Insights from negotiations models on water sharing conflicts in the development of water basin plans

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Abstract. Collective decision making and negotiated outcomes are promoted for the water sector in order to increase ownership, commitment and participation. Negotiation processes for the development of water basin plans are, however, complex and tedious. This paper investigates the contribution of negotiation theory in facilitating basin plan development as a collective decision-making process. It outlines the typical water sharing conflict during the development of a basin plan. Later, it explains benefits from the approaches of game theory and complexity science in framing the negotiation process. Knowledge from selected, commonly used models in the study of water sharing conflicts at the basin level is summarised and compared. These models provide useful and complementary insights into the value of participation and the careful design of the negotiation process by using negotiation support systems.

1. Introduction
In light of increasing resource scarcity and uncertainty due to climate change and variability, strategic resource conflicts are increasingly occurring in environmental and resource management. These conflicts often involve multiple issues and decision makers with different preferences as to how to share a common resource. They are ubiquitous in both local and national water resources management. The development of integrated basin plans with clear allocation and protection rules represents a prime example of multi-issue and multilateral conflicts. Basin plan development typically involves issues of unrivalled complexity with a large number of affected parties, several objectives and multiple issues of uncertain size. State-of-the-art water-management paradigms, e.g. integrated water resources management (IWRM), promote collective decision making and negotiated outcomes as the best way to define complex policies such as basin plans. The promotion of negotiations and bottom-up approaches to water management has become an integral part of water governance systems in countries such as Brazil or the European Union in order to ensure the sustainability of water management and planning decisions [1]. Furthermore, outcomes will be better adapted to local preferences, thus become more efficient. Besides, the alternative of letting a national regulatory body design a non-negotiated policy is risky due to unanticipated conflicts and low level of ownership and enforcement.

Knowledge on suitable negotiation models to support water management issues is still evolving. Negotiation support systems provide a range of different models depending on the type of water-sharing conflicts, see Dinar and Hogarth for a review of game theory based models [2]. Knowledge from recent applications of negotiation-support tools can prove helpful for facilitating such water-sharing processes at the basin level [3], for inter-basin water transfers [4], or for transboundary water
conflicts [5,6]. This paper compares insights from prominent formal negotiation models that have been applied to water sharing agreements. It summarises insights with the aim of providing useful recommendations for involving stakeholders in negotiations at water basin level.

2. The development process of a water-basin plan

2.1. Phases

The development process of water-sharing agreements such as basin plans starts ahead of the negotiation process itself. In order to ensure the success of the negotiation process, participation should be promoted in advance. In a negotiation process, both the rules and the context of such a process determine the success in implementing the negotiated outcomes. It is important to understand the overall conflict characteristics and provide adequate support before, during and after the negotiation process. Figure 1 summarises different critical factors for collective decision making via negotiation and shows which type of computer-based Negotiation Support Systems (NSSs) can be used for each phase. Thiesse et al had a similar classification of NSSs without relating these to the phases of water basin plans [7]. For the follow-up of the negotiation process, commitment to the negotiation outcomes and enforcement of rules are necessary to ensure implementation. For this phase, different monitoring systems (MS) can be used to prepare implementation reports on the adopted basin plan.

![Figure 1. Negotiation support systems for the development of water basin plans (NPS: Negotiation Preparation Systems; NIMS: Negotiation Information Management Systems; NPSS: Negotiation Process Support System (NPSS); NCSS: Negotiation Context Support Systems).](image)

2.2. Basic conflict setting

The negotiation process for developing basin plans is often long and involves various stakeholders with conflicting interests. Any negotiation support system needs to address the specific stakeholder groups, conflict lines and issues in the basin plan development process. Table 1 categorises the key stakeholder groups as well as the involved issues based on study on the Sebou basin in Morocco [8]. Basically, in a typical setting, the most important groups are the different water user groups. The interest group “Environment” represents heterogeneous actors with similar preferences.

| Conflict                        | Common issues                                                                 |
|---------------------------------|-------------------------------------------------------------------------------|
| Agricultural vs urban sector    | Increasing water supply demands for agriculture vs water used for irrigation; Water degradation through the use of pesticides in agriculture vs water quality; Reservoirs for irrigation or water supply. |
| Hydropower vs agriculture and urban water use | Negative effect of dams on water availability for other uses through evapotranspiration and water diversion; Unavailability of water used for electricity generation for downstream uses; Risk of flooding upstream of the constructed dams. |
3. Models for negotiation support and conflict resolutions

