Mechanisms to Reduce Uncertainty in International Water Treaties

Toolkit
A Toolkit of Mechanisms to Reduce Uncertainty in International Water Treaties

Alena Drieschova, University of Toronto
(the work was conducted while being a visiting scholar at Hebrew University)
and Itay Fischhendler, Hebrew University of Jerusalem

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A part of the Kalrakum reservoir (tajikistan). Source: Kai Wegeric
Table of content

Introduction | ................................................................. p. 4
Methodology | ............................................................... p. 6
Distinguishing between Different Types of Uncertainties | ......................... p. 7
Strategies and Mechanisms to Deal with Uncertainties | ......................... p. 12
The Practice of Treaty Making: Combining Strategies and Mechanisms | .... p. 25
Take Home Points | .................................................................................. p..32
References | ........................................................................................................  p.33
Introduction

Scientific knowledge regarding the natural environment has increased tremendously over the past decades. Despite such achievements, such knowledge will never be complete due to the sheer complexity and dynamic character of natural systems. Thus, it will never provide certainty regarding optimal natural resource management (Van Asselt and Rotmans 2002). For example, we do not know how climate change will impact a range of renewable resources (e.g., precipitation), and how these in turn will affect various ecosystems. Furthermore, we do not know how people will respond to such changes and what the impacts from this adaptation will be. Thus, in attempting to model environmental change, we now often add social factors to existing scientific uncertainties (Oppenheimer and Todorov 2006). The climate change debate underscores both the scientific and social aspects of uncertainty. An increase in occurrences of extreme weather events is expected, although their frequency and the locations in which they will occur, remains largely unknown (IPCC, 2007). Inadequate handling of extreme weather events can have negative consequences on economic growth and broader societal development. An increasing, costs of mitigating and recovering from such environmental hazards, for instance, exacerbates the uncertainties regarding optimal adaptation policy (Haque and Burton 2005).

The effects of climate change are likely to be significant in terms of water resource management (World Water Week 2009). In many places the future magnitude and frequency of floods or droughts remain unclear. For this reason, land-use planning and water infrastructure for flood plains and irrigation systems have been identified as two of the most crucial investment sectors when considering climate change impacts (Hallegatte 2009). Climatic change is likely to exacerbate uncertainty over water demand as well, via, for instance, its impact on global grain production (Hoekstra and Hung 2005), energy policy (De Fraiture et al. 2008), and human migration (Homer-Dixon 1999). As an example, the recent trend towards increased bio-fuel production has significantly increased the demand for irrigation water, and has affected the profitability, and thus the planting rates, of various crops. Given the stochastic nature of both water supply and demand, which is becoming less predictable due to climate change, water management cannot assume static conditions, but instead has to be adapted to changing and uncertain circumstances (Milly et al. 2008).

Uncertainty over international political and economic relations adds to the uncertainties inherent in water management, as over 500 aquifers and river basins cross international boundaries. Such transboundary water bodies affect over 148 countries and account for over 60% of global freshwater flows. Thus, successful water management requires international cooperation. In addition to the vagaries of bilateral political relations, collective action constraints and the absence of a centralized global governing body add to uncertainty in
transboundary water contexts. Research has shown that uncertainty decreases the size of coalitions adopting international environmental agreements (Kolstad 2004), and inhibits the formation of coalitions and the making of credible commitments, including acceptance of monitoring constraints (Durth 1996).

How should we address such realities? Given the limitations of scientific progress (in both natural and social sciences) to eliminate major uncertainties in transboundary water issues, we must adjust institutions to deal with them (Hallegatte 2009; Adger et al. 2009). Therefore, identifying the precise mechanisms by which water agreements can reduce and/or cope with multiple uncertainties is crucial. Such mechanisms have been found to improve agreement effectiveness and the willingness of parties to enter a given treaty regime. For example, the absence of effective treaty mechanisms increases the likelihood that drastic changes in water flow will lead to political tensions (Yoffe et al. 2003, Fischhendler 2004).

Growing water scarcity, uncertainty over resource accessibility and weak institutional arrangements all constitute risks to treaty stability and are key factors in contributing to water-related conflict (CEDARE 2006; Gonen & Zeitouni, 2008; Bernauer & Kalbhenn, 2010). Existing transboundary water treaties may prove inadequate to address future water management needs if they are not able to adapt to changing circumstances (IPCC, 2001; Nordas and Gleditsch, 2007). Such changes may cause countries to deviate from an agreement after it is in place (Bhaduri, 2006). When treaties lack flexibility, issues related to treaty implementation, such as changed water availability or demand, may lead to disputes (Giordano and Wolf, 2002; Vinogradov, et al, 2003; Ostrom, 2005).

In negotiating agreements, the problem of uncertainty is an essential challenge that needs to be dealt with for a variety of environmental problems (Faber et al, 1992; Sigel et al, 2007). Negotiations usually take place under conditions of considerable complexity and uncertainty, and it is not practical or even possible for the parties to specify in advance how they ought to behave under every conceivable contingency (Schwartz and Sykes, 2002). Conditions of uncertainty often create a need for specific regulations and mechanisms; however, states may be cautious about engaging in legally binding commitments. This often leads to a preference for soft-law mechanisms, which allow states to formulate more precise terms and conditions of agreements at a later point (Koppel, 2009).

There is a wide recognition of the need for technical responses to the uncertainties in the water sector; research on institutional and legal responses, however, lags behind (Matthews and Athukorala 2009). In this vein, this toolkit seeks to identify available uncertainty management strategies and mechanisms. The next step would be identifying the factors that affect the choice of these mechanisms to address uncertainties and evaluate their effectiveness in light of changes in the political, economic, and natural environment.

The structure of the toolkit is as follows: We first present a methodological chapter. We then identify the different types of uncertainties and their relevance to international water treaties. Following this, we then identify the language used in treaties to describe and address uncertainties. Next, we describe different strategies and mechanisms to deal with those uncertainties and examine the frequency of their use in a large sample of treaties. This is accompanied by a number of examples of how these mechanisms have been applied in practice. Finally, we discuss how these mechanisms together form a coherent treaty regime, drawing on the 1999 example of the Convention on the Protection of the Rhine.
This first phase of the toolkit is to develop a conceptual model outlining different types of uncertainties that can impact on water treaty negotiations, ratification and efficiency, based both on theory and empirical observation. Subsequently, we identify four broad strategies that can be employed in order to deal with those uncertainties. Each of these strategies is based on a different approach.

In order both to identify language used in treaties to describe uncertainties and to reveal the concrete mechanisms employed in treaties to address uncertainties, we conducted a broad based content analysis of international water treaties. We categorized the mechanisms according to the four different strategies mentioned above. The content analysis of international water treaties builds on earlier work in which documents selected in the analysis were also limited to those transboundary water treaties which govern rivers, lakes or aquifers which cross international borders and focus on “water as a scarce or consumable resource, a quantity to be managed, or an ecosystem to be improved or maintained” rather than those which deal “only with boundaries, navigation or fishing rights” (Hamner and Wolf 1998: 158). Agreements which focus only on navigation, border delineation and fishing rights (as distinct from water as a provider of habitat for fish) were excluded from our analysis. In addition, the analysis is limited to agreements focusing explicitly on specific basins. Under this limitation, “global” agreements such as the 1997 UN Convention on the Law of the Non-navigational Uses of International Watercourses, which lay out principles for water governance but do not apply those principles to actual water bodies, were also excluded.

