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Ruling out learning and change? Lessons from urban flood mitigation

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ABSTRACT
This article shows how particular rule configurations can create conditions for learning from experimentation on an operation level. It does so by using the IAD framework in a diagnostic analysis of decisions to fund the development of drainage in the Denver Metropolitan Area before and after the 2013 Colorado Flood. The discussion first synthesizes recent developments in this research area. Then, it demonstrates how formal institutional analysis can be used to address existing gaps. To conclude, recommendations for further research to develop our understanding of the link between learning and change are presented.

Introduction
Floods have become a chronic and costly risk for urban inhabitants and local economies worldwide. New settlements continue to encroach on floodplains, while climate change increases the frequency of heavy rainfall. Insufficient flood control places an unprecedented amount of pressure on urban stormwater drains that are often developed at a much slower rate, but are expected to manage higher levels of runoff from impervious areas such as paved streets, parking lots and building rooftops during rainfall and snow events (United Nations, 2014). It thus seems to be in everyone’s long-term interest to maintain and develop stormwater drainage and to protect flood plains so cities can resist or at least quickly recover from heavy rainfall. Still, the immediate need for more housing and wider roads often overrules considerations for flood control. In this case, the only feasible remaining solution is to provide adequate drainage facilities that can cope with the subsequent increase in runoff. However, local stakeholders are slow to – and sometimes fail to – respond to the aforementioned threats to their communities.

The Bloomington School, under the leadership of Elinor and Vincent Ostrom, has accumulated evidence that a polycentric governance system can facilitate collective action to effectively and sustainably manage the storage and flow of water at various geographic and administrative scales (Blomquist, 2006; Heikkila, Schlager, & Davis, 2011; Ostrom, 1962,
This argument is widely echoed in the literature on uncertainty, sustainability and change (Bahadur & Tanner, 2014; Béné, Cannon, Gupte, Mehta, & Tanner, 2014; Dovers & Handmer, 1992; Folke, 2006; Moench, 2014). The discussion is based on the postulate that robust and sustainable community governance is the result of learning from experimentation on the operational level, which is best realized in a polycentric setting (Ostrom, 2005b, p. 183). It is grounded onto the assumptions that any community governance system is vulnerable to threats (Ostrom, 2005b), and that particular settings can create conditions facilitating ex post learning efforts and enhance the system’s viability (Shepsle, 1989).

Yet scholars still have to specify what settings are particularly supportive of learning from experimentation at an operational level. The here presented article first synthesizes recent developments in this area. It then demonstrates how formal institutional analysis can be used to systematically describe a particular setting and the learning opportunities that it creates at the operational level. It concludes with recommendations for further research to increase our understanding of the theoretical relations between learning and change.

**Learning and change in polycentric systems**

The focal level of analysis of the aforementioned studies on water management is the action arena, which constitutes one of various nested arenas within a polycentric governance system (McGinnis, 2011, p. 52). It is described in terms of the seven working parts of a formal game. This includes a number of boundedly rational actors that come together to decide on an action to sustainably manage a particular resource system, the level of information about benefits and costs assigned to the action-outcome linkage and control over a negotiation process that the actors in particular positions could exercise to promote a potential outcome (Ostrom & Crawford, 2005, p. 189). Underlying this empirical work are two assumptions: a) public, private, voluntary and other types of actors from multiple administrative levels and issue domains operate within an action arena. The next assumption is that they b) operate within a jointly agreed and commonly known and used system of written and unwritten rules, including any strategies or plans that structure group behaviour. These so-called rules-in-use (‘rules’ hereafter) are described as the shared understanding of actors about enforced prescriptions concerning what actions (our outcomes) are required, prohibited, or permitted’ (Ostrom, 2005c, p. 18).

The Institutional Analysis Development (IAD) framework is used to illustrate the process of designing and developing rules. It recognizes that rule configurations affecting an action arena and the internal decision process within at a given time (t) might be different at time (t + 1). This means that t and t + 1 describe different state spaces (Ostrom, Cox, & Schlager, 2014). These illustrations are based on empirical studies that started to systematically investigate the composition of rules in the context of the management of common pool resources (Ostrom, 2005c; p. 18), such as water and forests (Clement, 2010; Ostrom, 1990). Theoretically, this can also entail the management of the infrastructure commons (Little, 2004) in an urban context (Foster, 2011), such as storm drainage facilities.

**The dependent variable problem**

It has become evident in this context that the rules, which actors agree on to govern common pool resources are not static prescriptions but on-going experiments (Cox, 2012;
This occurs as actors constantly learn and adapt the rules that do not conform to local conditions (Ostrom, 1990, pp. 61–69). These conditions are not durable, but change. Some change gradually over time, others change more rapidly (Cox & Ross, 2011). Actors in an action arena thus have to compensate as best they can, for predictable but also for sudden changes within their social-ecological context (Agrawal, 2003).

Shepsle (1989, p. 142) clarifies that this is an ‘ex post selection’, since actors face many uncertainties and intelligently use ‘what knowledge and information is available, but before the values of many parameters are known’. Hence, no combination of rules is an optimal fit for any particular context but constantly evolves to meet changing requirements. This ability of a governance system and/or its component parts to adapt to changing situations is often taken as an indicator of its resilience (Béné, Wood, Newsham, & Davies, 2012; Béné et al., 2014; Reid & Botterill, 2013). In some cases this involved paradigmatic rule changes, whereas in other cases rules are only moderately revised in order to clarify or strengthen their content (Ostrom, 2005b). Such moderate change can easily be missed. This can lead to false assumptions about actors’ failure to learn from their experiences as individuals (individual learning) but also as a group (collective learning), since rules are defined as the products of these two interdependent learning processes.¹ This dilemma is known to scholars, who study policy learning and change, as the dependent variable problem (Howlett & Cashore, 2009).