3.1. Game theory vs complexity-based models

This paper differentiates between game theory and complexity-based models. First, game theory can be divided into cooperative and non-cooperative. The approach of cooperative game theory is based on collective welfare maximization and has been applied to water issues (see the reviews in [9,10]). However, some prefer the use of non-cooperative game theory for environmental issues which are often characterised by a Prison’s Dilemma situation. Here, cooperation is not a dominant strategy while players distrust each other in negotiations and thus maximise their individual welfare in relation to utility and participation rules of the others. Within this approach, the basic negotiation game is that of Rubinstein [11], based on Stahl’s 1972 game [12] of a finite horizon alternating model. However, the Rubinstein game of only two players, a single issue and a known resource size (certainty) does not reflect most real negotiation setups. Therefore, scholars have extended this game to incorporate multi-issue and multi-party (multilateral) negotiations. These extensions include different multilateral setups with exit-options for players after certain satisfaction levels [13-16], the incorporation of the role of the agenda and sequencing [17-20], and the analysis of the uncertainty issue [21,22].

Formal negotiation models based on game theory are often used as NPSS, i.e. for illuminating the process itself. Despite their usefulness in this regard, in reality, they fail to predict negotiation outcomes due to the restrictive assumptions of complete rationality and perfect information. Often, negotiators have more opportunities to interact and learn from each other. As result, complexity-based models propose an alternative view using simulations of collective decision-making as Multi-Agent Systems (MASs) or Agent-Based Models (ABMs). These models attach certain behavioral rules and attitudes to the negotiation game. In water negotiations, the complexity-based approach can sometimes deliver similar results as game theory or complement knowledge from game theory by illuminating the conflict’s context and history [23]. Some examples of this approach used on water negotiation issues include the CATCHSCAPE model by Becu et al [24], or the iterative model of Barreteau et al [25] which is co-designed with stakeholders. Recent applications include transboundary water negotiations [5,6] or land-water-climate issues in water management related negotiations [26].

In this paper, the basic approach of game theory and complexity models with relevance to negotiations at the basin level is introduced and insights summarised. Here, under the game theory approach, the focus is on the Rausser-Simon model as the dominant model applied to basin-level water sharing conflicts. The Simon–Rausser is a multilateral, multi-issue non-cooperative bargaining model which represents an extension of the two-person, one-issue Rubinstein–Stahl game [27]. Here, a finite number of players select a policy from a policy package. If the players do not reach an agreement by a certain time, a disagreement policy is imposed on all players (e.g. the exclusion from benefits in some variables, or the continuation of the status quo). Such disagreement policy acts as a punishment for all players for not arriving at negotiated solutions, and represents the least preferred outcome for the players. Players randomly propose a policy package according to their exogenously specified vector of access probability. The access probability is understood as the political effectiveness of the strength of the player’s institutional role within the process. Each player has an ideal point in regard to each negotiation issue (i.e. most preferred negotiation results), and can weight issues according to their importance for him. Here, a player can be radical on an issue but still compromises in favor of another issue with a higher weight for him. Players can decide to enter into coalitions with other players. In
such a game setting, the access probability, ideal point, and relative importance of the issue for the players are key elements for understanding the behaviour of the players. In table 2, this paper designed an example of the negotiation set-up using the Simon–Rausser model parameters. Here, it uses the baseline conflict explained above to provide a picture of typical negotiations in a water basin sharing conflict. In this example, the access probability or power is distributed among the five important actors whose preferences on five important issues are known. Each actor has an ideal point on the level of issue implementation in the basin plan: High (H), Moderate (M), or Low (L), and weights the issues according to their importance to him or her. For example, new hydropower infrastructure is the single most important issue for the hydropower industry, which negotiates for a high level of such infrastructure.

**Table 2.** Example of the negotiation set-up in the Simon–Rausser model in water basin conflicts.

| Players          | Access Probability | Rates of water use fees | Level of pollution charges | New hydropower infrastructure | Investments in lake reservoirs for irrigation | Degree of environmental standards |
|------------------|--------------------|--------------------------|---------------------------|-------------------------------|---------------------------------------------|----------------------------------|
| Urban water suppliers | 25%               | Ideal point M 25%        | Ideal point L 20%         | Ideal point H 15%             | Ideal point M 17.5%                        | Ideal point L 25%               |
| Agriculture      | 25%               | M 25%                   | L 20%                     | M 15%                         | L 20%                                       | H 17.5%                         |
| Hydropower       | 15%               | M 12.5%                 | M 20%                     | M 15%                         | L 20%                                       | H 17.5%                         |
| Industrial users | 20%               | L 25%                   | H 20%                     | H 15%                         | L 20%                                       | L 17.5%                         |
| Environmentalists| 15%               | Ideal point M 17.5%     | Ideal point M 15%         | Ideal point L 17.5%           | Ideal point M 17.5%                        | Ideal point M 17.5%             |

