Water Policy 18 (2016) 803–825

Rivers and reciprocity: perceptions and policy on international watercourses

Yong Zhong[a], Fuqiang Tian[a,*], Heping Hu[a], David Grey[b] and Michael Gilmont[b]

[a]*Department of Hydraulic Engineering, Tsinghua University, Beijing 100084, China*
**Corresponding author. E-mail: tianfq@tsinghua.edu.cn*
[b]*School of Geography and the Environment, University of Oxford, Oxford OX1 3QY, UK*

Abstract

The paper analyses geopolitical dimensions of the 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses (UNWC) using quantitative data on transboundary flows and qualitative data on basin State location within a watercourse. The UNWC has had a long and difficult history. A tendency for downstream support for, and upstream ambivalence/opposition to, the UNWC is identified. It appears not widely recognized that adverse effects can be caused by any State on other States, regardless of their upstream or downstream location. Thus downstream States consider that their actions cannot harm upstream States, and upstream States consider that the UNWC provides them with greater obligations than downstream States. Clarification of the UNWC with the principle of reciprocal obligations on all States, both upstream and downstream, will remove any ambiguity, correct misperceptions, have clear policy implications for all States, promote UNWC engagement of upstream States, and contribute to long-term global water security.

Keywords: Notification; Reciprocity; Riparian States; Transboundary rivers; United Nations Watercourse Convention

Table of abbreviations

EU	European Union
EU-WFD	European Union Water Framework Directive

doi: 10.2166/wp.2016.229

FAO	Food and Agricultural Organization of the United Nations
UNWC	United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses (United Nations Water Convention)
NIW	Net International Water (% national water incoming – % national water outgoing)
UNECE	United Nations Economic Commission for Europe
UNECE-WC	UNECE Convention on the Protection and Use of Transboundary Water Courses and International Lakes (UNECE Water Convention)
SADC	Southern Africa Development Community
SADC-P	SADC Protocol on Shared Water Courses
USGS	United States Geological Survey
WWF	World Wildlife Fund

1. Introduction

Rapidly growing populations and economies coupled with a changing climate are placing increasing stresses on the world's freshwater resources, requiring smart water management and development. This challenge is compounded in the very large areas of the world where these water resources are within river, lake and groundwater basins that cross, or form the boundaries between, two or more Nation States (international legal entities, hereafter referred to as States)[1]. A sustainable future for these basins – and beyond them – requires that these water resources be well managed, which will need some form of cooperative or collaborative management by riparian States within an agreed and rational framework. It is clear therefore that the effective management of these international basins is only possible with a commonly understood and agreed set of principles that provide the basis for the sharing of international waters and their associated benefits and costs.

Since the 1960s, the international community has sought to achieve this goal through codifying international law in such a set of principles. This resulted in the adoption of the United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses[2] (UN Water Course Convention – UNWC) in 1997. The UNWC entered into force in 2014, 17 years later, when the required 35 ratifications were achieved.

This paper examines the evidence from UNWC voting and ratification patterns, both across countries (with varying numbers of international watercourses) and across major international basins (with varying numbers of countries). This evidence indicates that significant issues still remain in achieving a common understanding of the nature of international waters' challenges and a common interpretation of the UNWC as an instrument for cooperation. While recognizing the importance of the legal dimensions, this paper primarily takes a policy and geopolitical[3] perspective in exploring this evidence and the consequent challenges for the much wider adoption of the UNWC. Evidence is drawn from the history of the development of the UNWC to ratification, its current status, the apparently different interpretations of key elements of the UNWC by States with different geographic locations and interests within watercourses, and the potential consequences for negotiations and cooperation. The paper considers why States made their voting choices – for, abstain, against, or absent – in the UN General Assembly in 1997, why States made decisions thereafter to ratify or not, and why, when 103 States voted for the UNWC in 1997, after 17

[1] It is recognized that States within a federal nation may have 'transboundary waters', potentially with issues requiring resolution by national institutions; these are not considered with this paper.

[2] Article 2 of the UNWC defines terms as follows: watercourse means a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus; international watercourse means a watercourse, parts of which are situated in different States.

[3] Defined by the Oxford English Dictionary as 'politics, (esp. relations between States) as influenced by geographical factors …'.

years only 35 States have ratified the UNWC, of which only 24 originally voted for the UNWC. This paper analyses trends in these voting choices relative to primary watercourse location of States. The analysis displays tendencies for the endorsement of the UNWC by primarily downstream States and for the lack of engagement by primarily upstream States. Finally, the paper concludes that this geographic separation suggests misperceptions regarding the role of reciprocity given the unidirectional flow of rivers, and consequent misinterpretation of the rights and obligations set out in the UNWC. The paper suggests that primarily upstream States perceive the UNWC as prejudicing their interests, while primarily downstream States perceive the UNWC as favouring theirs. Challenging these perceptions presents both opportunities for reciprocity, through highlighting upstream benefits of the Convention, and difficulties in challenging assumptions under which downstream States have supported the UNWC.

The paper draws some conclusions and proposes a way forward that addresses current issues in the interpretation of international water law. It focuses in particular on the importance of reciprocity in the obligations and actions of States on international watercourses. Reciprocity is defined in the Oxford Dictionaries as 'the practice of exchanging things with others for mutual benefit, especially privileges granted by one State or organization to another'. In the legal context, reciprocity means that 'the State basing a claim on a particular norm of international law must accept that rule also as binding upon itself' (B. Simma, discussed in Leb (2013), p. 29). However, the interpretation of the UNWC, and the pattern of quantitative and qualitative analysis of States supporting and implementing it, suggest that the importance of reciprocity is not recognized. Reciprocal behaviour in international watercourses will include acknowledgement of the joint responsibilities of both upstream and downstream States to notify each other, at a minimum, and thereafter to consult and negotiate planned measures, including development, on international watercourses. Such an approach recognizes that adverse effects do not flow only in the obvious direction from upstream to downstream, as the physical and geopolitical consequences of unilateral actions that alter watercourse flows (in quantity, quality and/or time), but also from downstream to upstream, through the potential unilateral foreclosure of future use (recognizing that there are also some other ways in which harm can 'travel' upstream, such as blocking fish migration). Harm is a 'two-way street' (Salman, 2010). Yet this significant way in which a downstream State can harm an upstream State is not intuitively obvious[4] and is therefore rarely recognized. Introducing reciprocity will focus attention on transboundary equity, supported equally by both upstream and downstream riparian States. It might also reduce the current barriers to engagement in the UNWC, particularly by upstream States.

2. UNWC principles and voting: need for shared understanding

The world's 263 international river basins account for nearly one-half of the earth's land surface, generate roughly 60% of global freshwater flow and are home to approximately 40% of the world's population (Transboundary Water Database). Watercourses are always complex systems to manage, with variable flows and demands in space and time, and with extreme variability and associated unpredictability of flows characterizing tropical and monsoonal regions of the world (Blöschl *et al.*, 2013). The international nature of many watercourses makes water management particularly complex.

[4] The specific question 'how can a downstream State harm an upstream State on an international watercourse?' put to over 350 postgraduate students in classes taught by one of the authors (Grey) at the Universities of Oxford (UK) and Harvard (USA) between 2010 and 2015 has rarely obtained this answer.

Watercourses serve polities beyond their boundaries. Thus a watercourse wholly within a State (for example, the Yangtze River in China, the Sao Francisco in Brazil and the Volga in Russia) will provide multiple services (including water, food, flood and drought management, energy, transport, ecosystem services) to the whole country, with different services often being derived in upland (upstream) areas, such as hydropower, and lowland (downstream) areas, such as irrigation and navigation. A watercourse that crosses more than one State can similarly provide multiple services beyond its boundaries, to more than one State. With cooperation and some level of joint management, the benefits of these services can be optimized and shared by States (Sadoff & Grey, 2005). Without international cooperation between upstream and downstream States, the unilateral development of international watercourses can threaten sustainable development and stable inter-State relations (Dinar *et al.*, 2007). The United Nations designated 2013 the International Year of Water Cooperation 'to promote actions at all levels, including through international cooperation' (UN General Assembly, 2010). However, this cooperation will be extremely difficult to achieve without a common interpretation and understanding of the principles and rules for the utilization of international waters.