The source of the data used in the analysis is the recently expanded Transboundary Freshwater Dispute Database (TFDD), the most comprehensive source of transboundary water agreements that meet the criteria. The database had available full or substantial portions of 303 agreements meeting these criteria. Because of the low number of database agreements signed before the 20th century, we limited our sample for analysis to the 289 agreements signed after 1900.

Using the content analysis as a basis, the toolkit describes each of the treaty mechanisms and provides examples of how they have been employed in an actual treaty. In conducting the content analysis, we also identified the frequency of use of the different mechanisms and strategies dealing with uncertainty. This allowed us to identify trends over time in their use. Thus, in addition to the description of various mechanisms, the toolkit provides charts with the frequency with which many of them have been employed in international water treaties.

Based on a literature review, more in depth case studies are presented for the most important mechanisms that analyse how those mechanisms have helped to alleviate specific uncertainties.

Lastly, we present a case study of the development of the treaty regime of the Rhine in order to identify how different uncertainty strategies and mechanisms interact with one another over time in an actual basin institutional setting.
Uncertainty refers to “a situation in which there is not a unique and complete understanding of the system to be managed” (Brugnach et al., 2008, p. 4). Given the fundamental importance of uncertainty to natural resource management many scholars have tried to develop typologies of types of uncertainty. Some scholars, have, for instance, distinguished between epistemic and ontological uncertainty; where epistemic uncertainty stems from imperfect knowledge of a system, ontological uncertainty relates to variability and unpredictability inherent in a system itself, such as the stochastic nature of supply of many natural resources (Walker et al. 2003; Brugnach et al., 2008; Isendahl et al., 2009). Brugnach et al. (2008) add ambiguity as a third type of uncertainty. According to the authors, ambiguity is the result of «the simultaneous presence of multiple frames of reference about a certain phenomenon» which can lead to multiple interpretations, as thus, uncertainty regarding interpretation.

In addressing uncertainty in negotiations, Iida (1993), distinguishes between analytic uncertainty – that relating to limitations of knowledge of the system or model in question (e.g., future rainfall levels or future prices of agricultural goods) – and strategic uncertainty, which relates to limited knowledge of the attributes and preferences of one’s negotiating partners. Strategic uncertainty implies knowledge of one’s own payoff possibilities, whereas analytic uncertainty may include uncertainty regarding one’s own payoffs as well. Both forms of uncertainty can affect the distribution of gains and losses from an agreement. This distributional uncertainty can impact both the willingness of parties to enter an agreement and the stability of the regime created within an agreement (Kolstad 2007).

In this study we built our own typology of uncertainty as it pertains to transboundary water negotiations. We differentiate between two types of uncertainties that are independent of, or exogenous to, negotiations: exogenous resource uncertainties and exogenous background uncertainties. The resource based uncertainties are based in physical phenomena affecting the resources themselves. For instance, they may stem from natural variation in water quantity or quality, as experienced, say, in times of droughts or floods. Or they may be due to limitations in knowledge regarding the complex web of interactions that affects the hydrological cycle and the ecological effects of this cycle, for instance the impact of climate change, land use patterns, etc. Intricate and interconnected feedback loops between multiple complex systems affecting the hydrological system, as well as the existence of non-linear reactions (e.g., tipping points) to perturbations, are poorly understood (GWSP 2005). This limited understanding also results in uncertainties regarding the outcomes of water management decision-making.

The background uncertainties may stem from uncertainties about internal politics, like the possibility of changing...
domestic coalitions which can translate into different national interests and, thus, potential changes in state behavior; or may originate in the international domain, where shifts in balance of power, economic capacity, alliances, etc. can affect the priorities of nations and their ability to negotiate. International basins often face a combination of both resource and background uncertainties, which can lead to international tension. For example, in the case of the Nile River, uncertainties over future flow regimes due to changes in rainfall and land cover combine with political uncertainties over Egypt’s possible reactions to upstream water development; the outcome of which is inefficient resource use and threats of conflict.

Water treaties can mitigate some of these exogenous uncertainties, both natural and social. For instance, agreements on water storage and minimum allocations can mitigate uncertainties stemming from the stochastic nature of rainfall patterns. Agreements on issues such as conflict resolution procedures, benefit-sharing, side payments, or establishment of institutional bodies or mechanisms to monitor or oversee various treaty clauses, can reduce some of the background uncertainties that often inhibit efficient and effective transboundary water management. International water treaties often mitigate effects of uncertainty such as risk of conflict in river basins experiencing rapid physical and institutional changes (Yoffe et al 2003). The ability of treaties to absorb the detrimental effects of uncertainty is often a result of providing riparian countries with specific mechanisms and an established framework suited to facing specific aspects of uncertainty at play (Wolf, et. al. 2003, Odom & Wolf 2008). International water treaties can also help to elevate the level of transparency, decrease the transaction costs of cooperation, and clarify expectations among the parties (De Stefano et al 2010).

Failure to include equitable rules governing water use in transboundary water treaties aggravate the danger that existing uncertainties will result in undesirable outcomes such as increased water scarcity, resource degradation, and inequitable distribution (Fischhendler, 2004; Yoffe et.al. 2003). They may also result in less effective or less satisfactory treaty implementation. For example, Dinar et al. (2008) found that there is a preliminary correlation between water supply variability (measured in precipitation variation over time) and inter-country grievances (measured as the intensity of grievances among states).

While international agreements can address some aspects of uncertainty, they are unlikely to eliminate all such aspects. Furthermore, the creation of an agreement to address exogenous uncertainties can itself generate new uncertainties, endogenous to the agreement design. Such an endogenous uncertainty may be uncertainty about the implementation of a treaty by one or more parties, due to the anarchical nature of the international system or due to a lack of capacity of one or more parties to comply. Alternatively, uncertainty might be due to the ambiguity, whether intentional or not, of treaty texts and the resulting interpretation of the treaty or of collected data. Such uncertainty is not necessarily detrimental to treaty formation. In fact, designed ambiguity is often essential to forming an agreement. However, it may impede agreement implementation, or satisfaction of parties with such implementation. Furthermore, exogenous uncertainties often reinforce or exacerbate the impacts of endogenous uncertainties. For example, ambiguity in a binational treaty between Israel and Jordan was critical in getting the sides to sign on, however, a continuous drought coupled with deteriorating political relations between the states, became destructive as parties disputed interpretations of treaty clauses, which in turn further aggravated political relations (Fischhendler 2008).