An increasing number of IAD-based studies started to employ, test and develop the Institutional Grammar Tool (Basurto, Kingsley, McQueen, Smith, & Weible, 2010; Feiock et al., 2016; Ostrom & Basurto, 2011; Roditis, Wang, Glantz, & Fallin, 2015; Siddiki, Basurto, & Weible, 2012; Siddiki, Weible, Basurto, & Calanni, 2011) conceptualized by Crawford and Ostrom (1995, 2005). It is used to systematically describe the composition and evolution of rules that structure particular action arenas. More precisely, they use the tool to identify the working parts of particular rules: the Attribute (A), the Deontic (D), the Aim (I), the Condition (C) and the Or else (O). Attribute describes the animate agent that is to carry out a particular action. Deontic denotes the prescriptive operator specifying if an action is required, forbidden or permitted. Aim describes the action itself. Condition specifies the boundaries (spatial, temporal, procedural) in which the required action has to be performed. Or else denotes sanctions associated with the non-compliance of a prescribed action. Depending on which configuration of those working parts a rule is composed of, it is classified as a strategy, a norm or a principal rule (in the sense that it assigns a sanction to noncompliant behaviour). A strategy contains an Attribute, an Aim and a Condition (AIC); a norm contains, in addition, a Deontic (ADIC). With the addition of an Or else, the statement becomes a rule (ADICO) that either requires, permits or forbids an action (Crawford & Ostrom, 1995, p. 584). In order to decrease uncertainty among coders (p. 87), Siddiki et al. (2011) included a sixth category in each class: the receiver of the Aim (Object). Scholars have since started to use the revised tool to detect changes with regard to the actors affected by

¹In this context, Ostrom (1990, pp. 33–38) clarifies that it is a conscious decision not to include internal/in-mind variables as such, as they are difficult to measure. Hence, scholars give only some indication of where actors’ preferences for a specific rule configuration come from, and on the limitations that these preferences impose on an actor’s ability to make a choice. For instance, Ostrom recognizes that individuals weight benefits of avoiding future harms more heavily than the benefits of producing future goods (Ostrom, 1990, p. 208), which differentiates the IAD from other economic theories that simply assume goal-oriented behaviour.
This inspired Ostrom and Basurto (2011) to evaluate how a particular rule configuration has changed since its default condition (p. 330). They first distinguish principal rules from norms and strategies according to the classification proposed by Crawford and Ostrom (2005). They also take the time when these arrangements were agreed upon into consideration. Then they categorize these rules based on the elements of the action arena that they affected. Seven types of rules are distinguished in this context: rules that regulate who can enter and leave an action arena are defined as \textit{boundary rules}. \textit{Position rules}, in contrast, state whether there is a defined number of actors in specific positions in an action arena. Other rules influence the costs and benefits that actors assign to a particular action (\textit{payoff rules}), the scope of this action (\textit{scope rules}) and the way it is monitored \textit{information rules}. \textit{Aggregation rules} determine who decides which action or set of activities is to be undertaken. \textit{Choice rules} specify what actors in specific positions must, must not, or may do at a particular point in a decision process in light of conditions that have, or have not, been met at that point of the process (Ostrom, 2005d). In short, Ostrom and Basurto (2011) outline ‘a way of conducting empirical research that records change and can then be used for rigorous testing of various theories of how change occurs’ (p. 333). When combined with a thorough analysis of the institutional grammar, this can help solving the aforementioned measurement problem in policy learning studies that focus on how rule configurations change; leaving only the question of why these arrangements change.

\textbf{Factors supporting change in the dependent variable}

Decisions to change a rule are ultimately based on the actor’s learning about the decision process and the effectiveness of decisions from prior situations. It is assumed that individual actors acquire, translate and disseminate information and then adapt their thoughts and behaviour to transfer their insights onto others in the collective (Ostrom et al., 2014). In this context, actors weight the expected benefits of a new rule against the benefits of the current arrangement and the costs of negotiating and implementing the new rule (Poteete et al., 2010). Here, Elinor Ostrom and her associates follow Jones (2001) and utilize primarily Gerd Gigerenzer’s definition of bounded rationality (Ostrom, 2005a, pp. 104–109); acknowledging that a rational mind evolves over time (Stanovich, 2012, pp. 345, 346). It is argued in this context that the irreducible nature of socio-ecological and economic systems manifest in uncertainty and ambiguity (Ostrom, 2005b, pp. 270, 271). More specifically, actors in an action arena face many uncertainties, such as unforeseen contingencies, unknown states of the world and incomplete information about the preferences of others. The actors thus choose their preferred action \textit{ex post} following a history of experiences (Shepsle, 1989, p. 142). Personal or local experience biases their judgment about the problem at large. Hence, the available knowledge is contested. The results are power struggles and discussions between individuals who do not share a specific understanding about a given decision situation. Collective learning in an action arena is thus considered a ‘highly political affair’, since actors rarely share a common understanding of the desired outcomes (Agrawal, 2003, p. 245), nor is power equally distributed (Agrawal, 2014; Ostrom & Basurto, 2011).
Drawing on the analysis of small collective action settings, such as communal irrigation systems (Ostrom, 1990), scholars started to outline conditions that create opportunities for individual and collective learning in an action arena (Ostrom, 2005b, pp. 258–270). Eight design principles have been identified to date: Scholars established the need to clearly define a set of actors who are allowed to deduce a certain quantity of economic goods and values from a resource system at a specific time and frequency. It has also become evident that it is not sufficient to clearly define user boundaries alone. Clearly defined resource boundaries that can be enforced are as necessary. Also of importance is that the actors who are expected to obey the rules have the opportunity to engage in the prior development of these collective-choice arrangements. The evidence suggests that the arrangements have to be fair in a way that the allowed benefits of appropriating a good are relative to the costs of providing this good. Monitors and officials need to be available to detect and sanction violations of collective-choice agreements and to respond to changes in local conditions. Actors must be able to organize and have access to conflict resolution mechanisms. For these nested and complex arrangements to work, they have to concur with local conditions and have to be organized to work on multiple levels (Cox et al., 2010, p. 38).