The UNWC codifies rules of international law with regard to international watercourses, providing general guidance for their equitable and reasonable management and sustainable utilization and protection, a suite of procedural rules for planned measures, and a dispute-settlement provision. The development of the UNWC was a long and difficult journey, from UN studies initiated in 1959 to its ratification in 2014, reflecting the political and technical complexity of the subject. In 1959, the UN General Assembly adopted Resolution 1401 (XIV), calling for 'preliminary studies on the legal problems relating to the utilization and use of international rivers with a view to determining whether the subject is appropriate for codification' (Salman, 2007). The work of the International Law Association, which issued the 'Helsinki Rules on the Uses of the Waters of International Watercourses' in 1966, supported the codification process. In 1970, UN Resolution 2669 'Progressive Development and Codification of the Rules of International Law Relating to International Watercourses' was passed, after which the UN's International Law Commission (comprising legal experts nominated by States) commenced work on drafting the UNWC. In 1997, 27 years later, the UN General Assembly adopted the UNWC under Resolution 51/229, with 103 States voting for its adoption, three States voting against, 27 States abstaining and 52 States absent. In 2014, 17 years after UNWC adoption and 55 years after Resolution 1401, and with substantial lobbying by advocacy groups to obtain the required 35 ratifying parties[5], the UNWC entered into force. A full voting and ratification list as of the 2014 entry into force is provided in Appendix A1 (available with the online version of this paper).

The States that voted against the UNWC are Burundi, China and Turkey. All are the uppermost State on major watercourses. Burundi is the uppermost State on the Nile and the Congo watercourses. China is the uppermost State on 18 main watercourses, including the Lancang-Mekong, Nu-Salween, Ganges, Yaluzangbu–Brahmaputra, and Indus Rivers. Turkey is the uppermost State on eight main watercourses, including the Tigris and Euphrates.

Part II of the UNWC 'General Principles' includes the key principles of 'equitable and reasonable utilization' (Art. 5) and 'the obligation not to cause significant harm' (Art. 7), coupled with the 'obligation to cooperate' (Art. 8). Both upstream and downstream States typically claim that water is a natural resource, and proper exploitation is their right according to the 'equitable and reasonable utilization' principle. Cooperation sensibly requires negotiation to utilize and share the resource in an equitable and reasonable manner. Part III of the UNWC on 'Planned Measures' requires that States exchange information and

[5] The World Wildlife Fund was particularly active in lobbying for the UNWC ratification, see Section 3 (WWF, 2007).

consult on planned measures (Art. 11), with the specific obligation that before a State implements planned measures that may have a significant adverse effect on other States, it 'shall provide those States with timely notification thereof' (Art. 12). This is followed by detailed procedures for notification (Arts. 12–19).

The UNWC aims to ensure the utilization, development, conservation, management and protection of international watercourses, and promote optimal and sustainable utilization thereof for present and future generations. Moreover, it provides an optional framework for riparian States to adopt for cooperation and for settlement of dispute. The relationship between two key articles, i.e. 'equitable and reasonable utilization' and the due diligence obligation 'not to cause significant harm', results in some interpretational ambiguity, for which negotiation and possibly arbitration may sensibly be necessary on a case-by-case basis. However, there is evidence that the requirement to notify, and in particular the reference to 'significant adverse effect on other States' in UNWC Art. 12, has been and remains the subject of misinterpretation and misunderstanding by both upstream and downstream States.

Many downstream States on international watercourses, particularly in flood plains, have historically exploited water resources early, typically for irrigation, urban development and trade, given proximity to the sea, and have a higher degree of utilization than upstream States. In many cases this downstream exploitation has been and continues to be undertaken without notification of and consultation with upstream States, which may be planning upland water development, such as for hydropower and water supplies. Downstream States might then emphasize their accomplished benefits as acquired rights and require upstream States to inform and consult them for future development that might impact on their existing and planned uses. This might then be opposed by upstream States as unreasonable, thus impeding cooperation and damaging relationships.

The widespread perception that 'harm' and 'adverse effect' are physical, together with the fact that the flow of watercourses is unidirectional[6], results in the perception that harm is also unidirectional, i.e. that only upstream States can cause harm, except in specific cases where physical harm can actually be caused by downstream States, for example, by a dam causing upstream inundation across a border, or by affecting fish migration. As a consequence, there is a further assumption that international law, including the UNWC, requires upstream States to consult downstream States regarding planned developments on their stretch of the watercourse, but not vice versa (e.g. Subedi, 2003; Negash *et al*., 2015). Although some legal specialists (see the review in Salman (2010)) state that rights and obligations between upstream and downstream States should be equally treated in international watercourses, there is little discourse in the literature on this subject. In reality, unilateral development of infrastructure downstream locks in water use and can result in water being unavailable for subsequent upstream development, foreclosing equitable and reasonable utilization.

This is the concept of the foreclosure of future use (Salman, 2010), which occurs when a downstream State unilaterally develops a watercourse without consulting upstream States and later declares that future plans of these States are not acceptable, due to the harm caused to pre-established uses downstream. Upstream to downstream impacts are predominantly *physical*, such as altered flow volumes and patterns, sediment loads and water quality. In contrast, downstream to upstream foreclosure of future use can have *geopolitical impacts* if the water development options of upstream States are

[6] There are rare exceptions – such as the Tonle Sap system in the Mekong basin in Cambodia, where the river reverses its flow from season to season.

then exploited (through enhanced political tensions[7]) and *economic impacts* (through development opportunities foregone) if they are not exploited. These geopolitical and economic impacts have generally been absent in the literature and discussion on international watercourses.

A focus on unidirectional harm reduces the potential for coordination (sharing information), cooperation (supporting each other's goals) and collaboration (shared goals) between upstream and downstream States, each of which can provide extensive benefits (Sadoff & Grey, 2002). For example, storage reservoirs on a watercourse in upstream/upland States could potentially mitigate the risks of wet season flood and dry season drought in mid to lower reaches of the watercourse in lowland States with uneven spatial/temporal distribution of rainfall. We describe below the 1964 Columbia Basin Treaty between upstream Canada and downstream USA as an example, which provided the framework for storage reservoirs in Canada, reducing the regularity and severity of flooding in the USA, with both States sharing these and other benefits, including substantial additional hydropower.

Despite the benefits of cooperation achieved through recognition of bidirectional harm between upstream and downstream States, the pattern of UNWC support and ratification suggests that the potential for upstream States to engage is compromised. The analysis of voting patterns suggests that upstream support for the UNWC has been noticeably lower than that of downstream. The paper hypothesizes that misperceptions on the unidirectional transfer of harm and the associated interpretation of specific articles (particularly Articles 11 and 12) of the UNWC are underlying reasons for such patterns. If so, it is essential that misperceptions are clarified with regard to the reciprocal application of the UNWC to all States. Every effort needs to be made to achieve universal adoption of clearly understood rules and procedures for coordinated development and management of international watercourses, clearing the way for cooperation between upstream and downstream States that can yield positive sum outcomes. Failure to achieve this universal adoption threatens long-term sustainable development, which requires that watercourses are effectively managed from source to 'terminus'. All States aspire to achieve such management of the watercourses wholly within their national boundaries, including unified flow and quality standards, abstraction and discharge controls, drought and flood management plans, and effective monitoring and management institutions and tools. Co-riparian States need to work together to achieve similar management regimes of their international watercourses, to ensure sustainable development.

This paper seeks to understand the geopolitical behaviour of States in relation to the UNWC, through the analysis of voting patterns in relation to geographical positions within international watercourses, and to draw conclusions that can assist in harmonizing the interpretation of the UNWC, thus reducing the barriers to international cooperation. Two geographic dimensions need to be considered due to the fundamental mismatch between the national scale of voting and the basin scale of water resources. First, there is the sovereign State, the entity with a single UN vote for the UNWC, whose territory can be part of zero, one or several international watercourse basins, and may be upstream on one and midstream or downstream on another. For example, Botswana is downstream on the Okavango, midstream on the Zambezi and upstream on the Orange. Second, there is the international watercourse – whose basin boundaries will cut across State boundaries and will determine the upstream, midstream or downstream location of each State. In analysing voting patterns of States, the hypothesis is that States that perceive their priority

[7] For example, http://www.economist.com/news/middle-east-and-africa/21688360-largest-hydroelectric-project-africa-has-so-far-produced-only-discord-egypt.

position and interests to be upstream will tend to be against the UNWC, and that States that perceive their priority position and interests to be downstream will tend to be in favour of the UNWC. In analysing large multi-State international watercourse basins, similar voting patterns are expected, where States with a major stake in the basin will tend to be against the UNWC if upstream, and tend to be in favour if downstream, except when they have a different location within one or more other international watercourses that are even more important to them, shifting their vote accordingly. In order to analyse voting patterns taking these two geographic dimensions into account, two approaches are taken.