Since endogenous uncertainties are conditional upon the creation of an agreement there is a general trade-off between their manufacture and the handling of exogenous uncertainties through the management process. For example, when states try to deal with flow variability in water-sharing agreements by basing allocations
on percentages of river flows, uncertainty about treaty implementation can arise if insufficient data about the hydrological flow are available or if these data can be disputed by either party. Many of the disputes around the Ganges Water Treaty signed by Bangladesh and India in 1996 (Salman and Uprety 2002) can be attributed to such a scenario. The interplay between exogenous uncertainties and endogenous uncertainties creates three significant dangers for riparians – the dangers of resource degradation, resource scarcity and inequitable distribution of the resource. The consideration of these dangers of uncertainty, among other things, impacts on the treaty design and stability as countries may defect from an agreement once there is uncertainty about expected gains from the agreement. Hence these uncertainties in turn affect the likelihood of ratification and effectiveness. Figure two presents a conceptual framework for the uncertainty in transboundary water treaty design and implementation.

The Indus Waters Treaty from 1960: An example of political uncertainties impacting on treaty design

Evidence as to the importance of addressing uncertainty in international water management regimes can be seen by the fact that nearly two-thirds (65.7%) of 289 analyzed international water treaties in the period 1990-2007 directly mentioned at least one form of uncertainty. Flow variability, such as the occurrence of droughts or floods, is the type of uncertainty observed most frequently in water treaties (49%). It is followed by treaty created infrastructure uncertainty called for in treaties (18%). This uncertainty is about whether the work constructed under the treaty regime or other relevant infrastructure could collapse, leak, etc. This is followed by general environmental uncertainties related to the complexities of ecosystems (13%). Other uncertainties, such as about the actual implementation of a treaty (7%), the financing of a treaty regime (6%) or about international relations as manifested for example in the possibility of war (8%), are mentioned less frequently in treaties. Financial uncertainty implies uncertainty about the financial costs of an agreement and/or whether and/or how they will be met. Finally, there is treaty effectiveness uncertainty (4%) which is uncertainty about whether the goals of the treaties will be met with the help of the measures installed in the treaty; scientific uncertainty (4%) which is incomplete scientific knowledge leading to uncertainty of particular outcomes; and finally data uncertainty (1%) which is uncertainty about the validity of the data gathered by one or all of the parties for whatever reason. The fact that certain uncertainties were not explicitly mentioned in specific treaties does not mean that they were not important in the negotiation process or treaty regime, nor that they do not play a role in the implementation of a treaty. It only means that the negotiators of a treaty decided not to include them in treaty language.
Figure 1: Moisture Stress Index (Landsat TM/Landsat T5) of a selected area (see image location on the right) of the Indus Basin. Raw landsat bands and the location images obtained from University of Maryland (USA) and processed using ENVI software. The main river channel (in blue color) shows the least water stress. The 2005 image shows water stress in comparison to the 1999 and 2000 data. The northern portion of the river indicates a higher degree of water stress in 2005 relative to 1999 and 2000, which highlights the significance of flow variability and uncertainty. Author: Biniam Iyob.

Fig. 2: Uncertainty in transboundary water treaty design and implementation: A conceptual framework.
Evidence of the importance of uncertainty in transboundary water management can be seen by the fact that nearly two-thirds (65.7%) of 289 analyzed international water treaties in the period 1990-2007 directly mentioned at least one form of uncertainty (Drieschova et al. forthcoming). Flow variability, such as the occurrence of droughts or floods, is the type of uncertainty observed most frequently in water treaties (49%). It is followed by technological uncertainties surrounding the creation of infrastructure, such as dams, called for in treaties (18%), and by unspecified broader environmental uncertainties related to the complexities of ecosystems (13%). Other uncertainties, such as those related to political and economic factors affecting international relations between parties (8%), the actual implementation of a treaty (7%) or the financing of a treaty regime (6%) are mentioned less frequently in treaties, but this does not mean that they were not important in the negotiation process of a treaty regime or that they do not play out in the implementation of a treaty.

### Table 1: Uncertainty Language in Transboundary Water Agreements, 1900-2007

<table>
<thead>
<tr>
<th>Nature of Uncertainty</th>
<th>% of sample which mentioned</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exogenous Resource Uncertainty</strong></td>
<td></td>
</tr>
<tr>
<td>Flow variability</td>
<td>49%</td>
</tr>
<tr>
<td>General environmental</td>
<td>13%</td>
</tr>
<tr>
<td>Scientific</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Exogenous background uncertainty</strong></td>
<td></td>
</tr>
<tr>
<td>International Relations</td>
<td>8%</td>
</tr>
<tr>
<td>Demand uncertainty</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Induced endogenous uncertainty</strong></td>
<td></td>
</tr>
<tr>
<td>Treaty created infrastructure</td>
<td>18%</td>
</tr>
<tr>
<td>Treaty implementation</td>
<td>7%</td>
</tr>
<tr>
<td>Treaty finance</td>
<td>6%</td>
</tr>
<tr>
<td>Treaty effectiveness</td>
<td>4%</td>
</tr>
<tr>
<td>Data</td>
<td>1%</td>
</tr>
</tbody>
</table>
Academics have long stressed the need for developing robust strategies to address uncertainties in international water agreements (e.g., Hallegatte 2009). Such strategies need to perform well over a wide range of different scenarios (Adger et al. 2009). With this need for robustness in mind we can differentiate between at least four different strategies that have been employed in water treaties in order to deal with uncertainties: (i) a strategy of ignoring uncertainty, (ii) a strategy of complete contracts, (iii) a strategy of reducing uncertainty, and (iv) an open-ended approach. A brief description of each of the four strategies is followed by examples of concrete mechanisms in place to achieve these strategies in actual water treaties.

Ignoring Uncertainty

Only if uncertainty is perceived as such can it be acted upon. However, there are “cultures of risk denial” which can lead to the ignoring of uncertainty (Adger et al. 2009). Alternatively, negotiators can deliberately decide to ignore uncertainties of which they are well aware. One means is to eliminate any use of language acknowledging uncertainty in an agreement. For example, a treaty establishing fixed water allocations between two countries may be drafted to ignore the fact that flows will vary from year to year. Uncertainty may also be ignored by failing to include mechanisms for its management, such as conflict-resolution mechanisms, which could help to settle ambiguities inherent in the treaty text. Following Allan’s words, “it is better to do the right thing somewhat poorly, than the wrong thing extremely well” (Allan, in Zeitoun and Salame 2009: 9). In line with this dictum, strategies of ignoring uncertainty are best avoided, as they often lead to conflict in the implementation phase as soon as the situation deviates from typical situations.