A new generation of institutional analysis has started to investigate the applicability of these design principles to large-scale settings (Agrawal, 2014; Epstein et al., 2014; Heikkila et al., 2011; Huntjens et al., 2012; Villamayor-Tomas et al., 2014), such as special districts managing the flow and quality of water (Fleischman et al., 2014). Furthermore, this recent work has shown that two conditions in particular are crucial. First, clear resources and user boundaries help managing the use of a particular good. Secondly, monitors have to be in place to evaluate the development of the resource system and to observe whether resource users obey the agreed rules (Fleischman et al., 2014). Fleischman et al. (2014) pursued this line of inquiry further and highlight the importance of integrating not only local insights but also scientific knowledge to monitor large-scale resource use and development. Indeed, without monitoring there is no cause for sanctions and without sanctions there is little initiative to comply with the agreed rules. In large settings, this information is hardly directly accessible (Fleischman et al., 2014, p. 15). Here, actors depend on other actors to share their knowledge or to establish a bridge between the actors (Berkes, 2009). This dependency becomes visible in the development of institutional arrangements that facilitate the exchange of information (Lubell et al., 2016). Furthermore, it has become evident that not all potential sources of information are granted entry to an action arena or are recognized in their position as such, nor is information equally weighted (Berkes, 2007). Contested and ambiguous information is unlikely to mobilize sufficient support for sanctioning an actor’s noncompliance with shared agreements (Martens & van Weelden, 2014). Therefore, information has to be reliable. However, not all reliable information is accessible. This poses a challenge since only accessible information can be utilized to mobilize change (Berkes, 2007).

Much of this evidence is grounded on case studies. Only just recently have scholars started to employ methods that allow them to systematically map formal dependencies between the actors and action arenas. Siddiki et al. (2015) employed the Institutional Grammar Tool to analyse and formal dependencies outlined in various policy designs. For example, they identified the animate agent (Attribute) that is to carry out a particular action (Aim). Here, scholars measure the quality of a particular rule configuration ex ante. Heikkila et al. (2011, p. 128) argue that ‘measuring the quality of a linkage requires the linkage to be
tested, or used, in practice to determine how well it works.’ Hence, they analysed the content of signed agreements with focus on the functional linkages that they create and compared the findings to the linkages reported in meeting minutes and annual reports. Combined with an analysis of the institutional grammar, this approach can help to outline evaluation criteria to assess rules designed to enhance the capacity of actors to learn in a large-scale action arena and to adapt collective choice arrangements to new challenges.

Returning to the initially mentioned problem of urban flooding, the discussion next introduces a study that employs such a combined approach to study the evolution of specific rule configurations and formal dependencies. The aim is to identify factors that supported necessary rule changes following the 2013 Colorado Flood in the United States. While prior research covering this event focused on the county level governance (Albright & Crow, 2014), this study looks at the Urban Drainage and Flood Control District; a special district that was established in 1969 to coordinate flood risk mitigation efforts in the Denver Metropolitan Region – The second most populated area in the Southwest of the United States.

Case study

The Denver Metropolitan Area recorded the costliest and deadliest of the 11 flood disasters that Colorado experienced since 1959. The scope and layout of the area still continues to change as it copes with a rising population. This further increases the risk of flooding, which is already high due to its foothill environment and rapid climatic changes. In other words, flooding is a predictable risk. Therefore, it is of utmost importance to local governments, businesses and inhabitants that stormwater drains are sustained over the long term. Initially though, actors in uphill counties were oblivious to the damage their actions caused in the valley. Out of this realization, a group of county engineers together with Colorado Senator Joe Shoemaker pushed for the implementation of a state statute that created the Urban Drainage and Flood Control District (‘the District’ hereafter). Their aim was to enhance the capacity of local communities to learn about the risk flood hazards inherent in the Denver Metropolitan area as a whole pose to persons and property. Additionally, they planned on adapting their efforts to coordinate, plan, construct and maintain drainage and flood control infrastructures within the region.

The District is unique in the United States as a multi-county special district established exclusively for flood hazard mitigation. This regional special district operates since 1969 as an independent agency, which – until today – consists only of a small number of staff as well as engineering contractors and is governed by a Board of Directors (‘the Board’ hereafter). The board members of which are appointed to represent their community (e.g. City and County of Denver). In the early days, the group established institutional mechanisms that could best allow the arena to perform its appointed duties. This includes monthly meetings where the Board decides where to conduct multi-jurisdictional flood risk assessments and

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2The South Platte River flood hit Denver in 1965, and left an estimated 2.7 billion US dollar (in 2010 dollars) damage. The greatest loss of life occurred during the Big Thompson flood of 1976 with 145 deaths (State of Colorado 2013).