The first approach is an innovative and exploratory quantitative analysis that seeks to assess the predominant geographic location of all UN States within international watercourse basins, which include the possibility of no such basins, one basin, or many basins, with different geographic locations within the latter, and to correlate this predominant location with voting patterns. There are many challenges to this approach, not least that geopolitical behaviours associated with international watercourses will always be complex to analyse, reflecting a wide range of factors beyond geography, including broader international relations, the associated politicization of international water issues among co-riparian States, and the scarcity of robust and relevant data.

The second approach is the more common qualitative approach, where voting patterns are analysed in specific international basins. Voting behaviours of riparian States are examined in relation to their geographic position within the basin and consideration is given to political factors, such as alliances and disputes, as well as to the geographic positions of these States within other international basins and their relative importance.

The many complexities have led to the argument that it is impossible to research international water relationships effectively (Allan & Mirumachi, 2010). Yet, despite these complexities, quantitative analysis of trends in behaviours that emerge on a global scale demonstrate opposition upstream, followed by abstention, then absence, then support, in order of increasing importance moving downstream. Such an ordered trend would be unlikely to be evident in a purely random distribution. The trends in the quantitative analysis, reinforced by the qualitative analysis later in the paper, point to the potential for further research in examining physical water availability and distribution, including relative national and basin distributions of wet and dry areas, and annual and seasonal precipitation, and relationships to resultant State policies on international waters. This will be important in increasing the understanding of the multiple concerns that influence the geopolitical positions of States, addressing these concerns, building common understanding and enhancing the potential for cooperation between co-riparian States. There is considerable further thought needed on pragmatic ways of clarifying the centrality of reciprocity in the UNWC to promote equal engagement of all riparian States, upstream and downstream.

3. UNWC voting and ratification patterns: a quantitative analysis

This section provides an initial numerical analysis of voting and ratification trends of the UNWC that examines the hypothesis of differential engagement between States predominantly upstream and those predominantly downstream, recognizing that this might include different positions in two or more basins. The work is an exploratory step in a deeper numerical analysis of the geopolitical concerns of States with regard to the UNWC. In the context of the complexity and opacity that characterize international waters, it should therefore be expected that a quantitative analysis of voting and ratification behaviours for the UNWC will exhibit considerable spread in terms of signals on water resources (inflows, outflows, relative position in a basin) as related to voting behaviour.

Taking full account of these challenges, a statistical analysis of voting and ratification patterns for the UNWC relative to States' water resource relationships with their neighbours has been carried out. Data from the FAO Aquastat database (Food and Agriculture Organization of the United Nations (FAO), 2015) were used to inform this analysis. The first indicator is the FAO 'dependency ratio' of a State (the percentage of its total water resources derived from outside its territory).

$$\text{dependency ratio } \% = (\text{surface water accounted inflow} + \text{groundwater accounted inflow}) \div (\text{surface water accounted inflow} + \text{groundwater accounted inflow} + \text{total internal renewable water resource})$$

The second indicator is the reverse of the dependency ratio, namely an 'outflow ratio', i.e. the percentage of a State's total water leaving to a neighbouring State. For a State at the lowest end of the river, flows to the sea (or other 'terminus', such as a lake) are not considered to be water leaving the State (as they flow into territorial waters), therefore outflows are considered zero. This indicator was derived from the following FAO Aquastat indicators as shown below. In a few cases the data indicate that the water leaving the State is more than 100% of total water resources available[8]. In these instances, maximum outflows are capped at 100% of available water.

$$\text{outflow ratio } \% = (\text{surface water accounted outflow} + \text{groundwater accounted outflow}) \div (\text{surface water accounted inflow} + \text{groundwater accounted inflow} + \text{total internal renewable water resource})$$

Both indicators of dependency ratio (inflows) and outflow ratio demonstrate a tendency of downstream support and upstream ambivalence towards the UNWC. However, this trend is stronger when the two indicators are brought together. Combining the indicators provides a representation of whether a State's transboundary water resources tend towards upstream (where water leaving is much greater than water incoming) or downstream (water leaving is equal to or less than water incoming). The dependency ratio (%) is subtracted from the outflow ratio (%) to indicate the 'Net International Water (NIW)' of a riparian State.

$$\text{Net International Water (NIW)} = \text{dependency ratio (\%water incoming)} - \text{outflow ratio (\%water outgoing)}$$

A negative NIW value equates to a predominantly upstream State (i.e. the State's international water is dominated by outflows) and a positive NIW value equates to a predominantly downstream State (i.e. the State's international water is dominated by inflows). It should be noted that groundwater inflows and outflows are challenging to estimate (FAO, 2015), as they are generally very slow flows. An assessment of FAO inflow data and outflow data reveals that these transboundary groundwater flows play a negligible role in transboundary flows in almost all States[9]. The dependency ratio and the outflow ratio do, however, include internal groundwater resources within their calculations of total water resources.

[8] States where outflows are capped in calculation to 100%: Bolivia, Burkina Faso, Czech Republic, Lao, Syria, Tajikistan and Uzbekistan.

[9] Kuwait and Qatar (100% of inflows) and Libya and Saudi Arabia (100% of outflows) are the only States noted with significant groundwater transboundary flows that do not reflect trends in surface water flows (and will therefore have results heavily skewed by groundwater). Excluding these States from the analysis had no noticeable impact on the results presented, and they are included for completeness.

Attempts at this stage to isolate internal water to surface water only are hindered by inconsistencies in FAO data, although such analysis showed similar indicative trends to the NIW results presented below. Isolating groundwater and surface water and their impacts on UNWC engagement need to be the subject of future research into national trends following this initial analysis. Despite the limitations of data, promising results emerge in trends in voting patterns.

It is important to recognize that the NIW is not a watercourse or basin indicator but an indicator of the overall positioning of a State in terms of its co-riparian States on all the watercourses that it shares – and it may be upstream, midstream and downstream on different watercourses. Brazil is upstream on two major tributaries (Paraguay and Parana Rivers) of the important Rio Plata, but it is downstream on the much more important Amazon, with the greatest flow of all the world's rivers, which might influence voting behaviour accordingly. Brazil, with a highly positive NIW of 27.8, voted for the UNWC.

The results of the global analysis of 1997 voting are shown in Table 1, illustrating that voting 'For' (support), 'Absent' (no interest), 'Abstain' (deliberate non-participation in voting process and possible reservations), and 'Against' (opposition), corresponds to a gradually increasing 'upstream' average NIW in that order.

Table 1 suggests that, at the global scale of all 185 UN States, upstream States tend to be ambivalent or negative, while those supporting or absenting have a much weaker upstream signal. This supports the hypothesis that downstream States tend to hold the view that the principles embodied in the UNWC support their interests and that upstream States tend to hold the view that they do not. This aligns with the qualitative observation, drawn from informal discussions with decision makers in many basins, for example, the Nile, Tigris–Euphrates, Ganges–Brahmaputra and Mekong, that the obligation to notify on planned measures is interpreted to fall on upstream States and not on downstream States. These trends emerge from the analysis in spite of the geopolitical complexity and inadequate data. This points to the robustness of the hypothesis of the tendency for downstream support for, and upstream opposition to, the UNWC. It should be noted, however, that the statistical evidence provides only indicative support, due to the differences in means and the large NIW standard deviations in each voting category. However, for the four voting categories to be associated with the order of decreasing NIW means identified is a 1/24 probability. Discounting the three votes against, and the strong upstream nature of these States, the likelihood of the remaining three variables randomly appearing in the order observed is 1/6. Despite the statistical weakness, the probability of these trends being a random outcome is relatively low. This gives further credence to the hypothesis of upstream opposition and downstream support.