Fixed allocation: Mechanisms allocating absolute quantities of water to the riparians. Since a certain degree of flow variation occurs in every basin, these allocation mechanisms clearly ignore the uncertainty of flow variability.
Fixed Allocation Mechanisms in the Aral Sea

Before the countries in Central Asia attained independence, the Aral Sea basin was managed by the Soviet Union as an integrated system. The aim was above all to maximize cotton production downstream, in Uzbekistan, Kazakhstan and Turkmenistan. The upstream riparians, Kyrgyzstan and Tajikistan, that needed water mainly for the production of hydropower, were compensated through the centralized Soviet power system. As these entities became independent this integrated system broke down and the allocation of water resources remains one of the most contentious issues between the different countries. Though a number of water-sharing agreements have been signed, to date they have proved inadequate to resolve the tensions. The existing allocation of water resources is perceived as unfair by the upstream riparians and inadequate monitoring mechanisms lead to mistrust between the parties. Growing demands for water, as well as four consecutive years of drought have further strained relations. Clearly, the allocation of fixed water resources on a monthly basis, such as stipulated, for instance, in the 1998 “Agreement between the governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the joint and complex use of water and energy resources of the Naryn Syr Darya cascade reservoirs” does not help to ease the strain. Kyrgyzstan, upstream, is obliged to provide fixed quantities of water on a monthly basis to the downstream riparians and thus has to bear the entire burden of the fluctuating water availability. This situation caused Kyrgyzstan to pass a law stipulating that water is its own national resource and that it will only be sold at a price to others. It could be argued that this development contributed to Uzbekistan’s decision to conduct military maneuvers around the Toktogul reservoir (ICG 2002; Gregory 2003).

“A Floating pumping station, which takes water from the Kairakum reservoir in Tajikistan and lifts it in 3 stages up to a height of 180 meters. Source: Kai Wederich”
Complete Contracts
At the other extreme, agreements may aim for a complete contracts approach (Simon 1981; Hart and Moore 1988) focused on reducing the implications of uncertainty. Under such an approach, agreements specify each party’s obligations under all potential scenarios that may arise out of uncertainty, leaving no space for ambiguity in treaty interpretation or performance. Such a “bulletproof agreement” includes provisions such as monitoring frameworks, escape clauses for unexpected conditions, and binding arbitration mechanisms which describe fully the possible responses no matter how uncertainty eventually materializes.

Variable Allocation Mechanisms: The Niagara Water Diversion Treaty
In 1909, the Boundary Waters Treaty, signed between the US and Britain as head of the Commonwealth established absolute quantities of water the US and Canada could divert from Niagara Falls. By 1927 both countries had reached the maximum allotment of water diversion and during low-water conditions the Falls had an insufficient flow to cover the entire crest lines. The previously established International Niagara Board of Control recommended remedial work, which was conducted through the 1950s. During World War II, the two governments authorized the maximum diversion of waters from the Niagara River for power generation, which was itself a response to variable water demands due to uncertainties resulting from the international regime. Negotiations throughout 1949 resulted in the signing of the Niagara Water Diversion Treaty the following February. The treaty sought to develop a compromise between the dual need for hydropower generation for the growing industrial sectors in the Niagara Falls region and for the tourist industry to maintain the scenic beauty of the Falls. A creative solution was found: during the summer months between 8am and 10pm a minimum of 100,000 cubic feet per second had to be available in the river. At other times up to 50% of the water could be withdrawn for hydropower production, which was to be divided equally between the two parties. While the percentage allocations allow for variability of water supply, the treaty also considers the possibility of variability in demand. Article 8 states that “until such time as there are facilities in the territory of one party to use its full share of the diversions of water for power purposes agreed upon in this Treaty, the other party may use the portion of that share for the use of which facilities are not available.” In 1965 the New York State Power Authority and Ontario Power Generation signed an agreement to share generation capacity. The two power companies rented available power-generating capacity from each other in order to maximize the use of their respective water allotments (Cech 2009).
**Variable allocation:** Mechanisms allocating water based on a percentage of flow rather than in a fixed manner as described above. This highly flexible mechanism implies that parties will share the benefits of water surpluses in wet years and deficits in dry years.

**Variable water or hydropower needs:** These mechanisms allow states to redistribute water flows or hydropower energy in case one of the parties has an excess or lack of these resources; in other words, they take into account the variability of water demand.

**Minimal water consideration:** These mechanisms set aside a guaranteed minimum amount of water available to communities living in border areas. For example, Article 5 of the “Agreement between the Federal Republic of Nigeria and the Republic of Niger concerning the equitable sharing in the development, conservation and use of their common water resources,” signed in 1990, states that “in determining the equitable share to which each contracting party is entitled pursuant to Article 2, the following factors shall be taken into account,” including among others “the dependence of local populations on the waters in question for their own livelihood and welfare.”

**The right to construct:** These mechanisms provide a right for one or more parties to the agreement to construct particular types of infrastructure in the future. They are oriented towards identifying uncertain potential future opportunities to employ water resources in permissible ways. For instance, the “Treaty of friendship and neighbourly relations, and six annexed protocols,” signed between Iraq and Turkey in Ankara in 1946, states in Protocol 1, Article 4 that “the Turkish Government accepts in principle the construction, in conformity with the agreement mentioned in the next paragraph, of any works which may be found necessary as a result of the studies provided for in Article 1. Each work, other than the permanent observation stations, shall be the subject of a separate agreement in respect of its site, cost, operation, and maintenance, as well as its use by Turkey for purposes of irrigation and power production.”

**The right to compensation:** These mechanisms provide a right to compensation if one party is unexpectedly adversely affected by undesirable developments under the control of other parties to the agreement. For example, Article 12 of the “Agreement between Norway and the Union of Soviet Socialist Republics on the utilization of water power on the Pasvik (Paatso) River,” signed in 1957, states that “Compensation caused by a break in the dam resulting from poor workmanship and compensation for any other kind of unforeseen damage shall be paid by the party which carries out or has contracted with others to carry out the construction or operation of the installations which have caused the damage.”

**Alternative scenarios uses:** These mechanisms prescribe procedures to be taken under possible future contingencies. This approach can be highly efficient, for instance, if it includes built-in-procedures to respond to biophysical changes, minimize their occurrence or reduce their impact (Young 2008). For instance, the “Agreement between the government of the Union of Soviet Socialist Republics, the government of Norway and the government of Finland concerning the regulation of Lake Inari by means of the Kaitakoski hydroelectric power station and dam and additional protocol” (1959) states in Annex 3, Article 2 that “the water-level of Lake Inari shall be lowered to a level not exceeding 116.53 meters above sea level by 1 May. If the forecasts indicate that the spring flood will be very heavy, the water-level of Lake Inari shall be reduced to below 116.53 meters above sea level by 1 May; however, during the period from the beginning of January to the end of April the discharge from the lake shall not exceed 280 cubic meters per second.”

**Agreement finance:** These mechanisms stipulate rules about the sources and division of financing of agreements. For example the 1967 “Treaty between the Republic of Austria and the Czechoslovak Socialist
Republic concerning the regulation of water management questions relating to frontier waters states in Article 8 that “Each (1) Contracting State shall bear the costs of the execution of water management measures which are to be carried out by it in its territory for its exclusive benefit. (2) The costs of the execution of water management measures from which both Contracting States are to derive benefit shall be borne by the Contracting States in proportion to the benefit which each is to derive therefrom, regardless of whether the works are executed in the territory of only one Contracting State or in the territory of both. (3) The costs of the execution of water management measures which are carried out in the territory of one Contracting State to the exclusive benefit of the other Contracting State shall be borne by the Contracting State which is to benefit from the measures.”