3McGinnis (2011, p. 171) refers to special districts as an example of specialized, cross-jurisdictional political units within a polycentric governance system. These units have already been focus of IAD-based research on water management in the US (Heikkilä, 2004, p. 171).
master planning studies; how to prioritize the recommended measures; and how to plan the project budgets. It is authorized to impose a mill levy to finance its operations and to maintain, as well as preserve, floodways and floodplains. Though central to the relationship among local actors in the Denver Metropolitan Area, the district is only one public enterprise within a polycentric system of public and private entities engaged in flood mitigation in the South West of the United States.

Research design and data

The District has already been cited as a positive example of sustainable stormwater management in Handmer (1990) and Grigg (2011a, 2011b, Grigg, 2012), and has recently become more visible to the general public as an agent of learning in the aftermath of the 2013 Colorado flood. The case study presented here is an effort to further unpack this complex and adaptive system to better understand and learn from this example. It draws descriptive inferences about the link between rules and the District's capacity to learn and to adapt regional drainage facilities to ecological changes from a recurring empirical situation in which actors negotiated the budget and appropriation for the year ahead. It focuses in particular on the process of planning infrastructure investments before and after the 2013 Colorado flood. Temporary/emergency solutions that were locally implemented without consultation during or immediately after the flood event are not included in the analysis. Actors participating in the Board meetings with the aim to jointly develop a sustainable drainage system for the Denver Metropolitan Area are the unit of analysis. The data for this paper was collected and analysed between September 2014 and April 2015 as part of a scoping study that will feed into a larger research project currently being developed by the author. The process involved three stages.

Data collection started with an open-ended interview with David Bennetts, leader of the District’s Design Construction Maintenance program. The one-hour interview was conducted in their headquarters on 22 September 2014. The data from this interview was used to outline the case settings and verify research findings. In a second step, two independent coders identified and analysed the content of the rules that – according to the District’s Comprehensive Annual Finance Reports (‘CAFR’ hereafter) for these years- were significant for deciding on a budget and subsequent five year plan for capital investments (‘CIP’ hereafter) in 2011, 2013 and 2014. Policies outlined in these documents can be defined as collective-choice rules affecting the operational level action arena (Ostrom, 2005c). These statements were analysed and classified using an approach that combined the tool presented in Ostrom and Basurto (2011) and ABDICO-based institutional analysis proposed in Siddiki et al. (2011). In a third step, the temporal sequence, structure and attributes of collective actions in relation to the capital investment planning process were mapped for each action arena and subsequently compared. The analysis focused on publicly available records of monthly Board meetings. In this context it is important to note that the analysis views collective action through the formal rules that are said to have guided activities in this context. Not included in the analysis are informal rules, which matter more in studies of weakly institutionalized contexts.

4The 2011 CAFR and 2013 CARF were available on www.udfcd.org until 2015, the 2014 CAFR still is available.
Ex ante analysis of operational level dependencies

The District’s accounting policies for 2011, 2013 and 2014 were coded sentence-by-sentence using the ABDICO scheme, and accordingly categorized into the three types of institutional statements (Strategies, Norms, or Rules) (Siddiki et al., 2011). The analysis identified and coded 158 statements for the year 2011, 165 for the year 2013 and 164 for the year 2014. The majority of statements were coded into strategies rather than more binding statements including a Deontic (norm) and an Or Else (principal rule). Only eight principal rules could be identified and in each case Or else was implicit in the phrases ‘by statute’ or ‘by law’. Theoretically, this can be described as a norm backed up by a metanorm (Ostrom, 2005d, p. 178).

With the exception of 14 statements, the wording of the District’s account policies for 2013 was identical to the policy statements for 2011. The data shows that the wording of three statements in total changed; for example:

Formal budgetary integration is not employed for the Project Private-Purpose Trust Fund or the Federal Grants Special Revenue Fund because effective budgetary control is achieved through specific contract agreements. (2011)

The District does not adopt a formal budget for the Project Private-Purpose Trust Fund or the Federal Grants Special Revenue Fund because effective budgetary control is achieved through specific contract agreements. (2013)

The coders also observed a total of eleven instances in which a statement was either added or removed. All of these statements were coded into strategies. The 2013 document introduced nine new strategies and deleted two. The changes are primarily incremental and concern the measurement (information) and order of spending (choice), but not the other elements of the action arena, for example

It is the District’s policy to use restricted amounts first, then committed, then as- signed, and then unassigned, as they are needed. (2013)

The 2011 document does not entail such a statement.

The wording in the statements in the 2013 and 2014 CAFRs are identical. Only three differences were recorded. The most significant is the number of Board members that was reduced from 23 to 22 (the City of Boulder – no longer having a population in excess of 100,000 – has one less seat on the table).

The two coders agreed that neither of these changes is likely to have an effect on the action arena. Thus, it seems fair to conclude that no paradigmatic change in the rules that could have fundamentally altered one or more characteristics of the action arena was observed at this stage of the analysis. This implies that the analysed policy design supports stable formal dependencies on the operational level. The next step is to look beyond the surface of the observed incrementalism and to investigate the link between the components of each statement (Ostrom & Basurto, 2011) as well as the aspects of the action arena in 2011, 2013 and in 2014.6

The evidence suggests that the District, the Board and other participating governmental entities (represented by individual Board members) were the key players within the action

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5 Coders disagreed in 1 out of 167 cases analysed in this context (99% agreement).
6 Two coders coded statements in the 2011 and 2013 CAFRs. They disagreed in 18 out of 167 cases analysed in this context (89% agreement). Only one coder coded statements in the 2014 CAFR.
arena in 2011, 2013 and in 2014. During this period, these actors engaged in accounting and budgeting activities to plan, coordinate and justify activities associated with the District’s main function to plan, coordinate, maintain and develop drainage facilities on the operational level in the Denver Metropolitan Area.