The analysis presented in Table 1 is potentially clouded by the inclusion of groups of States already bound by substantive international waters agreements that existed before the 1997 UNWC. These agreements include the European Union's Water Framework Directive (EU-WFD) binding on 28 States, the

Table 1. Average NIW of States according to UNWC voting behaviour in 1997, for States with available data.

	Voting record (number of votes)	NIW Mean	NIW Standard Deviation
All UN States	In Favour (103, data for 101)	−0.2	40.2
	Absent (52, data for 51)	−2.5	43.7
	Abstention (27, data for 24)	−10.4	50.9
	Against (3)	−31.5	8.5

1992 (entry into force 1996) United Nations Economic Commission for Europe's Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE-WC) binding on 40 States (of which 22 are EU member States) and the 1995 Southern Africa Development Cooperation's Protocol on Shared Water Courses (SADC-P) binding on 12 mainland Southern Africa States. A total of 52 States are bound by these agreements, each of which requires coordinated action on international watercourses, supported by international institutions. It is important to note that these States may not be bound with regard to non-member States: for example, Tanzania is a SADC member State within the Nile Basin, within which it is one of 11 riparian States and is a significant upstream State. Table 2 illustrates the elements from the UNECE-WC and the SADC-P that have clear salience to the UNWC.

Due to their obligations under the EU-WFD and UNECE-WC, EU States are disproportionately likely to vote in favour when compared to non-EU members of the UN. The 24 EU States voting in favour of the UNWC had an average NIW of 3.3, suggesting dominance of downstream location in a way not evident in non-EU States. Conversely, the four EU States abstaining had an average NIW of −34.5, indicating a dominance of upstream conditions, to a degree otherwise associated with those voting against. It is suggested that the presence of existing agreements made the conditions of the UNWC atypically palatable for European States. Even without these agreements, the bulk of the European population already benefits from extensive water development, is typically not suffering significant water scarcity or stress, and therefore major new water development opportunities that may affect other international riparian States are of lower priority than in less-developed regions. There are therefore likely to be much greater tendencies for homogenous voting in the EU bloc.

Considered together, this suggests that the EU, UNECE and SADC water agreements have core principles and associated institutions that are aligned with the UNWC, making it more likely that there is understanding of, and engagement with, the principles and requirements of the UNWC. The NIW analysis has therefore been re-computed without EU, UNECE and SADC States and the results are shown in Table 3. Here the evidence is even clearer than in Table 1: downstream States (as indicated by a positive NIW) tend to vote in favour of the UNWC with progression upstream through being Absent, Abstention and, finally, the most upstream States tending to vote against the UNWC.

Table 2. Relevant extracts from UNECE-WC and SADC-P.

UNECE-WC Statement on Reciprocity	'The Riparians shall cooperate on the basis of equality and reciprocity, in particular through bilateral and multilateral agreements, in order to develop harmonized policies, programmes and strategies covering the relevant catchment areas, or parts thereof, aimed at the prevention, control and reduction of transboundary impact' (Article 2, General Provision 6, UNECE, 1992).
SADC-P Statements on cooperation, information exchange, and transboundary consideration	'Close cooperation with regard to the study and execution of all projects likely to have an effect on the regime of the water course system' (Article 2(4)); 'exchange [of] available information and data' (Article 2(5)); use of 'a shared watercourse system in an equitable manner' (Article 2(6)); 'the social and economic needs of member States concerned' be taken into account in utilizing shared watercourses (Article 2 (7.b)) (SADC, 1995).

Table 3. Average NIW of States according to UNWC voting behaviour in 1997, for States with available data with the exclusion of EU, UNECE and SADC States.

	UNWC Voting behaviour	Mean	Standard Deviation
Without EU, UNECE and SADC States	In Favour (62, data for 62)	0.7	34.8
	Absent (46, data for 45)	0.4	43.2
	Abstention (21, data for 19)	−5.7	54.7
	Against (3)	−31.5	8.5

The UNWC entered into force 17 years after the vote. However, of the 103 States that voted in favour of the UNWC, only 24 have eventually ratified (Table 4). Of the other States that have ratified, in the 1997 vote three had abstained and seven were absent (while Montenegro was only re-established in 2006). It is postulated that part of the absence of uptake by those originally voting for the UNWC might also be due to uncertainty about the relationship between 'equitable and reasonable utilization' and 'obligation not to cause significant harm'. Examining the list of ratifying States based on their location on the majority of their transboundary watercourses, or average tendency of mix of international watercourses, shows that the majority of the ratifying States are downstream (21), with three having no international watercourses, seven being upstream, and four being generally midstream. Upstream States continue to be disengaged from the UNWC, together with no States in the Americas. Notably absent among ratifying States are major international watercourse States, including the USA, Russia, India, Brazil and China. Even where there are existing bilateral and multilateral treaties, it is important that all States endorse the universal principles embodied in the UNWC (24 EU States voted for the UNWC, although already bound by the EC-WFD).

The analysis presented in Table 4 clearly shows that the downstream tendencies of support through the ratification of the UNWC are even more pronounced than the downstream tendencies evident in the NIW analysis of the 1997 voting patterns. Of the 35 ratifying States enabling entry into force of the UNWC in 2014, 15 (43%) are EU States and two (6%) are SADC States. Removing EU ratifying States from the analysis further strengthens the trends towards downstream, with a greater positive NIW indicator (Table 4, lower section).

The disproportionate number of EU States that have ratified the UNWC can be related to both the existing WFD and to EU members being a particular target of lobbying for ratification, in which the

Table 4. Average NIW of States ratifying the UNWC (excluding Montenegro for which there are no data).

	Mean	Standard Deviation
All (34)	3.9	39.0
Benin, Burkina Faso, Chad, Cote D'Ivoire, Denmark, Finland, France, Germany, Greece, Guinea-Bissau, Hungary, Iraq, Ireland, Italy, Jordan, Lebanon, Libya, Luxembourg, Morocco, Namibia, Netherlands, Niger, Nigeria, Norway, Portugal, Qatar, South Africa, Spain, Sweden, Syria, Tunisia, United Kingdom, Uzbekistan, Viet Nam, (no data for Montenegro).		
Excluding EU (19)	4.7	45.6
Benin, Burkina Faso, Chad, Cote D'Ivoire, Guinea-Bissau, Iraq, Jordan, Lebanon, Libya, Morocco, Namibia, Niger, Nigeria, Qatar, South Africa, Syria, Tunisia, Uzbekistan, Viet Nam, (no data for Montenegro).		

World Wildlife Fund (WWF) played a significant role, driven by its belief in the importance of cooperation to improve environmental, social and political outcomes, particularly in developing States (WWF, 2011). The WWF emphasizes in its literature the harmony between the UNWC and existing EU legislation, and the minimal legal impact of the Convention on EU States (WWF, 2011). There is no available evidence that the lobbying efforts were accompanied by an analysis of why key States were not engaging with the UNWC, therefore lobbying for ratification was carried out without recognizing or resolving any concerns or misperceptions these States may have. The UNWC has therefore entered into force without the engagement of significant upstream States. While the UNWC may have become an established legal instrument, the limited range of its ratifying parties calls into doubt the extent to which it is usefully adopted. Ratification was instead mostly achieved through States that already subscribed to similar principles of cooperation and reciprocity, leading to perpetuation of misunderstanding over the UNWC by non-ratifying States, indicated by an even greater alienation of upstream States than in the original voting.

The tendency for downstream States to ratify (NIW +3.9) is further emphasized by comparing the NIW data of ratification with the global NIW for UN members. For All UN members with available data, the NIW is −2.7. Of those States sharing land borders with others (i.e. excluding Island States), the NIW is −3.3. The average NIW for those States that have not ratified the UNWC is −4.3. This evidence clearly suggests the unusually downstream nature of ratifying States compared to all States and those States not ratifying.

The overall conclusion of the quantitative analysis is that the greater the importance of flows leaving a State to other States, i.e. the greater the tendency of a State to be upstream, the more likely the State will not support the UNWC. While the statistics show a considerable amount of noise in the quantitative analysis, further drilling down using qualitative methods in the following section reveals the strength of these trends in key international basins.

