, V.A., Dyball, R. (Eds.), Social Learning in Environmental Management: Towards A Sustainable Future. Earthscan, London, pp. 3–21.
Laes, E., Meskens, G., D'Haeseleer, D., Weiler, R., 2004. The Belgian nuclear phase-out as a strategy for sustainable development: unstructured problems, unstructured answers? In: Biermann, F., Campe, S., Jacob, K. (Eds.), Proceedings of the 2002 Berlin Conference on the Human Dimensions of Global Environmental Change "knowledge for the Sustainability Transition: The Challenge for Social Science". Global Governance Project, Amsterdam, Berlin, Potsdam, Oldenburg, pp. 271–284.
Lebel, L., Grothmann, T., Siebenhuner, B., 2010. The role of social learning in adaptiveness: insights from water management. Int. Environ. Agreem. 10, 333–353.
Lebel, L., Anderies, J.M., Cambell, C., Folke, S., Hatfield-Dodds, S., Hughes, T.P., Wilson, J., 2006. Governance and the capacity to manage resilience in regional social-ecological systems. Ecol. Soc. 11 (1) 19.
Li, W., 2005. Community decisionmaking participation in development. Ann. Tour. Res. 33 (1) 132–143.
Loorbach, D., 2007. Transition Management: New Mode of Governance for Sustainable Development. International Books, Utrecht.
Mackenzie, J., Krogman, N., 2005. Public involvement processes, conflict, and challenges for rural residents near intensive hog farms. Local Environ. 10 (5) 513–524.
Manning, S.L., Pearsall, S., 2006. Creating an adaptive ecosystem management network among stakeholders of the lower Roanoke river, North Carolina, USA. Ecol. Soc. 10 (2) 1–22.
Michener, V., 1998. The participatory approach: contradiction and co-option in Burkina Faso. World Dev. 261979, 2105–2118.
Morales, H., Espinoza, R., 2005. Organizaciones de Usuarios de Agua de la Cuenca del Rio Elqui. IACC Report. Available at: http://www.parc.ca/mcri/iacc015.php.
Morito, B., 2008. Institutional Values and Adaptive Capacity to Climate Change. Institutional Adaptation to Climate Change Research Project, University of Regina. In: http://www.parc.ca/mcri/pdfs/papers/iacc085.pdf.
Moser, S.C., Ekstrom, J.A., 2010. A framework to diagnose barriers to climate change adaptation. Proc. Natl. Acad. Sci. U. S. A. 107 (51) 22026–22031.
Mostert, E., Pahl-Wostl, P., Rees, Y., Searle, B., Tàbara, D., Tippet, J., 2007. Social learning in European river-basin management: barriers and fostering mechanisms from 10 river basins. Ecol. Soc. 12 (1) 19.In: http://www.ecologyandsociety.org/vol12/iss1/art19/.
Mussetta, P., 2013. Secondary Source Research and Literature Review. (Unpublished Manuscript).
Norton, B.G., 2005. Sustainability: A Philosophy of Adaptive Ecosystem Management. University of Chicago Press, Chicago.
Nowotny, H., Scott, P., Gibbons, M., 2001. Re-Thinking Science: knowledge and the Public in an Age of Uncertainty. Blackwell, Malden, MA.
Olsson, P., Gunderson, L.H., Carpenter, P., Ryan, P., Lebel, L., Folke, C., Holling, C.S., 2006. Shooting the rapids: navigating transitions to adaptive governance of socio-ecological systems. Ecol. Soc. 11 (1) 1–18.
Olsson, P., Folke, C., Galaz, V., Hahn, T., Schultz, L., 2007. Enhancing the fit through adaptive co-management: creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike biosphere reserve, Sweden. Ecol. Soc. 28 (12:article).
Pahl-Wost, C., 2006. The importance of social learning in restoring the multifunctionality of rivers and floodplains. Ecol. Soc. 11 (1) 10–24.
Pahl-Wostl, C., Craps, M., Dewulf, A., Mostert, E., Tabara, D., Taillieu, T., 2007a. Social learning and water resources management. Ecol. Soc. 12 (2) 5.In: http://www.ecologyandsociety.org/vol12/iss2/art5/.
Pahl Wostl, C., Sendzimir, J., Jeffrey, P., Aerts, J., Berkamp, G., Cross, 2007b. Managing change toward adaptive water management through social learning. Ecol. Soc. 12 (2) 30–48.
Pahl-Wostl, C., 2009. A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. Glob. Environ. Change 19, 345–365.
Plummer, R., 2009. The adaptive co-management process: an initial synthesis of representative models and influential variable. Ecol. Soc. 14 (2) In: http://www.ecologyandsociety.org/vol14/iss2/art24/.
Plummer, R., 2006. Sharing the management of a river corridor: a case study of the co-management process. Soc. Nat. Resour. 19 (1) 1–13.
Pretty, J., Ward, H., 2001. Social capital and the environment. World Dev. 29 (2) 209–227.
Raik, D.B., Decker, D.J., 2007. A multisector framework for assessing community-based forest management: lessons from Madagascar. Ecol. Soc. 12 (1) 14.In: http://www.ecologyandsociety.org/vol12/iss1/art14/.
Razzaque, J., 2009. Public participation in water governance. In: Dellapenna, J.W., Gupta, J. (Eds.), The Evolution of the Law and Politics of Water. Springer, pp. 307–324.
Reyes, B., Salas, S., Schwartz, E., Espinoza, E., 2009. Chile Governance Assessment Final Report. Available at http://www.parc.ca/mcri/pdfs/papers/gov03.pdf.
Richards, C., Blackstock, K.L., Carter, C.E., 2004. Practical Approaches to Participation, SERG Policy Brief, No., 1. Macauley Land Use Research Institute, Aberdeen.
Rittel, H., Webber, M., 1973. Dilemmas in a general theory of planning. Policy Sci. 4, 155–169.
Rojas, A., Reyes, B., Magzul, L., Morales, H.L., Borquez, R., Swartz, E., 2007. Analysis of the Role of Institutions in Water Conflicts Final Report. IACC Project Report. Available at: http://www.parc.ca/mcri/iacc057.php.
Rotmans, J., Kemp, R., Van Asselt, M., 2001. More evolution than revolution: transition management in public policy. Foresight 3 (1) 15–31.
Ruitenbeek, J., Cartier, C., 2001. The Invisible Wand: Adaptive Co-Management as an Emergent Strategy in Complex Bio-economic Systems. Occasional Paper No. 34. Centre for International Forestry Research, Bogor, Indonesia.
Salas, S., Jimenez, E., Montana, E., Garay-Fluhmann, R.G., Gauthier, D., Diaz, H.P., 2012. Vulnerability to Climate Change. Challenges for Adaptation in the Elqui and Mendoza Basins. Inter-American Institute for Global Change Research, La Serena, Chile.
Schneider, A.L., 2006. Patterns of change in the use of imprisonment in the American states: an integration of path dependence, punctuated equilibrium and policy design approaches. Polit. Res. Q. 59 (3) 457–470.
Schneider, A., Ingram, H., 1993. Social construction of target populations: implications forpolitics and policy. Am Polit Sci Rev 334–347.
Shiva, V., Bandyopadhyay, J., 1986. Environmental Conflicts and Public Interest Science. Econ. Polit. Wkly. XXI (2) 84–90.
Siebenhuner, B., 2008. Learning in international organizations in global environmental governance. Glob. Environ. Polit. 8 (4) 92–116.