Furthermore, for each year the statements outline the same intermediate steps that the collective needs to accomplish before the budget for the year ahead can be passed (Table 1). Following the example of Heikkila et al. (2011) joint activities are described as linkages between players in an action arena (denoted L). The first set of linkages (L1) describes all collective action taken to draft a budget. In this context, the District sent out letters to other participating governmental entities inviting them to request support for capital improvement projects. L2 describes a set of joint activities that involves the general public in the budgeting process. The overall budget (including mill levies that are ring-fenced for specific programs, i.e. Information Services and Flood Warning, Masterplanning, Floodplain Management and Design, Construction and Maintenance) and more specific capital improvement plans (CIPs) need to be presented and discussed at a public hearing. L3 describes the interactions between the District and the Board. The District maintains financial records and prepares reports for each fiscal year. The latter, as the governing body, has to authorize the budget for the year but also the spending activities. Any budgetary changes need to be authorized as well, i.e. joint projects and master planning studies. L4 describes activities in which the Board audits the District’s budgeting activities, for they, as the governing body, are then accountable to the state government (L5). Since the arrangements that outline this particular process did not noticeably change between 2011, 2013 and 2014, it can be expected that the players in each case followed the same routine when preparing and reporting the District’s budget. The data presented in the following section verifies this conclusion.

**Ex post analysis of operational level dependencies**

We next compare the aforementioned process to the empirical situation in 2011, 2013 and 2014. Two independent coders collected the data to determine which players engaged in which joint activities at what point in time.7 The records of monthly Board meetings were reviewed in this context with a focus on joint activities that could be linked to one of the aforementioned intermediate steps in the budgeting process. To establish a link between

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7They coded the minutes for the years 2011 and 2013. Only one coder coded the minutes for the year 2014.
the dynamics in the action situation and changes in the context, the activities were time stamped. In total 28 meetings were analysed.

The results summarized in Tables 2, 3 demonstrate that a small group of players follows an established routine that arranges their actions related to the allocation and reporting of their fiscal resources. More specifically, the evidence in Table 2 suggests that the Board, on a monthly basis, reviews the record kept by the District’s accountant to record all financial expenditures made and revenues received by the District (L4: Cash Disbursement). The District also presents the Board almost monthly with requests to authorize studies that provide the engineering basis but also estimate the costs/benefits of projects that are to be included in the CIP (L4: Joined Projects). The process to draft and agree the CIP for the years ahead stretches over a period of five months. Between August and September the District’s staff evaluates the project needs by sending out request letters or a CIP Draft to the local governments (L1: CIP Request Letters). This gives them the opportunity to include or change drainage improvement projects in the CIP. In the next meeting in September a draft of the mill levy and budget for the year ahead is presented by the executive director on behalf of the District (L1: [Year] Mill Levy [Year] Budget). In October, the Board certifies the mill levy and budget (L3: [Year] Mill Levy [Year] Budget) after it has been disseminated in a public hearing (L2: [Year] Mill Levy [Year] Budget). This hearing takes place prior to the Board meeting. After the overall budget is authorized, the draft CIP is presented to the Board in November (L1: CIP [Period]). In November or December, the Board authorizes the CIP (L3: CIP [Period]) after it has been verified at a public hearing (L2: CIP [Period]). Approximately a year later, an independent auditor evaluates the accounts. The findings are discussed with the Board (L5: [Year] Accounts) and then published (L5: CAFR[Period]). Meanwhile, the data presented in Tables 3 suggests that a small group of key players repeatedly engages in these activities in the years studied. In particular noteworthy are the District’s Executive Director (Paul Hindman) and Program Managers for Information Services and Flood Warning Program (Kevin Stewart), Masterplanning (Ken MacKenzie), Floodplain Management (David Mallory) and Design, Construction and Maintenance (David Bennetts) but also the current Board’s Executive Committee, including the Chair (Paul Lopez, Council Member, City and County of Denver), the Chair Pro Tem (Joyce Downing, Mayor, City of Northglenn), Treasurer (Heidi Williams, Mayor, City of Thornton), the Secretary (Greg Stokes, Mayor Pro Tem, City and County of Broomfield) and the Member at Large (Dave Sellards, Engineer). The latter is one of two registered engineers selected by the Board whose other members are all locally elected officials (e.g. mayor, city council member). Least engaged are the District’s administrative staff and construction managers (e.g. Jeff Fisher).

This data is indicative of sustained information exchange between engineering experts, actors that understand local development needs and solutions and actors with the knowledge and skills to facilitate the development of an integrated stormwater management system. Furthermore, it suggests that this group follows an established routine to draft, disseminate, authorize the budget and the subsequent CIP as well as report spending activities. This routine seems to have evolved around specific Conditions embedded in the analysed statements, e.g.