4. UNWC voting and ratification patterns: a qualitative analysis

A detailed qualitative basin-level analysis of basin States within major individual multi-country international watercourses provides further evidence of the skewed support and ratification behaviours of the UNWC. All transboundary basins with four or more significant riparian States, using basin composition analysis by Wolf (1999), were analysed. For the purpose of identifying basins for this analysis, States listed as occupying 1% or less of the basin area (according to the database)[10] and States not listed as riparians by their respective basin organizations or not recognized as riparians in key literature were excluded from this count of basin States. Twenty-four qualifying basins were identified, of which nine have no States that have ratified the UNWC. Tendencies are shown for upstream States not to engage with the UNWC, and for downstream States to be more likely to have supported and/or ratified the convention. For 12 basins this trend is relatively clear. Two basins do not fit the hypothesis of downstream support/upstream disengagement, with a further 10 that do not clearly fit the hypothesis but have clearly explainable patterns. The population of the basin States that are riparians of the 24 basins analysed comprises 76% of the world's population.

[10] With very few exceptions where significant flows are known to occur.

Twelve of the 24 basins show a relatively clear trend, namely tendencies of downstream support and upstream opposition either through voting or ratification or both. The statistical trends discussed above are exemplified in the basin maps in Figures S1–S12 (see Appendix A2, available with the online version of this paper). The basins represent a hydrologically and geopolitically diverse range of transboundary environments. Despite this diversity, the patterns of support and disengagement/opposition are seen in each. These trends lend credence to the argument of upstream States not supporting the UNWC, which can be traced back to the hypothesis of both upstream and downstream States misinterpreting the obligations of the UNWC and of the need to recognize reciprocity.

Figures S1–S12 show the cartographic boundaries (sourced from the United States Geological Survey (USGS) HydroSHEDS (2006–2008) analysis) of 12 watercourse basins, showing all basin States extant at the time of the 1997 vote (i.e. since then, new States, e.g. South Sudan and the Balkan States, have been created and are not listed). For completeness and faithfulness to the original cartographic data, the maps include those States below 1% of basin areas (according to Transboundary Water Database). Confirming the assumptions for exclusion of such States in the filtering above of basins for analysis, these small areas are usually hydrologically insignificant (e.g. Saudi Arabia in the Tigris–Euphrates Basin, Algeria and Libya in Lake Chad Basin, Myanmar in the Ganges, Nepal in the Indus, etc.). The following analysis is by basin; in some cases a particular State may be a riparian in two or more basins and its voting behaviour will be influenced by its perceptions of the relative importance of its different locations within these basins.

Two of the 24 river basins do not fit the hypothesis, offering either a confused picture, or a clear upstream support/downstream disengagement, running counter to the hypothesis (Table 5).

Ten of the 24 river basins are rationalized exceptions, with three having significant numbers of SADC members, two dominated by EU/UNECE signatories and two dominated by UNECE members. These basins have explainable trends that tend towards either universal acceptance or rejection of the UNWC by basin States. Importantly, most of these basins are characterized by a large number of EU, UNECE or SADC members, represent minor basins for the riparians concerned, or (for the Jordan) the riparians potentially have other and overriding political concerns (Table 6).

5. Illustrative cases: towards reciprocity

While the management of international watercourses affects most of the world's continental States, every watercourse is unique in its combination of geography, history, politics, economics and culture. Each watercourse is also characterized by different management challenges, including the need for flow regulation, pollution control and allocation, and by different levels of cooperation, from dispute to active collaboration. Comparative analysis of different watercourses enables us to understand the factors governing behaviour. The following three case studies serve to illustrate both the negative consequences of the absence of reciprocity in international water contexts, and the role of reciprocity in contributing to cooperative international water relationships.

5.1. The Nile: upstream and downstream needs and concerns

The 6,700 km long Nile River is generally considered the longest river in world, with 11 riparian States (Burundi, D.R. Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania,

Table 5. Summary of the two major transboundary basins that do not fit the hypothesized voting behaviour.

Basin name (riparian States)	Trend description	Detailed description
Kura-Araks Basin (6 States: Armenia, Azerbaijan, Georgia, Iran, Russia, Turkey)	Upstream objection, midstream support and downstream disengagement	This basin includes the States of Armenia, Azerbaijan, and Georgia, which gained independence from the USSR in 1991 and 'depend greatly on the Kura-Araks Basin' (Campana *et al*., 2012, p. 22). Upstream Turkey voted against and midstream States Armenia, Georgia and Iran voted for the UNWC. Downstream Azerbaijan abstained. No States have ratified. With upstream objection, some midstream support and downstream ambivalence, the basin does not fully fit the hypothesized behaviour.
Volta (6 States: Benin, Burkina Faso, Cote D'Ivoire, Ghana, Mali, Togo)	Some upstream support and downstream disengagement	This basin has upstream States that are coastal and themselves downstream on important basins, including Cote D'Ivoire (downstream on rivers rising in Guinea and Burkina Faso), which voted for and has ratified, and Benin (downstream on the Oueme River), which was absent and has ratified, both of which fit our hypothesis for these basins. Upstream Mali (see Niger River) abstained and Togo was absent and neither State has ratified. However, the Volta Basin does not support the hypothesis, with the main upstream State Burkina Faso voting in favour and ratifying and downstream Ghana abstaining and not ratifying.

and Uganda). The Nile's 3 million km^2 basin occupies 10% of Africa's land mass. Its mean natural flow at Aswan on downstream Egypt's border is, however, very small at about 85×10^9 m^3, due partly to losses on its long journey through large lakes and wetlands and deserts. Ethiopia, upstream on 3 major 'eastern Nile' tributaries, provides 85% of this flow to Egypt via Sudan, which characterizes their upstream–downstream relationship. Egypt and Sudan fully allocated this flow in their 1959 'Agreement for the Full Utilization of the Nile Waters', without the engagement of upstream States. There is, however, a long history of Nile treaties during the colonial era, largely favouring Egypt, which has always been and remains wholly dependent on Nile flows.

As a Mediterranean floodplain State with ancient irrigation systems and trading patterns, Egypt has long developed the Nile, and has continued to do so on a considerable scale during the 20th century without consultation with upstream States, except within the framework of its agreements with Sudan. Ethiopia, also the home of an ancient civilization, but a highland and less geographically connected State, has recently begun a major programme of modernization. This includes large-scale development of the Nile, initiated without consultation with Egypt and Sudan. Ethiopia served notice to Egypt in 1956 and 1957, prior to the building of the Aswan High Dam on the Nile, and again in 1997, prior to the Toshka Project on Lake Nasser (behind the High Dam), declaring that it would not accept Egypt's Nile developments, on which it had not been

Table 6. Summary of the 10 basins that are rationalized exceptions, with explainable trends that neither support nor oppose the hypothesis.

Basin name: riparian States	Explanation	Description
Rhine & Danube **Rhine States**: Belgium, Luxembourg, Netherlands, Austria, Switzerland, Germany, France, Italy, Liechtenstein **Danube States**: Slovenia, Moldova, Ukraine, Montenegro, Albania, Bosnia and Herzegovina, Serbia, Croatia, Hungary, Slovakia, Romania, Bulgaria, Macedonia, Switzerland, Germany, Italy, Austria, Czech Republic, Poland	All EU, UNECE members, with significant lobbying for ratification	EU-WFD and UNECE-WC obligations can explain the high degree (5/8) of UNWC ratification in the Rhine and the general voting support for the UNWC. Of extant States in the Rhine and Danube at the time of the vote, only Belgium, France and Bulgaria abstained, with Moldova absent. Belgium may have intended to support the UNWC (Loures *et al*., 2009), aligning with most other EU States. For the 9 Rhine and 19 Danube riparians, there is support for the UNWC regardless of State location. WWF lobbying focused on gaining ratification from EU States, emphasizing harmony with existing EU legislation (WWF, 2011). While not on mainland Europe, ratification by UK and Ireland on 13 and 20 December 2013 can be linked to lobbying efforts and political cooperation together that characterize EU adoption of the UNWC. These factors combine to demonstrate the unusually high engagement by the EU during both the voting and ratification process.
Limpopo (Mozambique, Botswana, South Africa, Zimbabwe)	All SADC signatories	All four Limpopo States are SADC protocol signatories and voted for the UNWC, with only South Africa ratifying. South Africa's ratification can be linked to its downstream position on the important Orange Basin (discussed above).
Zambezi (Zimbabwe, Angola, Botswana, Namibia, Zambia, Mozambique, Malawi, D.R. Congo, Tanzania)	All SADC signatories	The Zambezi riparians generally voted in favour of the UNWC, with only the hydrologically minor upstream Tanzania abstaining (which also has a major upstream stake on the Nile). Only Namibia, downstream on the Orange, has ratified to date. All States are members of SADC.