**Prior consent:** Prior consent means that the parties are not allowed to add new water uses or build infrastructure unless the other side agrees. This principle allows parties to secure their share of water, thereby mitigating uncertainty concerning future plans of the other partner to develop new water uses. For example, it says in Article 12 paragraph 12 of the “Treaty on the development and utilization of the water resources of the Komati River Basin between the government of the Kingdom of Swaziland and the government of the Republic of South Africa,” signed in 1992, that “No party shall allow within its territory the construction of any water storage work in the Komati River Basin with a capacity in excess of 250,000 cubic meters without the prior approval of the JWC [Joint Water Commission].”

**Legal means of dispute resolution:** These mechanisms guarantee an independent solution to any conflict between the parties. Since arbitration or a settlement by the International Court of Justice is binding upon the parties, legal means of dispute resolution have a higher degree of authority than diplomatic channels. Hence, they provide a higher degree of certainty that conflicts, should they emerge, can be resolved.
The Gabcikovo Nagymaros System of Locks: A Case for the International Court of Justice

A typical example of the use of legal means of dispute resolution occurred in a matter surrounding the “Treaty on the Construction and Operation of the Gabcikovo Nagymaros System of Locks,” signed by Czechoslovakia and Hungary in September 1977. The treaty provided for the joint construction and operation of a system of locks for the purposes of power generation, flood control, improved navigation and environmental management. However, in the early 1980s Hungary stopped construction on the works, as it became concerned about the project’s environmental implications and lack of finance. As a response, Czechoslovakia threatened to implement a unilateral variant of the project. When further negotiations failed Slovakia went ahead with a unilateral construction of the Gabcikovo dam and a subsequent diversion of water from the Danube in order to fill it. Hungary considered this a breach of its territorial integrity. After efforts at mitigation conducted by the European Commission, this legal dispute between Slovakia and Hungary over the terms of the treaty led to the only case in which the International Court of Justice (ICJ) has adjudicated over international water law. Interestingly, the 1977 treaty does not mention a possible reference to the ICJ in case of a dispute. Article 27 merely states that “(1) the settlement of disputes in matters relating to the realization and operation of the System of Locks shall be a function of the government delegates. (2) If the government delegates are unable to reach agreement on the matters in dispute, they shall refer them to the Governments of the Contracting Parties for decision.” However, on 7 April 1993 the “Special Agreement between the Republic of Hungary and the Slovak Republic for Submission to the International Court of Justice of the Differences between Them Concerning the Gabcikovo-Nagymaros Project” was signed. The final judgment of the ICJ was mixed in that it stated, on the one hand, that Hungary did not have the right to unilaterally abrogate the treaty and, on the other, that Slovakia’s unilateral withdrawal of water from the Danube was a breach of the principle of equitable and reasonable sharing of the resources of an international watercourse. The parties were instructed to achieve the objectives and principles of the treaty insofar as was feasible (Fitzmaurice 1998, Nakamichi 1998).

Monitoring: Monitoring mechanisms provide some certainty that the parties respect their agreement obligations. They help to prevent free-riding and reinforce the strength of the treaty. For example, Article 11 of the “Agreement between the Federal Republic of Nigeria and the Republic of Niger concerning the equitable sharing in the development, conservation and use of their common water resources” states that “the Nigeria-Niger Joint Commission for cooperation […] shall monitor the implementation of the provisions of this Agreement.”
Reducing Uncertainty

An uncertainty minimization strategy is a mechanism according to which agreements attempt to reduce either the implications of uncertainty or its core causes. The assumption behind this strategy is that uncertainty reduction can produce social benefits, especially regarding the effects of climate change (Yohe 1996; Nordhaus and Popp 1997). In the realm of transboundary water management, such agreements can adopt mechanisms such as data exchange or technology transfer to increase the understanding of natural systems or facilitate the creation of shared hydrological models to predict water resources futures and provide a platform for building and understanding possible future scenarios (Courtney 2003; Van Asselt and Rotmans 2002).

Variability management: These mechanisms reduce the uncertainty of flow variability and/or alleviate its consequences. Examples include early warning systems, dam construction, or insurance schemes. Early warning systems or insurance schemes are reversible strategies in that they can be adjusted annually (Hallegatte 2009). For instance, it is stated in Article 3.1 of the “Joint Water Commission Terms of Reference,” signed between Mozambique and South Africa in 1996, that “the functions and powers of the Commission shall be to advise the Parties on all technical matters relating to (a) measures that can be implemented by any one or both Parties to alleviate short-term problems resulting from water shortages in any water resource of common interest to the Parties during periods of drought […] (e) the monitoring and exchange of relevant information and other relevant data, including the timely exchange of information needed for the implementation of alleviating measures during drought periods and for flood forecasting and warning systems.”

Bans on particular construction: These mechanisms forbid the construction of particular infrastructure by parties of a treaty. They aim to reduce uncertainty related to potentially undesirable water uses and/or basin developments by one or more of the parties. For example, Mexico and the US agreed in Article 4.1 of the 1970 “Treaty to resolve pending boundary differences and maintain the Rio Grande and Colorado River as the
international boundary” that “Both in the main channel of the river and on adjacent lands to a distance on either side of the international boundary recommended by the Commission and approved by the two Governments, each Contracting State shall prohibit the construction of works in its territory which, in the judgment of the Commission, may cause deflection or obstruction of the normal flow of the river or of its flood flows.”

**Predictive models:** These mechanisms aim at reducing the uncertainty of future developments by creating models to predict future outcomes. They help identify stresses early so that the parties can deal with them quickly and effectively (Young 2008). They are a form of soft strategies that facilitate the creation of long-term planning horizons (Hallegatte 2009). For instance, the 1987 “Agreement between the government of the French Republic, the government of the Federal Republic of Germany, and the government of the Grand Duchy of Luxembourg on flood warning for the catchment basin of the Moselle” establishes in Article 8 that “the Contracting Parties will undertake efforts to improve the system of flood announcements for the Moselle and the Sarre by establishing their own mathematic models of flood forecasting and by exchanging information about the models which will have to be put into place in the future.”

**Technical and financial cooperation:** These mechanisms guarantee provision of technical and financial support under extreme conditions, such as floods, or more generally ensure cooperation in developing technological solutions to issues such as flow variability or water quality. They can also increase state capacity and thus lead to enhanced treaty compliance and a decreased likelihood of treaty defection. They can further boost compliance by changing the incentive structure of the parties and creating mutual gains. Moreover this is a reversible mechanism; it is highly flexible and can be adjusted regularly (Hallegatte 2009). For instance, in Article 2 of the “Convention on the international commission for the protection of the Elbe” (1990) Germany, Czechoslovakia and the European Economic Community agreed that “the Commission shall: […] (d) propose and coordinate the implementation of joint programmes of measurements and investigations to demonstrate the quality of the waters, sediments and effluent and to describe the aquatic and coastal communities, and shall record and evaluate the findings.”