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8 The District welcomes CIP requests throughout the year, but the opportunity to change the 5-Year CIP is limited once it is adopted in December.
Table 2. Activities reported to the Board at the monthly meetings in 2011, 2013 and 2014.

| Key actors | The District | The Public | The Board | The Board | Independent auditor |
|------------|--------------|------------|-----------|-----------|---------------------|
| Activities | L1: Draft Budget | L2: Disseminate Budget | L3: Authorize Budget | L4: Internal review | L5: Audit |
| Month      |              |            |           |           |                     |
| 01 Feb 2011| Cash Disbursement, Joint Projects | 2010 Accounts |
| 17 Mar 2011| Cash Disbursement, Joint Projects | 2010 Accounts |
| 21 Apr 2011| Cash Disbursement, Joint Projects | CAFR 2010 |
| 16 Jun 2011| Cash Disbursement, Joint Projects |                     |
| 18 Aug 2011| CIP Request Letters |                      |
| 15 Sep 2011| 2012 Mill Levy, 2012 Budget | 2012 Mill Levy, 2012 Budget |
| 20 Oct 2011| CIP 2011–2015 | CIP 2011–2015 | 2012 Mill Levy, 2012 Budget |
| 17 Nov 2011| CIP 2011–2015 | CIP 2011–2015 | Cash Disbursement, Joint Projects |
| 01 Feb 2013| Cash Disbursement, Joint Projects | 2012 Accounts |
| 21 Mar 2013| Cash Disbursement, Joint Projects | 2012 Accounts |
| 15 Dec 2013| Cash Disbursement, Joint Projects | CAFR 2012 |
| 17 Apr 2014| Cash Disbursement, Joint Projects | CAFR 2013 |
| 21 Aug 2014| CIP Request Letters |                      |
| 18 Sep 2014| 2015 Mill Levy, 2015 Budget |                      |
| 16 Oct 2014| CIP 2014–2018 | 2015 Mill Levy, 2015 Budget |
| 20 Nov 2014| CIP 2014–2018 | CIP 2014–2018 | 2015 Mill Levy, 2015 Budget |
| 18 Dec 2014| Cash Disbursement, Joint Projects |                     |

Source: UDFCD website (past board meetings).
Table 3. Board meetings in 2011, 2013 and 2014: Board Members.

| Participating entity | Year 2011 | Year 2013 | Year 2014 |
|----------------------|-----------|-----------|-----------|
| The Board*            |           |           |           |
| Adams County          |           |           |           |
| Alice Nichol          | 8         | 0         | 0         |
| Charles Tedesco       | 0         | 7         | 7         |
| Arapahoe County       |           |           |           |
| Susan Beckman         | 8         | 0         | 0         |
| Nancy Sharpe          | 0         | 8         | 6         |
| City of Avada         |           |           |           |
| Bob Dyer              | 8         | 0         | 0         |
| Mark Goff             | 0         | 2         | 8         |
| Ken Lucas             | 0         | 0         | 1         |
| City of Aurora        |           |           |           |
| Rachel Zenzinger      | 1         | 7         | 0         |
| Barbara Cleland       | 1         | 0         | 0         |
| Marsha Berzin         | 0         | 8         | 0         |
| Renie Peterson        | 9         | 0         | 0         |
| Bob Roth              | 0         | 1         | 9         |
| Bob Murphy            | 0         | 0         | 7         |
| Boulder County        |           |           |           |
| Cindy Domenico        | 1         | 0         | 0         |
| Deb Gardner           | 0         | 3         | 3         |
| City of Boulder       |           |           |           |
| Lisa Morzel           | 2         | 6         | 6         |
| Ken Wilson            | 7         | 0         | 0         |
| George Karakegian     | 0         | 0         | 5         |
| City/County of Broomfield |       |           |           |
| Walt Spader           | 7         | 0         | 0         |
| Greg Stokes           | 1         | 8         | 8         |
| City of Centennial    |           |           |           |
| Vorry Moon            | 7         | 0         | 0         |
| Stephanie Piko        | 0         | 8         | 0         |
| City/County of Denver |           |           |           |
| Cary Kennedy          | 2         | 4         | 2         |
| Paul Lopez            | 4         | 6         | 8         |
| Peggy Lehman          | 7         | 7         | 5         |
| Mary Beth Susman      | 1         | 7         | 5         |
| Marcia Johnson        | 3         | 0         | 0         |
| Bill Vidal            | 1         | 0         | 0         |
| Douglas County        |           |           |           |
| Jill Repella          | 4         | 4         | 2         |
| City of Edgewater     |           |           |           |
| Bonnie McNulty        | 9         | 8         | 9         |
| Jefferson County      |           |           |           |
| Faye Griffin          | 8         | 8         | 8         |
| City of Lakewood      |           |           |           |
| Bob Murphy            | 7         | 5         | 4         |
| City of Littleton     |           |           |           |
| Doug Clark            | 7         | 0         | 0         |
| Debbie Brinkman       | 0         | 5         | 0         |
| Bruce Beckman         | 0         | 0         | 7         |
| City of Northglenn    |           |           |           |
| Joyce Downing         | 8         | 7         | 7         |
| Town of Superior      |           |           |           |
| Andrew Muckle         | 7         | 1         | 0         |
| City of Thornton      |           |           |           |
| Heidi Williams        | 2         | 9         | 7         |
| Mack Goodman          | 6         | 0         | 0         |
| City of Westminster   |           |           |           |
| Nancy McNally         | 9         | 7         | 0         |
| Herb Atchison         | 0         | 0         | 7         |
| Consulting Engineer   |           |           |           |
| Mark Hunter           | 0         | 6         | 9         |
| Consulting Engineer   |           |           |           |
| Bob Hoffmaster        | 9         | 0         | 0         |
| Consulting Engineer   |           |           |           |
| Dave Sellards         | 10        | 8         | 8         |
| The District          |           |           |           |
| UDFCD                 |           |           |           |
| Amelia Deleon         | 0         | 9         | 9         |
| UDFCD                 |           |           |           |
| Barbara Chongtoua (6) | 6         | 7         | 5         |
| UDFCD                 |           |           |           |
| Bill DeGroot (8)      | 8         | 3         | 1         |
| UDFCD                 |           |           |           |
| Bryan Kohlenberg (3)  | 3         | 7         | 7         |
| UDFCD                 |           |           |           |
| Dave Bennetts (10)    | 10        | 6         | 9         |
| UDFCD                 |           |           |           |
| David Mallory (8)     | 8         | 6         | 8         |
| UDFCD                 |           |           |           |
| David Skuodas (10)    | 10        | 5         | 6         |
| UDFCD                 |           |           |           |
| Ed Krisor (10)        | 10        | 9         | 9         |
| UDFCD                 |           |           |           |
| Frank Dobbins (6)     | 6         | 7         | 0         |
| UDFCD                 |           |           |           |
| Geanesia Hinton (3)   | 3         | 0         | 0         |
| UDFCD                 |           |           |           |
| Holly Piza (9)        | 9         | 7         | 8         |
| UDFCD                 |           |           |           |
| Joanna Czarnecka (1 ) | 1         | 4         | 5         |
| UDFCD                 |           |           |           |
| Julia Bailey (1)      | 1         | 9         | 9         |
| UDFCD                 |           |           |           |
| Ken MacKenzie (9)     | 9         | 9         | 8         |
| UDFCD                 |           |           |           |
| Kevin Stewart (8)     | 8         | 5         | 9         |
| UDFCD                 |           |           |           |
| Laura Kroeger (9)     | 9         | 7         | 6         |
| UDFCD                 |           |           |           |
| Margaret Corkery (3)  | 3         | 0         | 0         | (Continued)
In the fall of each year [Condition], the District’s Board of Directors holds public hearings... (CAFRs 2011, 2013, 2014).