(*Continued.*)

Table 6. (*Continued.*)

Basin name: riparian States	Explanation	Description
Congo (13 States: Angola, Burundi, Cameroon, Central African Republic, D.R. Congo, Republic of Congo, Gabon, Malawi, Rwanda, Sudan, Tanzania, Uganda, Zambia)	Upstream engagement and downstream disengagement, but hydrologically explainable	Downstream D.R. Congo (SADC) and Republic of Congo absent (along with upstream Central African Republic). Upstream riparians Angola, Zambia (both SADC) and Cameroon (Lake Chad littoral State) voted in favour and upstream Tanzania (SADC) abstained. Each of the other six basin States occupies less than 1% area, including upstream Burundi which voted against. The Congo partially counters the hypothesis. However, the basin's extremely large flow (second only to the Amazon and 20 times the Nile) is dominated by run-off generated within D.R. Congo (70%). The consequences of upstream water use on D.R. Congo, and of foreclosure of future upstream use by D.R. Congo's downstream use, are both very limited.
Senegal (Guinea, Mali, Mauritania, Senegal)	No States engaging with voting process, existing treaty	The Senegal River has no engagement with the UNWC, with all four riparians absent from the vote and none have ratified. The three midstream and downstream States have a robust treaty, which upstream Guinea joined in 2006.
Neman (Belarus, Lithuania, Poland, Russia)	UNECE signatories	All four Neman Basin riparians voted in favour of the UNWC, but none have ratified. All riparians are UNECE signatories. The roles of Russia (through the Kaliningrad enclave) and Poland are relatively minor and are unlikely to have influenced their national voting behaviour.
Jordan (Egypt, Israel, Jordan, Lebanon, West Bank, Syrian Arab Republic)	Israeli/Arab split and regional politics	Three of the States have ratified the UNWC (Jordan, Lebanon, Syria). Previously Jordan and Syria (downstream and upstream) had voted for the UNWC, while Lebanon was absent. Israel, jointly downstream on the Jordan, abstained and has not ratified. With a clear contrast between Arab and Israeli behaviour on the UNWC, this may reflect the broader political relationships in the region.

(*Continued.*)

Table 6. (*Continued.*)

Basin name: riparian States	Explanation	Description
Drin (Montenegro, Albania, Macedonia, Serbia)	Many States not extant at time of vote	The Drin Basin cannot be analysed due to Serbia and Macedonia in their current forms coming into existence after the 1997 vote.
Narva (Belarus, Estonia, Latvia, Russian Federation)	UNECE signatories	All four Narva riparians are UNECE signatories and all voted for the UNWC. Only two riparians (Russia and Estonia) represent significant riparians in terms of supply and use of the basin, with Latvia and Belarus having minor contributions.

consulted, as affecting Ethiopia's Nile share[11]. Since 2011, Egypt has objected to Ethiopia's unilateral 'Grand Ethiopian Renaissance Dam' project currently under construction on the Blue Nile. Egypt, Ethiopia and Sudan are now engaged in trilateral negotiations in a positive attempt to find a solution. The Egyptian President made a historic speech in the Ethiopian Parliament in March 2015 about partnership and cooperation on the Nile, which was well received (Agence France-Presse, 2015).

A precedent for positive communication between Egypt and Ethiopia was set in 2007, when the full details of planned irrigation projects financed by the World Bank in both Egypt and Ethiopia were notified, through the Nile Basin Initiative office in Uganda, to all Nile States, upstream and downstream. The notification was required and reasonable time was allowed for it to be considered and responded to, within the framework of the Bank's Operations Policy 7.50. No objections were received. The Ethiopia Irrigation and Drainage Project (US$100 million, International Development Association) and the Egypt West Delta Water Conservation and Irrigation Rehabilitation Project (US$145 million, International Bank for Reconstruction and Development) were submitted at the same time to, and approved by, the World Bank Board on 21 June 2007[12], in a milestone of cooperation on the Nile. This insight from the Nile clearly demonstrates that reciprocity is not just a requirement for World Bank financing, but an operational implementation of international law, as codified in the UNWC, recognizing reciprocity in the rights and obligations of all riparian States.

5.2. Lancang-Mekong: a diverging past but a converging future

The 4,900 km long Lancang-Mekong River rises in the Tibetan Plateau and flows down through Yunnan Province, China, along the border with Myanmar, on through Lao People's Democratic Republic, along the border with Thailand, then through Cambodia into Viet Nam's Mekong Delta and into the

[11] '*Ethiopia wishes to be on record as having made it unambiguously clear that it will not allow its share of the Nile waters to be affected by a fait accompli such as the Toshka Project, regarding which it was neither consulted nor alerted*' 20 March 1997 Note Verbale from the Ministry of Foreign Affairs of the Federal Democratic Republic of Ethiopia to the Ministry of Foreign Affairs of the Arab Republic of Egypt, also attaching a 23 September 1957 Aide Memoire from the Imperial Ethiopian Government and a 6 February 1956 Communique from the Ministry of Foreign Affairs of Ethiopia.

[12] World Bank Staff Brief to Board, June 2007.

South China Sea. The mean average flow contribution from the upstream Lancang in China is estimated to be about 13.5% of the flow into the delta in Viet Nam.

China has developed six hydropower projects since 1995, feeding electricity into the southern transmission grid in China. The dams are also operated to regulate the impact of floods and drought in China, which results in about 30% reduction in the flood season and 70% increase in the dry season of the outflow from the Lancang into the lower Mekong (Lei, 2014). Although this flood season reduction has a limited effect on very large downstream flood flows, the dry season uplift is significant, bringing the potential of increased flow benefits to downstream States, particularly in a dry year.

This upstream development by China, without notification to the lower Mekong States downstream, has led to concerns by these States. On the other hand, China has not been notified by these States, which are themselves developing main-stem and tributary dams in the Mekong Basin, although Cambodia, Lao, Thailand and Viet Nam have 'Procedures for Notification, Prior Consultation and Agreement' amongst themselves, defined in their 1995 Mekong Agreement and its associated procedures.

Constructive communication between Lancang-Mekong States has recently been growing and China is now actively sharing information with downstream States (having provided flood season hydrological data since 2002). This increasing engagement could progressively lead to even greater cooperation, for example, in upstream flow regulation to increase downstream economic and environmental benefits. A clear call for enhanced cooperation was made in China's recent ministerial statement 'Work Together as One for Common Progress' at the Mekong Summit in April 2014 (Lei, 2014), and reiterated in a visit by China's Vice Minister of Water Resources to the Mekong River Commission Secretariat in November 2014 (Mekong River Commission, 2014). In 2015, China and the five Mekong States established the Lancang-Mekong Cooperation Mechanism, to enhance regional cooperation; the six States list water resources cooperation as the flagship activity.

Initial steps are being taken towards reciprocity, where the rights and obligations of all riparian States are recognized and effective cooperation can be achieved. This could potentially lead to multiple enhanced and shared benefits, including economic (e.g. energy, irrigation), environmental (e.g. water quality, biodiversity) and risk reduction (e.g. drought and flood mitigation) outcomes, and even broader benefits 'beyond the river'.

5.3. The Columbia: from flood losses to 'win-win' cooperation

The mean annual run-off of the Columbia River is 234×10^9 m^3, with 40% of this flowing from upstream Canada to downstream USA. Regular flooding in the US portion of the Columbia, such as the serious floods in Oregon in 1948 that severely damaged the city of Vanport, led to the 1964 USA–Canada Columbia River Treaty. Canada agreed to build storage dams for US flood control and detailed arrangements for sharing costs and benefits were negotiated. In exchange for building and operating storage reservoirs, Canada would receive half the benefit of downstream flood control and half the value of the additional power generated in power plants in the USA for the minimum 60-year life of the Treaty. Canada used the flood control payment and the sale of the first 30 years of its ('Canadian Entitlement') power through a one-time payment to finance the construction of its three 'treaty dams'.