3.2. Key insights

3.2.1. Power and influential actors. Consistent with intuition, the political weight leads to a more favourable allocation towards the powerful user or other users with similar preferences. In game theoretical models, such power is often represented by the probability of access to the negotiation process. In the Simon–Rausser model, for example, bargaining power is represented not only by the access to the negotiation, but also by relative utility to the disagreement policy. Low relative loss from the disagreement policy acts as a bargaining power of the respective player [28]. Assuming that the disagreement policy is the continuation of the status quo, environmentalist groups have a better bargaining position if the current level of environmental protection is high. Usually, they are not directly enduring the costs of water pollutions or droughts. However, since environmental standards are still weak in many countries, the continuation of the status quo thus gives a better bargaining position to the big polluters. On the other hand, the biggest losers from the status quo are local governments who endure costs resulting from externalities of resource use and securing of access for future generations.

3.2.2. Number of negotiators and issues. Ideal issue points and the relative importance of the issues affect the final outcome. A common way to examine the impact of these variables is by excluding one player or one issue from the negotiation (e.g. water-use charges). With regard to the exclusion of one issue from negotiation, Adams et al. [28] emphasised the danger of shrinking the negotiated policy
package. Under certain circumstances, excluding a controversial issue or limiting its admissible values can lead to loss of mutual gains inherent to any bargaining process. Another application of the Simon–Rausser game is found in three publications [29] [30] [31]. The authors applied the model to negotiations in the Adour Basin in the South West of France. In this instance, seven players (one representative farmer from each of the three sub-basins of the river, a water manager, a local representative called a “tax-payer”, and two environmentalists, or an environmentalist and a downstream user) negotiate over dam sizes in the sub-basins and the correspondent residential flows, quotas, and prices. This application looked at the issue of excluding one player from the negotiation table. In such a case, his preferences will not be considered in the optimisation problem of the other players, and thus the final outcome will move away from his vector of ideal points. It is thus important for certain interest groups to participate even if their access probability is zero (no negotiation power, especially in the case of unanimity). This might be important in the case of ethnic minorities or marginalised groups. This notion of the value of stakeholder participation in basin negotiations despite lack of access and power finds some support in qualitative studies. Horagnic et al. [32] showed in the example of the Klamath Basin, in the United States, that past negative experiences did not translate in nonparticipation while perceived power differentials encouraged both participation and non-participation.

3.2.3. Coalition and Strategic behaviour. Goodhue et al. [31] considered an interesting game modification in regard to shifting the access probability from one player to another. Their results indicate that the more moderate players might benefit from an increase in the access of the more extreme player with principally the same preference. To illustrate this with the example in Table 2, agricultural and industrial users have similar preferences with regard to low water-use and pollution charges, as well as the investment in hydropower infrastructure. They differ in preference level and weight with regard to the other issues. A shift of negotiation access from industrial to agricultural user, or vice versa, will not result in a much worse outcome for both of them compared with a shift towards other players. For example, agricultural users could benefit from the more extreme position of industrial users in regard to pollution standards. Such a result is more pronounced if one considers a heterogeneous group of players representing industrial users. A moderate industrial user A might prefer to let an extremist industrial user B dominate the process. In fact, group heterogeneity poses a lot of problems for predicting the best negotiating strategy. Intuitively, group heterogeneity (A and B with different preferences over the same issue) weakens the bargaining power of the whole group. In fact, narrative evidence from real-life basin plan negotiations indicates that divisions within negotiating groups might lead to opposition to the negotiation process [32]. In this regard, Adams et al. [28] emphasised the role of the consensus rules of the game. If the institutional setting requires unanimity of all interest groups (not all members of within all negotiating groups), A and B will compete to represent the industrial users. As a result, heterogeneous coalitions are expected. This impacts poorly on the negotiations as the utility of excluded sub-groups and members as well as of included sub-groups will suffer. To counteract this, one should require the support of a significant number of sub-groups. Another solution discussed by Goodhue et al. [31] is the appointment of a common spokesperson for heterogeneous groups. This benefits the whole group, as this negotiator can discriminate against one member through side-payments and incentives, or point out interdependencies and externalities between behaviours of the members.