**Establishment of national programs to support treaty goals:** These mechanisms oblige the parties to adopt national programs in order to achieve treaty goals, making them subject to national legislation. This is significant because domestic law enforcement is considerably higher than international law enforcement. Thus the incorporation of these mechanisms leads to a diminished likelihood of defection from treaties. For example, Brazil and Uruguay agreed in Article 3 of the “Treaty on cooperation for the utilization of the natural resources and the development of the Mirim Lagoon basin (Treaty of the Mirim Lagoon basin) and Protocol (Jaguarão River Protocol)” from 1977 that “in accordance with the aims of this Treaty, the Contracting Parties shall: (a) Take within their respective jurisdictions, in accordance with their plans and priorities, such action as is needed to promote the development of the basin.”

**Open-ended approach**

Finally, agreements can use an open-ended strategy. The premise behind this option is that uncertainty is inevitable. The solution, then, is to leave room for change by including flexibility and adaptability in the design of management systems (Pahl-Wostl and Jeffrey 2007). Agreements using this strategy may include provisions for consultation, a broadening of cooperation, mutual assistance, indirect allocation, or a reliance on the ambiguous language of international law. They may also include the option of the sequential construction of regimes over time rather than immediate finalization (Abbott and Sindal 2002). The emphasis of the open-ended approach is on procedures while the emphasis in the complete contracts and uncertainty minimization approaches is on clear and defined rules or outcomes. The mechanisms available in this strategy are by their very nature reversible and flexible, as the strategy is a form of soft adaptation (Hallegatte 2009).
Stakeholder participation: This mechanism allows stakeholders to play a role in water management, thus, ideally, making the adopted policies less contested at the national level. Stakeholder participation can guarantee that social factors of adaptation are taken into account (Adger et al. 2009) and that people’s worldviews, their culture, values and norms are considered in the process of adaptation (Haque and Burton 2005). However,

![Figure 5: Percentage of Reducing Uncertainty Mechanisms in Water Treaties over time](image1)

![Figure 6: Percentage of Reducing Uncertainty Mechanisms in Water Treaties over Time](image2)
together with stakeholder participation the entire management process also becomes inherently more open-ended. For example, the “Agreement between the Governments of the Republic of Botswana the Kingdom of Lesotho the Republic of Namibia and the Republic of South Africa on the Establishment of the Orange-Senqu Commission,” signed in Windhoek in 2000, states in Article 5.2 that “the Council shall take all measures required to make recommendations, or to advise the Parties, on the following matters: […] 5.2.4 The extent to which the inhabitants in the territory of each Party concerned shall participate in respect of the planning, development, utilisation, protection and conversation of the River System, as well as the harmonisation of policies in that regard and the possible impact on the social, cultural, economic and natural environment.” Incorporating the inhabitants of a region into a treaty regime allows treaty makers to integrate important social and economic factor. This makes the precise management outcomes more open-ended, as the inhabitants can impact upon the treaty regime in various different ways, including bringing the implementation to a deadlock. On the other hand, leaving the inhabitants of a region out of a treaty regime does not mean that they will disappear from a given region. They will still impact upon the implementation of a treaty regime as agents in their own right. Not taking their agency into account can lead to unforeseen and potentially undesirable outcomes.

**Joint Commissions:** Joint commissions provide an institutional framework for parties to discuss and manage the water resource, but they do not provide any clear rules or procedures to follow. They are thus inherently open-ended, adaptable and flexible. Past research suggests that joint management institutions help to ease conflict between riparians (Gerlak and Grant 2009, Yoffe et al. 2003), but they do not guarantee improved coordination or more effective water management. Joint Commissions appear in 62% of all analyzed treaties (Drieschova et al. forthcoming), but their mandates and degree of institutional strength can vary from shallow cooperation with very loose institutional cooperation to bureaucratic organization with regular meetings up to formal intergovernmental organizations. These institutional arrangements can help overcome transaction costs related to sharing scientific information and bureaucratic knowledge, and they can incorporate spill-over mechanisms, where cooperation in one issue area requires further enhanced cooperation in another issue area (Gerlak and Grant 2009).

**Vague allocation mechanisms:** These are allocation mechanisms, which are vague in that they incorporate clauses (such as an agreement to consult in case flow variability occurs) without stipulating any precise measures according to which water flow is supposed to be allocated between the parties. They are unclear as to the basis upon which final decisions will be made. For instance, it says in Article 2 of the “Treaty between the Government of Afghanistan and His Britannic Majesty’s Government for the Establishment of Neighbourly Relations,” signed in 1921, that “the British Government agrees that the Afghan authorities shall be permitted to draw water in reasonable quantities through a pipe which shall be provided by the British subjects”; however, “reasonable” was never defined.

**Amendment mechanism:** The inclusion of mechanisms that formally recognize right of parties to amend a treaty makes that treaty inherently open-ended. In some cases this mechanism comes in the form of a “periodical review process” which allows the parties to make amendments whenever new conditions arise. An example of an amendment mechanism is Article 20 in the “Agreement for the Establishment of the Organization for the Management and Development of the Kagera River Basin,” concluded by Burundi, Rwanda, Tanzania and Uganda in 1977, which states that “the present Agreement may be amended or revised by the member States:”
**Joint Commission on Lake Titicaca**

The Lake Titicaca region experiences a high variability of water flow leading to frequent floods and droughts, thus causing uncertainty. In 1957 Bolivia and Peru signed the “Preliminary Convention for the Study of the Use of the Waters of Lake Titicaca,” which stipulated the joint ownership of the lake's waters and created an entity known as the Joint Sub-Commission. The goal of the treaty was to promote the joint management of the region. As such, the treaty was inherently open-ended. It focused on financial and technical cooperation and on the development of the necessary institutional structure, without stipulating concrete management strategies. While Peru ratified the Convention immediately, in 1957, it took until 1986, after the 1982-83 drought and the 1986-87 floods, for Bolivia to ratify it. The Joint Sub-Commission became SUBICOMILAGO (Joint Sub-Commission for the Development of the Integrated Region). In 1996 the two countries started to implement the “Binational Master Plan for the Control and Prevention of Floods and for the Use of Resources of the TDPS System (Lake Titicaca, Desaguadero River, Lake Poopo and Coipasa Salt Lake)” with the help of the European Community. It was only at this point that cooperation became more concrete and focused on reducing uncertainty. As part of the master plan the “Binational Autonomous Authority of Lake Titicaca (ALT)” was established. Since its creation, ALT has achieved some considerable successes, such as the construction of a major dam for flood control. The mutual efforts show the advantages of technical and financial cooperation, and highlight the understanding that the water resource is shared equally between the parties. However, it has been observed that the Binational Master Plan falls short of its stated objectives, mainly because stakeholder participation is not included in the joint management project. Given the poverty and the level of conflict in the region, stakeholder participation of local communities is considered a crucial component in order to advance their development (Wolf and Newton 2008; Revollo 2001).