A serious Columbia River flood occurred in 1972 with an estimated peak discharge of 29,500 m^3/s, with the treaty provisions resulting in clear evidence of damage prevention. With joint operation of the upstream and downstream reservoirs, the discharge was reduced to 17,600 m^3/s. The water level in Vancouver was 3 m lower than under natural conditions, saving lives as well as about US$250 million in predicted damage.

Under the robust framework of the Columbia River Treaty, the USA and Canada share the benefits of flood control and hydropower, achieving win–win outcomes. However, there are current discussions on whether and how to modify the treaty, with upstream Canadian voices seeking more compensation, claiming that the benefits of flood control are underestimated by downstream USA (Palmer, 2013), and increased concern over environmental conditions and the rights of first nation populations (Osborn, 2012). The Columbia River case demonstrates the benefits that can be gained when basin States cooperate in the management and operation of a river. The example of the Columbia, as well as instances of improved procedures in the Nile and Mekong, demonstrates the relevance of reciprocity in the context of the UNWC.

5.4. Lessons from experience: what examples of reciprocity mean for clarifying underlying principles

These three cases provide some evidence that where there is reciprocity between upstream and downstream States, with mutual obligations, information and action, win–win benefits can be achieved and sustained. Absence of reciprocity can have adverse effects on all parties. It is useful to recognize the wide range of benefits that can be generated through cooperation, described as: benefits *to* the river, benefits *from* the river, reduction of costs *because* of the river, and benefits *beyond* the river (Sadoff & Grey, 2002). Applying this framework to explore a wide range of benefits can generate the incentives needed to work together to create specific benefits and share them fairly between upstream and downstream States (Sadoff & Grey, 2005). However, if key principles and rules of international water law are interpreted differently, with different perceptions of the rights and obligations of upstream and downstream States, cooperation between riparian States and, therefore, sustainable management and development of international watercourses will be very difficult, if not impossible, to achieve. The current interpretation of the UNWC, as evidenced in this paper by the differential position of States voting in favour and ratifying, suggests that international law is presently interpreted as applying differently to upstream and downstream States.

6. Conclusions: reciprocity matters

A future without cooperation on international watercourses is an unstable and unsustainable future and cannot be considered a rational option. Managing a major river basin within a State, allocating costs and benefits and assessing trade-offs, is not an easy task. It is even more difficult within federal States. The scale of the challenge of achieving effective management of the world's 263 significant international rivers shared by States that are the home for over 90% of the global population is immense and unprecedented. Addressing this challenge is at the heart of achieving global water security, and essential for sustainable economic development and peace. Based on our analysis, we draw four key conclusions.

6.1. Upstream and downstream States tend to have different perceptions of the UNWC

This paper has analysed trends in voting patterns on the UNWC relative to watercourse location. The evidence indicates that downstream States tend to vote in favour of the UNWC, with upstream progression through States being absent and abstaining to a few of the most upstream States voting

against the UNWC. From our analysis, we infer that downstream States tend to consider that the UNWC on balance favours them and that upstream States tend to consider that the UNWC on balance disfavours them.

6.2. There are widespread perceptions that the rights and obligations of upstream and downstream States are different

Cooperation on international waters requires a universally understood, accepted and adopted set of principles and procedures that will enable all riparian States to reach rational, robust and reliable agreements. The world still appears far away from this outcome today, despite the UNWC's entry into force in 2014. By 2014, the UNWC was ratified by 35 States (of which 15 are EU States bound by the Water Framework Directive), 55 years after studies were commissioned in 1959 UN Resolution 1401, 48 years after the International Law Association's Helsinki Rules were drafted, 44 years after 1970 UN Resolution 2669, 43 years after the International Law Commission commenced drafting the UNWC, and 17 years after UNWC adoption in 1997 UN Resolution 51/229.

Achieving the balance between the 'no significant harm' rule (widely considered to favour downstream States) and the 'equitable utilization' rule (widely considered to favour upstream States) is an issue that has been addressed by arbitration (as discussed with reference to the Gabčikovo–Nagymaros case by McCaffrey (2001)). Here, the issue is the belief that 'adverse effects' travel only downstream and that therefore the 'notification of adverse effects' is an obligation only on upstream States. This results in criticism by downstream States of un-notified upstream actions, with little recognition that upstream States need and deserve similar notification of planned downstream actions, as these can restrict their opportunities. Upstream States consider this obligation to be unreasonable and unacceptable, provoking unilateral action, with geopolitical consequences.

This paper argues that this interpretation is a misunderstanding. It is widely recognized that upstream development can harm a downstream State and that, with collaboration, it can also benefit a downstream State (with regulated flows, for example). But it is rarely recognized that the prior use of the waters of an international watercourse downstream, without notification, negotiation and agreement, can cause adverse effects on upstream States by potentially 'foreclosing its future use'. This will always have costs on upstream States – economic and domestic political costs if they do not proceed with development, and geopolitical costs if they do proceed.

6.3. Reciprocity is the key to cooperation

Reciprocity is implicit in the principles and rules set out in the UNWC and is a fundamental principle of customary international law. Reciprocity also leads to practical outcomes, such as joint technical analysis and planning, coordinated development, rational benefit sharing and compensation mechanisms. Reciprocity can deliver effective cooperation, as, for example, the Columbia River case demonstrates, where upstream development creates substantial downstream benefits and downstream (hydropower) benefits are transferred upstream. The explicit recognition that reciprocity underpins the UNWC makes it clear: that there are equal and mutual obligations on all States sharing an international watercourse, upstream and downstream; that adverse effects can be caused by any State; and that notification and, where necessary, negotiation, of planned measures is an obligation on all States. The geopolitical consequences of such clarity could include significant benefits 'beyond the

river', with enhanced mutual understanding and economic cooperation facilitating a much wider range of shared benefits.

To achieve and sustain global water security there is no choice but to ensure that reciprocity in the application of the principles and rules for the management and development of international watercourses is universally understood, accepted and adopted. Without reciprocity, the upstream–downstream polarization apparent today will deepen and unilateral actions will increase, with significant consequences for regional and global sustainability and stability.

6.4. Reciprocity underpins the UNWC: clarification of why and how

The UNWC is the result of almost 50 years of hard work by many parties in order to bring all States together to manage and develop international watercourses. Without clarification on reciprocity, the evidence suggests that the UNWC has tended to do the opposite, with clear patterns of support from downstream States and absence of support from upstream States. With clarification on reciprocity, the UNWC comprises a robust set of principles and rules that will provide a solid foundation for the sustainable and peaceful management of the world's international watercourses, as it is intended and needs to do.

However, this clarification may not be straightforward. Upstream States that have opposed the UNWC, due to the perception that it prejudices their interest, may welcome this clarification as resolving the perceived imbalance. On the other hand, downstream States that have supported the UNWC due to a perception that it favours them, may not welcome this clarification. However, the current situation where upstream States are tending not to engage with the UNWC and to act unilaterally creates great risk to downstream States. It is therefore in the interest of both upstream and downstream States to have clarity regarding reciprocity, particularly with regard to potential adverse effects and the obligation to notify thereof, and also with regard to the potential upstream and downstream benefits of the cooperation that reciprocity can trigger.

Formal clarification of the significance of reciprocity within the UNWC, with no substantial changes in its formulation, could be a game changer. The prize for this is great, as it would provide a window for all riparians, upstream and downstream, including riparians with major and many international watercourses, such as China, India, Russia, Turkey and the USA, to engage within the framework of a universally understood and endorsed UNWC. Even where existing bilateral agreements (e.g. USA–Canada and USA–Mexico treaties) and multilateral agreements (e.g. the EU States, already bound by treaty, whose UNWC ratification has enabled entry into force) exist, this universal endorsement by all States is important, as water resources are central to all life, livelihoods and security. With this universal understanding and endorsement, the cooperative management and thus the sustainable future of our planet's international watercourses can be secured. In this era of rapid economic, demographic and climatic changes, this would provide some certainty to a very uncertain water future.

Acknowledgements

We thank the Editor and the two reviewers for their insightful comments and many valuable suggestions. We also thank Professor Guangheng Ni and Dr Hui Liu for the constructive advice on improving the manuscript. The assistance from Dr Xiang Li and Mr Bo Liu with the technique for preparing the

figures is greatly appreciated. The financial support is from Ministry of Science and Technology of P.R. China (2016YFA0601603).