3.2.4. Resource uncertainty. Sgobbi and Carraro [33] applied the Simon–Rausser model to the Piave River Basin in Italy while considering the key aspect of uncertainty over the size of the negotiated variables. They showed that with unpredictable availability of water, the negotiation will be on average longer, and sometimes players’ strategies do not converge to a feasible solution. Furthermore, players tend to bargain harder in an effort to secure themselves higher shares of the resources, and therefore hedge against scenarios of increasing water scarcity or effects of climate changes and variation. In fact, uncertainty about the negotiated variables is a major concern in water negotiations since it causes delay and lower allocation levels as Nasiri-Gheidari et al. [34] show in the case of inter-basin water resource allocations. As a general conclusion from these applications, there is value in
carefully choosing the policy space of the negotiation, as well as reducing uncertainties regarding the size of the issues at the negotiation table: i.e. better quantifications of resources or a targeted reservoir management strategy. Basin agencies are thus advised to include measures to reduce uncertainty in their basin plans. Good data on resource availability and reservoir investments help facilitate the negotiation process.

3.2.5. Confidential and assisted negotiations. Game theoretical models provide for facilitators and players a means of managing a process of proposals exchanged openly. Such a setting allows for strategic behaviour and can be time-consuming. Support systems based on complexity approaches try to solve this by assisting the finding of a compromise through confidential negotiations. One prominent example is the Interactive Computer-Assisted Negotiation Support System (ICANS). It represents a multi-stakeholder and multiparty negotiation support tool that works based on confidentiality, and aims at improving agreements and saving valuable negotiation time [7]. Here, negotiating parties must provide information on their preferences and ranking of issues. This information is provided confidentially. Each player publishes his or her own proposal for the final outcome and accepts or rejects proposals by other players. This process is guided by a negotiation facilitator using the software-based ICANS. The software is able to generate equivalent alternatives and compromises, and presents them to the players. Once a tentative compromise has been agreed upon (i.e. a certain proposal has been accepted by all parties), ICANS can create a more satisfying improvement. The advantage of such systems is the acceptability to the players whose willingness to participate may be higher. Often in water-basin plan negotiations, there is no regular negotiation platform with clear rules to attract the different groups mentioned in (by-)laws. Confidential and software-assisted systems are perceived as less biased. This sense of fairness, and with it, ownership of the process, is highly important for sensitive negotiations such as those regarding basin plans. Furthermore, software-assisted tools can improve any negotiated outcome by bring any deal to the efficiency frontier, where nobody is worse off, and some are better off.

In complexity-based tools, the political power of a group is often not considered, as all parties are assumed to have the same access probability. Of course, in practice, it is difficult to involve all groups in the negotiations based on equal access rights. Although it is in the interest of every party to participate, a selection of all “important” groups or representatives is more likely. Besides, negotiation process support tools are only useful if people are “willing” or “forced” to negotiate. In the absence of a disagreement policy as in the Simon–Rausser model, and of a clear legal obligation to join the negotiation table, players will weight their strategic choices of participating, delaying, or boycotting.

4. Conclusion
Despite the increase in regulations towards participation and negotiated outcomes, current basin-plan processes in many parts of the world largely focus on resource quantification and use. Basin-plan development is often associated with by delay and weak participation. Insights from negotiation models deliver useful perceptions of the value of increased of participation. Different formal negotiation models reconfirm the importance of participation and the expansion of the process. Negotiation facilitators such as basin agencies are advised to open up the process to include all issues, especially those concerning the future rules and regulations, to ensure an adequate level of environmental protection and sustainability in resource use. Limiting the negotiated area by excluding a controversial issue or a relevant actor leads to loss of mutual gains. Game theory also stresses that groups with limited political power still have indirect power, since their relative utility from a break-up of the negotiations is higher. Here, good negotiation rules to counteract heterogeneity of involved groups are required. Overall, different tools from negotiation models can help facilitate such a bottom-up development process for basin plans. Game theoretical models provide some general but valuable advice for basin agencies, for example, on the basic structure of a negotiations and key factors determining any outcome. They do, however, exhibit restrictive assumptions, and should be complemented by multi-agent, complexity-based decision support tools. These tools can improve the
negotiation process, for example by allowing for confidentiality and computer-based optimisations of selected outcomes.

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