**Diplomatic means of dispute resolution:** Typically, these take the form of “consultations” – an inherently vague mechanism that does not specify any clear measures to adopt to alleviate uncertainty. Rather the possible solutions are left open to negotiations between the parties. One typical area of dispute concerns the question of whether a party has a right to accommodate new water needs. This mechanism is open-ended, since it is not binding upon the parties and it does not clarify how parties will be able to reach an agreement to a dispute.
The International Joint Commission’s Contributions to Settling Disputes between Canada and the United States with regards to the 1909 Treaty

The 1909 Boundary Waters Treaty, which regulates the boundary waters between Canada and the United States, established the International Joint Commission (IJC) and granted it the judicial, investigative and administrative power to implement the treaty.

One of the main tasks of the IJC, which is composed of three US and three Canadian representatives, is to investigate and potentially adjudicate disputes, if called upon by the two parties. When severe unexpected droughts in the Great Lakes region between 1961-64 combined with increased water use, the two governments decided to use the services of the IJC and of a Panel of Experts to investigate further possibilities of regulation that could provide some certainty to water supply and demand. In 1977, a reference resulted out of this process which expanded the IJC’s scope of activity beyond the boundary waters to include the entire basin for regulation. Further, it was decided to maintain the 1909 Boundary Waters Treaty in its existing form and to address remaining disputes with supplementary treaty regimes. Thus, for example, the 1972 Great Lakes Water Quality Agreement, its 1978 amendment and 1986 protocol addressed issues of water quality and environmental considerations (Fischhendler 2004).
Fig. 7: Percentage of Open-ended Mechanisms in Water Treaties over Time
In practice, the overwhelming majority of treaties contain multiple mechanisms, and often multiple strategies. In the last twenty years there has been an increase in the number of uncertainty management strategies and mechanisms employed in water treaties. Historically we have seen an increase of the use of open-ended strategies, in particular. Use of such an open-ended strategy has been in addition to, rather than instead of other strategies.

On average, a single treaty is composed of 6.3 different mechanisms which correspond to 2.5 strategies. This raises the question of how strategies and mechanisms can be combined in treaties in order to create an effective treaty regime. Given that the uncertainties riparians face differ in every basin (some basins are prone to flooding, others are prone to drought; in some basins the relations between riparians are tense, in others they are amicable), there is no single blueprint for combining mechanisms and strategies in treaties. There are nonetheless a few general principles which should ideally be taken into account when designing a treaty regime. Here we provide a case study of the Rhine treaty regime, which is often hailed as a “best practice” case when it comes to combating river pollution.

Some early initiatives of cooperation on the Rhine emerged already in 1886 with the establishment of the Salmon Commission by Germany, the Netherlands and Switzerland, which was designed to prevent overfishing of salmon. The first hearing on the impact of water quality on the salmon took place in 1922. However, these initial efforts were disrupted by the economic recession, the outbreak of the Second World War, and the disappearance of the salmon from the Rhine. From 1950 onwards international cooperation was concentrated in the International Commission for the Protection of the Rhine (ICPR), with members from France, Germany, Luxembourg, Netherlands, Switzerland, and later the European Economic Community. The ICPR found its legal standing with the Convention signed in 1963. The ICPR is composed of high-level civil servants, who lead a national delegation to the plenary meeting of the ICPR each year. The coordinating group meets four times a year and is responsible for the actual planning and the coordination, while working groups and expert groups conduct research and planning during the whole year. Additionally, the annual Rhine Ministers meeting was instituted in 1972 (Bernauer and Moser 1996). The initial tasks the ICPR was supposed to fulfill were inherently open-ended. The main focus was on including mechanisms that can foster coordination of research, the exchange of information, propose measures for protecting the Rhine against pollution, and prepare the text of future agreements. The 1963 Convention essentially lays down an open-ended institutional design of the water regime without developing any precise obligations or commitments of the parties.
This changed only with the signing of the Convention on the Protection of the Rhine against Pollution by Chlorides and the Convention on the Protection of the Rhine against Chemical Pollution, both signed on the 3 December, 1976. The primary aim of the Chlorides Convention is regulating the emission of salt into the Rhine. The potassium mines in France are the single most significant emitter. The aim of the Convention on Chemical Pollution is the gradual elimination of emission of black list substances into the Rhine and regulation of emissions of grey substances. The ICPR was to propose emission targets which would be binding upon the parties for black list substances. It was foreseen that the parties would develop national programs for the regulation of grey substances. In their design and with their precise stipulations, both of these treaties came close to a complete contracts approach toward dealing with uncertainty. However, the implementation of both Conventions proved to be quite difficult. France did not ratify the Chlorides convention until 1983 because of resistance in the Alsace, where the potassium mines were located. Even after ratification, technical difficulties emerged which made the storage of chloride underground impossible. A new technological solution was ultimately found, but its implementation began only in 1987, 11 years after the signature of the Chloride Convention. In 1991 the Additional Protocol to the Convention was signed, and entered into force in 1994. The Netherlands, as the party most concerned about the potassium level in the Rhine, accepts it as the last word on the problem (Nollkaemper 1996).

Difficulties also emerged with the formulation of emission standards for the Convention on Chemical Pollution, as from 1976 to 1986 only three substances were put on the black list (Verweij 1999). These problems were
due to scientific uncertainty about the risks involved, a lack of political will and Germany’s competitiveness concerns (Nollkaemper 1996). Germany suspected that France and the Netherlands wanted to gain a competitive advantage over the German chemical industry located on the Rhine, as that industry in the other two countries would not have been affected by the Convention due to the territorial treaty applicability. For this reason Germany waited for EU-wide regulation, which would subject everybody to the same quality standards, before signing the treaty (Mostert 2009). The case illustrates that despite the fact that both treaties were binding and very specific, the complete contracts approach is not a guarantee for treaty implementation, particularly if uncertainties are not adequately addressed through appropriate mechanisms. Neither the scientific uncertainties nor Germany’s uncertainty about the market competitiveness of its chemical industry were dealt with appropriately. Despite the difficulties of implementing the treaties, Moser and Bernauer (1996) observe that the 1976 Convention led to the unification of measurement standards, which proved to be crucial for the success of subsequent regulation measures in that it allowed the parties to unify their perceptions of uncertainty.