Here, the rule outlines not only the activities and the actors expected to engage in them, but also defines a timeframe.

**Observed learning and change at the operational level**

These observations suggest that the action arenas in 2011, 2013 and 2014 were grounded in a set of rules (primarily strategies) that facilitated communication and reciprocity between a small number of locally elected officials and senior District staff who drafted and authorized the District’s plans for capital improvements. This evidence complements prior research highlighting the District’s modest size and its cordial rapport with general purpose governments as essential factors to explain why the group is able to sustainably manage different perspectives on the risk of flooding in the Denver Metropolitan Area as well as on the benefits and costs of potential mitigation measures (Grigg, 2011a, 2011b, 2012; Handmer, 1990). Theoretically, collective action is particularly successful where a homogenous group of players engages in continued interaction to sustain a clearly defined resource system (Cox et al., 2010; Fleischman et al., 2014). According to Agrawal (2014), communication, reciprocity and trust are the only conditions by which collective learning and collective action can be achieved in response to endogenous and exogenous changes (Agrawal, 2014). Thus, it seems fair to assume that the observed players operated under conditions favourable for learning and adaptation when confronted with shifting resource needs after the September 2013 flooding event.

The minutes of the four Board meetings that took place between the flood in September and the adoption of the next CIP in December 2013 support this conclusion. The records mention that the fiscal resources funding infrastructure developments were limited and...
in order to add a new project, another project had to be omitted or postponed. Although the Board ultimately authorized the list of projects to which priority should be given in December 2013 (see Table 2, L3 ‘CIP 2013–2017’), the plan itself was the outcome of a consultation process that involved the District and all other participating governmental entities. First, the District issued a call for funding applications a few weeks before the draft budget and mill levy for the coming fiscal year was presented in the September Board meeting (see Table 2, L1 ‘2014 Budget and 2014 Mill Levy’). As the area experienced heavy rain and catastrophic flooding between the 9th and 15th of September 2013, the District decided to resend their request for calls and initiated another consultation that took flood-related changes into account (see Table 2, L1 ‘CIP Request Letters’). The record of the September 2013 meeting shows that the District diverted from the established routine in 2013 only in so far as to initiate a second round of CIP requests to accommodate and/or prioritize flood related projects in the CIP (UDFCD 21 Nov 2013):

The District has worked closely with local governments to incorporate priority projects in the CIP, including incorporating follow-up requests that were submitted as a result of the 2013 flood. These draft plans will be sent out to our local government contacts for their review and comment.

According to David Bennetts, central to the discussion with the other participating governmental entities to prioritize projects are the planning studies that are carried out to estimate the hazard and costs of the measures to mitigate the risk. The records of the Board meetings suggest that these planning studies are managed by highly specialized contractors and consultants in collaboration with the District, affected government entities, local inhabitants and businesses that reside in the study area. The Board ultimately authorizes the research but also disseminates the final report. In other words, every other participating governmental entity could apply for funding support, but only projects for which planning studies have been concluded were considered. Although the consultation itself is not captured in the records of Board meetings, one can assume that any conflict at this stage would have surfaced in December when the District presented the agreed plan at the public hearing and to the Board for scrutiny and approval. No such conflict was recorded in the 2013 or 2014 meeting minutes, suggesting that all players arrived at a shared understanding of what projects should be prioritized to receive funding support within the time period available to them. This suggests that the conditions were indeed favourable for learning and adaptation in the context of rapid ecological changes.