SISS, 2014 (Superintendencia de Servicios Sanitarios) (n.d.) webpate of Gobierno de Chile, Available at: www.sess.gob.cl.

Swanson, D., Bhadual, S., 2009. A Guide for Policy Making in an Uncertain World. Sage IISP.

Tippett, J., Handley, J.F., Ravetz, J., 2007. Meeting the challenges of sustainable development – a conceptual appraisal of a new methodology for participatory ecological planning. Prog. Plan. 67, 9–98.

Tsaang, S., Burnett, M., Hills, P., Welford, R., 2009. Trust, public participation and environmental governance in Hong Kong. Environ. Policy Gov. 19, 99–114.

Tschakert, P., Dietrich, K.A., 2010. Anticipatory learning for climate change adaptation and resilience. Ecol. Soc. 15 (2) 11–34.

Vasileiadou, E., Hisschemoller, M., Peterson, B.C., de Hoog, I., Hazeleger, W., Min, E., 2012. Adapting to extreme weather events: perspectives of social actors. In: Conference paper at The Governance of Adaptation. March, 2012, Amsterdam Available at: http://www.adaptgov.com/wp-content/uploads/2012/03/Vasileiadou-et-al_adaptation-governance-conference-Tframing.pdf.

Voß, J., Bauknecht, D., Kemp, R. (Eds.), 2006. Reflexive Governance for Sustainable Development. Edward Elgar, Northampton, MA, pp. 3–28.

Warren, M.E., 2009. Governance-driven democratization. Crit. Policy Sci. 3 (1) 3–13.

Wolf, J., 2012. Climate change adaptation as a social process. In: Ford, J.D., Berrang-Ford, L. (Eds.), Climate Change Adaptation in Developed Nations. Springer, London.