On the 1 November 1986 a fire at Sandoz AG near Basel, in Switzerland, led to the spill of 10,000 to 15,000 cubic meters of heavily contaminated water into the Rhine, which had devastating effects on the ecosystem.
and caused the interruption of drinking water supply and irrigation systems (Bernauer and Moser 1996). The incident led to heightened awareness about the vulnerability of the ecosystem and about existing uncertainties. A Rhine Ministers Conference was called within two weeks of the incident, and there the idea for the Rhine Action Plan (RAP) emerged with the ambitious goal to return the salmon to the river by the year 2000. The RAP contained a statement of clear goals, among them: the return of higher species, in particular salmon, to the Rhine; making Rhine water potable; the reduction of emissions by 50% based upon the application of the state-of-the-art technologies; and the development of measures to reduce accidents. While the RAP was never legally enforceable, because it had not been ratified, it was politically binding upon the parties. The great improvement of the water quality in the Rhine has been mainly attributed to the success of the RAP, as many of the emission targets set out in it have been met. Interestingly, the RAP was less binding upon the parties than the Chlorides and the Chemical Pollution Conventions were, yet it was more successful. The case
illustrates that more flexible mechanisms can, at times, better deal with uncertainties than precise and highly rigid mechanisms.

As a consequence of the 1993 and 1995 floods on the Rhine, the ICPR’s mandate was further broadened and Action Plan Flood Protection was adopted in 1998 (Mostert 2009). This led to the signing of a new Rhine treaty, the “Convention on the Protection of the Rhine,” on 12 April 1999. It has remained in effect since 1 January 2003. The 1999 Convention has been identified as the international water treaty with the most frequent reference to uncertainties in the text (Drieschova et al. forthcoming), namely, variability, general environmental uncertainty, scientific uncertainty, uncertainty about treaty implementation and about treaty effectiveness and infrastructural uncertainty. Furthermore, with a total of 14 uncertainty mechanisms, it boasts more than double the average amount of mechanisms per treaty. What is more, the treaty incorporates almost three quarters of all the treaty mechanisms which have been identified herein. In sum, the 1999 Convention on the Protection of the Rhine is a comprehensive treaty which combines an impressive mix of flexible and enforceable mechanisms to deal with a wide array of existing uncertainties (see Table 2). The treaty text itself clearly demonstrates that the negotiators were fully aware of those uncertainties.

Yet, it has to be acknowledged that it took 50 years of intense cooperation between the various Rhine riparians to reach the current treaty regime. The case of the Rhine is a typical example of the progressive development of a treaty regime, which started with the institutionalization of the ICPR – and the ICPR was crucial for the further development of the treaty regime in a number of different respects. While it has neither independent decision-making power nor independent financing and is entirely based on consensus, the ICPR provided a crucial platform for negotiations, trust building, the development of a community of experts, the exchange of information, and the coordination of research and monitoring. Thus though international cooperation started while significant scientific uncertainties remained, the ICPR crucially helped to reduce political uncertainties and it helped to develop a common language, which allowed the parties to harmonize their perceptions of the existing uncertainties. The coordination of information exchange and monitoring mechanisms allowed governments to use the same “facts” as a starting point for negotiations (Dieperink 1998), to identify a unified interpretation of sampling results (Dieperink 2000), and to homogenize perceptions about the problem and of available technical solutions to it (Bernauer and Moser 1996). In particular, the ICPR contributed to the harmonization of different industry classifications, diverging emphases on effluent limits and water quality standards, and the different categorizations of chemical substances (Verweij 2000, Verweij 1999), factors which had significantly marred negotiations prior to 1987. Information exchange and research and technical cooperation also enhanced the problem-solving capacity of governments, which in itself reduced the likelihood of involuntary defection from the treaty regime.
<table>
<thead>
<tr>
<th>Use of management mechanisms in the 1999 Rhine Convention</th>
<th>% of international water treaties employing management mechanisms</th>
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<tr>
<td>Ignoring</td>
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<tr>
<td>Fixed allocation</td>
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<td>Complete contracts</td>
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<td>Variable allocation</td>
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<td>Variable water or hydropower needs</td>
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<td>Local needs consideration</td>
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<td>Right to construct</td>
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<td>Compensation</td>
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<td>Alternative scenarios uses</td>
<td>Y</td>
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<tr>
<td>Agreement finance</td>
<td>Y</td>
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<td>Prior consent</td>
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<td>Legal means of dispute resolution</td>
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<td>Monitoring</td>
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<td>Reducing Uncertainty</td>
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<td>Variability management</td>
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<tr>
<td>Ban on particular constructions</td>
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<td>Model building for future prediction</td>
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<tr>
<td>Technical or financial cooperation</td>
<td>Y</td>
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<td>Information exchange</td>
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<td>Establishment of national programs to support agreement</td>
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<td>Open Ended</td>
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<td>Stakeholder participation</td>
<td>Y</td>
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<td>Joint commission</td>
<td>Y</td>
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<td>Vague allocation mechanisms</td>
<td>Y</td>
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<td>Amendment mechanism</td>
<td>N</td>
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<tr>
<td>Diplomatic means of conflict resolution</td>
<td>Y</td>
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</tbody>
</table>

Table 2: Comparison of uncertainty management mechanisms and strategies employed in the 1999 Convention of the Rhine and the percentage of all international water treaties employing the mechanism (adapted from Drieschova et al. forthcoming). Y= Yes; N= No.
The Rhine clean-up is definitely a success story in terms of addressing uncertainties, and while international cooperation contributed to this outcome to a large extent, it is unlikely that it can be widely imitated in different geo-political and institutional contexts. Furthermore, it has to be acknowledged that the improvement of water quality in the Rhine is due not just to the international treaty regime, but to a whole array of other contextual factors which played an important role in minimizing the uncertainties: the European Community and other international bodies (among them the North Sea Ministerial Conference), domestic legislation, the work of environmental NGOs, growing public awareness, the changing structure of industry in the basin, and a host of private initiatives (Mostert 2009). Nonetheless, the case of the Rhine provides us with some important and generally applicable insights, such as the possibility of facilitating international cooperation despite the existence of uncertainties, the utility of progressive development of treaty regimes, the significance of institutionalized fora for negotiations, information exchange, harmonization and technical and financial cooperation, the need for flexible mechanisms and, crucially, the importance of a willingness to surmount political uncertainties and mistrust between the parties.
Take Home Points

- Uncertainty has to be accepted as a given; often there is no point in delaying regime construction and treaty negotiations until new information emerges.

- Treaties must contain flexible mechanisms that can deal with multiple existing uncertainties and which can cope with various unforeseen outcomes.

- There are indeed numerous strategies and mechanisms to deal with multiple existing uncertainties.

- A number of mechanisms and strategies should be combined in a treaty to address multiple existing uncertainties. This allows a spreading of the risk of treaty failure in the face of uncertainties.

- At the same time it is better to “get real” than to “stay ideal”: treaty regimes are constructed gradually; one should not expect all mechanisms and strategies to be included in one master treaty.

- There is no free lunch: employment of uncertainty mechanisms in treaties comes at different costs for the different players; they have to be negotiated and operationalized.

- A treaty regime cannot be constructed on an assembly line: there is no one-size-fits-all treaty regime, rather the mechanisms employed in treaties have to fit the unique political, institutional and ecological context of the parties involved.


Schwartz W.F and Alan O. Sykes. (2002). The Economics Structure of Renegotiation and Dispute Resolution in