To sum up, although this discussion extends the study of collective action to an urban commons context (Blomquist & deLeon, 2011; Foster, 2011), the focus of the article is on collective choice-level rule configurations and the opportunities that they generate for learning in an operational level action arena where players constantly adapt their plans to fund the development of drainage facilities in the Denver Metropolitan Area. The evidence presented in this section adds weight to the conclusion that in 2011, 2013 and 2014 these actors operated under conditions that the Bloomington School highlights as supportive of learning and adaptation in small collective action settings but also large-scale settings (Cox et al., 2010; Fleischman et al., 2014; Villamayor-Tomas et al., 2014). First, rules were in place to ensure that the process of drafting the budget and subsequent CIP was transparent and accessible to all parties. The setting supported a monitoring system involving local players but also independent expert auditors. Second, the existing rules facilitated communication and reciprocity between all the players in the action arena. Third, the rules clearly outlined
the actors engaging in the action arena. This group of players was small. Fourth, the rules clearly focused on activities with the goal to develop drainage facilities to mitigate flood risk in the Denver Metropolitan Area. Finally, the rules also maintain a system of checks and balances ensuring that each player can be held accountable for his or her actions. The rules defining these conditions have remained constant between 2011 and 2014, supporting reciprocity. Furthermore, the fact that the vast majority of these statements was worded into strategies rather than binding norms and principal rules implies high levels of trust between the players (Ostrom, 2005a). This assumption, although supported by Grigg (2012) and Handmer (1990), has yet to be verified.

**Research gaps and recommendations for further research**

The present diagnostic study is explorative in the sense that it tests the usefulness of an approach introduced by Ostrom and Basurto (2011), modified by Siddiki et al. (2011) studying the configurational character of particular rules over time and with regard to the elements of the action arena that they affect. It describes the rule configuration that structures the actions and outcomes of the operational level action arena. This negotiates the distribution of resources to fund the development of drainage facilities in the Denver Metropolitan Area in 2011, 2013 and 2014 in an effort to mitigate the predictable risk of flooding. The IAD framework is used to guide this research. The analysis focuses particularly on rules that structured the conditions supportive of learning and adaptation in response to the 2013 Colorado flood. In this context, change is defined as the product of hidden learning processes (Heikkila & Gerlak, 2013). At the same time it elicits assumptions about the cognitive process itself. The study found that the actors in this operational level action arena were able to quickly respond to the 2013 Colorado Flood, due to the institutional design creating high levels of trust and reciprocity. According to Ostrom (2005b, p. 272), conditions that undermine mutual trust and reciprocity threaten robust and sustainable community governance.

The analysis falls into the category of contemporary studies of policy learning and change (Capano & Howlett, 2009; Dunlop & Radaelli, 2013; Howlett & Cashore, 2009; Knill et al., 2011). It acknowledges that policies are the result of policy experiments (Radaelli, 1995; Wildavsky, 1979) trying to improve the fit between rules and decision processes as well as the fit between rules and the social-ecological context (Epstein et al., 2015).

The findings are case specific and only describe the action arena before the 2013 Colorado flood (2011), the year in which the flood occurred (2013) and the year after (2014). In future research, the method tested in this case study can and should be used to study the evolution of rules from the origin of this action arena and in relation to prior floods in the region. Prior studies have already outlined the use of studying the evolution of public spending plans in a systematic way over time. Most of these studies cover several decades. For example, research analysing the evolution of budgeting data at the federal level in the United States showed that long periods of incrementalism are only occasionally punctured by a short period of major change (Baumgartner & Bonafont, 2015; Berry, 1990; True, 2000). The action arenas that have been described in this study seem to fall in a period of incrementalism, since the configurations of the analysed rules fall under what would best be described as first order change (Hall, 1993). The research design tested in this study seems to be suitable to complement current approaches that have been used to detect and
monitor incremental changes over time. It can thus help to address the dependent variable problem (Howlett & Cashore, 2009).

While a longitudinal study is one possible line along which this research can be further developed, another is to explore the links between multiple interrelated action arenas. For example, a potential step forward in this direction could be research integrating the present analysis of the capital investment planning process with evidence about the master planning process that provides expert information on the costs and benefits of drainage investments. At this point, there is potential to utilize the findings by Albright and Crow (2014), who analysed obstacles to local stakeholder’s participation in flood risk mitigation at the local level. Follow-up research can also look beyond formalized dependencies and directly ask actors about their collaborators (Ingold, 2014). This way, previous research identified brokers, actors with the opportunity to facilitate learning between two otherwise disconnected action arenas.

On a more general note, it may very well be that we are no closer to measuring and understanding the hidden learning process (Biegelbauer, 2007a, 2007b; James & Lodge, 2003). However, this does not mean that we cannot study the link between learning and change in polycentric governance systems. In fact, Howlett and Cashore (2009, pp. 34, 35) outlined the advantages of longitudinal research on the effects of institutional change on policy-making. The present discussion highlights an innovative approach to detect and monitor particular rule configurations in relation to the structure of an action arena. It is well integrated within the IAD framework, which simplifies the process of developing it further. To put in a nutshell, there is an availability of tools to systematically measure the evolution of rule configurations and formal dependencies, and to relate these observations to evidence about changes in the conditions under which actors in a particular action arena learn and adapt to endogenous and exogenous changes. The next step is to aggregate sufficient data to develop theoretical arguments with regard to the conditions supportive of learning at an operational level.

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No potential conflict of interest was reported by the author.

**Notes on contributor**

Antje Witting is a Postdoctoral Research Fellow. Her current research explores individual and collective decision-making in the context of urban policy development, with particular focus on the measurement of policy learning.

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