References

Agence France-Presse (2015). *Egypt stresses Nile water rights in Ethiopia dam project*. Agence France-Presse reported on Yahoo News. Available at: http://news.yahoo.com/egypt-stresses-nile-water-rights-ethiopia-dam-project-191717687.html (accessed 30 March 2016).

Allan, J. A. & Mirumachi, N. (2010). Why negotiate? Asymmetric endowments, asymmetric power and the invisible nexus of water, trade and power that brings apparent water security. In: *Transboundary Water Management: Principles and Practice.* Earle, A., Jägerskog, A. & Öjendal, J.J. (eds), Earthscan, London.

Blöschl, G., Sivapalan, M. & Wagener, T. (2013). *Runoff Prediction in Ungauged Basins: Synthesis across Processes, Places and Scales*. Cambridge University Press, Cambridge.

Campana, M. E., Vener, B. B. & Lee, B. S. (2012). Hydrostrategy, hydropolitics, and security in the Kura-Araks Basin of the South Caucasus. *Journal of Contemporary Water Research & Education 149*, 22–32.

Dinar, A., Dinar, S., McCaffrey, S. & McKinney, D. (2007). Bridges over Water: Understanding Transboundary Water Conflict, Negotiation and Cooperation *(Series on Energy and Resource Economics)*. Cambridge University Press, New York.

FAO Aquastat (2015). Indicators: '*Dependency Ratio'*, '*Surface water: leaving the country (total)*', '*Total renewable surface water*'. Available at: http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en (accessed 30 April 2015).

FAO (2011). *Ganges-Brahmaputra-Meghna river basin*. Available at: http://www.fao.org/nr/water/aquastat/basins/gbm/gbm-CP_eng.pdf (accessed 30 March 2016).

Leb, C. (2013). *Cooperation in the Law of Transboundary Water Resources*. Cambridge University Press, New York.

Lei, C. (2014). *Work Together as One for Common Progress*. Address by the Minister of Water Resources of the People's Republic of China at the Second Mekong River Commission Summit, Ho Chi Minh City, 5 April. Available at: http://www.mrcsummit.org/download/China-statement.pdf (accessed 30 March 2016).

Loures, F., Rieu-Clarke, A. & Vercambre, M. (2009). *Everything you need to know about the UN Watercourses Convention*. WWF, Gland. Available at: http://www.unwater.org/downloads/wwf_un_watercourses_brochure_for_web_1.pdf (accessed 30 March 2016).

McCaffrey, S. (2001). The contribution of the UN Convention on the law of the non-navigational uses of international watercourses. *International Journal of Global Environmental Issues 1*(3/4), 250–263.

Mekong River Commission (2014). *China commits to continue and enhance cooperation with the MRC*. Mekong River Commissions news website, 7 November 2014. Available at: http://www.mrcmekong.org/news-and-events/news/china-commits-to-continue-and-enhance-cooperation-with-the-mrc/ (accessed 30 March 2016).

Negash, M., Hassan, S., Muchie, M. & Girma, A. (2015). *Ethiopia: Perspectives on the Declaration of Principles regarding the Grand Ethiopian Renaissance Dam*. Available at: http://www.ethiopia.org/files/Perspectives_on_the_Declaration_of_Principles_of_the_Grand_Ethiopian_Renaissance_Dam.pdf (accessed 30 March 2016).

Osborn, R. P. (2012). Climate change and the Columbia River Treaty. *Washington Journal of Environmental Law & Policy 2*(1), 75–123.

Palmer, V. (2013). B.C.'s financial honeymoon ends with Columbia River Treaty anniversary. *Vancouver Sun*. 17 June.

SADC (Southern African Development Community) (1995). Protocol on shared watercourse systems in the Southern African Development Community (SADC) region. Available at: http://www.internationalwaterlaw.org/documents/regionaldocs/Revised-SADC-SharedWatercourse-Protocol-2000.pdf (accessed 30 March 2016).

Sadoff, C. W. & Grey, D. (2002). Beyond the river: the benefits of cooperation on international rivers. *Water Policy 4*(5), 389–403.

Sadoff, C. W. & Grey, D. (2005). Cooperation on international rivers: a continuum for securing and sharing benefits. *Water International 30*(4), 420–427.

Salman, S. (2007). The United Nations Watercourses Convention ten years later: why has entry into force proven difficult? *Water International 32*(1), 1–15.

Salman, M. A. S. (2010). Downstream riparians can also harm upstream riparians: the concept of foreclosure of future use. *Water International 35*(4), 350–364.

Subedi, S. P. (2003). Resolution of international water disputes: challenges for the 21st century. *International Bureau of the Permanent Court of Arbitration: Resolution of International Water Disputes 6*, 33–47.

Transboundary Water Database. Available at: http://transboundarywater.geo.orst.edu/publications/atlas/atlas_html/interagree.html (accessed 30 March 2016).

UN General Assembly (2010). Resolution 65/154, 20/12/2010.

UNECE (United Nations Economic Commission for Europe) (1992). *Convention on the protection and use of transboundary watercourses and international lakes*. Available at: http://www.unece.org/fileadmin/DAM/env/water/pdf/watercon.pdf (accessed 30 March 2016).

USGS (2006–2008). HydroSHEDS data for South America, Asia, Africa and Europe. Available at: http://hydrosheds.cr.usgs.gov/index.php (accessed 30 March 2016).

Wolf, A. (1999). The transboundary freshwater dispute database project. *Water International 24*(2), 160–163.

WWF (World Wildlife Fund) (2007). United Nations freshwater agreements project news update n.01 – July 2007. Available at: http://assets.panda.org/downloads/united_nations_freshwater_agreements_project_1_july_2007_1.pdf (accessed 30 March 2016).

WWF (World Wildlife Fund) (2011). The 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses: what is in it for the European Union Member States? Available at: http://assets.panda.org/downloads/brief_eu_apr2011_final.pdf (accessed 30 March 2016).

Received 9 November 2015; accepted in revised form 19 January 2016. Available online 29 February 2016

Appendix A1: Voting patterns for the Convention on the Law of the Non-Navigational Uses of International Watercourses (UNWC), 1997, with States later ratifying marked *

States voting in favour (103)

Albania
Algeria
Angola
Antigua and Barbuda
Armenia
Australia
Austria
Bahrain
Bangladesh
Belarus
Botswana
Brazil
Brunei Darussalam
Burkina Faso*
Cambodia
Cameroon
Canada
Chile
Costa Rica
Cote D'Ivoire*
Croatia
Cyprus
Czech Republic
Denmark*
Djibouti
Estonia
Finland*
Gabon
Georgia
Germany*
Greece*
Guyana
Haiti
Honduras
Hungary*
Iceland
Indonesia
Iran
Ireland*
Italy*
Jamaica
Japan
Jordan*
Kazakhstan
Kenya
Kuwait
Lao
Latvia
Lesotho
Liberia
Libya*
Liechtenstein
Lithuania
Luxembourg*
Madagascar
Malawi
Malaysia
Maldives
Malta
Marshall Islands
Mauritius
Mexico
Micronesia
Morocco*
Mozambique
Namibia*
Nepal
Netherlands*
New Zealand
Norway*
Oman
Papua New Guinea
Philippines
Poland
Portugal*
Qatar*
Republic of Korea
Romania
Russia
Samoa
San Marino
Saudi Arabia
Sierra Leone
Singapore
Slovakia
Slovenia
South Africa*
Sudan
Suriname
Sweden*
Syria*
Thailand
Trinidad and Tobago
Tunisia*
Ukraine
United Arab Emirates
United Kingdom*
United States
Uruguay
Venezuela
Viet Nam*
Yemen
Zambia

States voting against (3)

Burundi
China
Turkey

States abstaining (27)

Andorra
Argentina
Azerbaijan
Belgium
Bolivia
Bulgaria
Colombia
Cuba
Ecuador
Egypt
Ethiopia
France*
Ghana
Guatemala
India
Israel
Mali
Monaco
Mongolia
Pakistan
Panama
Paraguay
Peru
Rwanda
Spain*
Tanzania
Uzbekistan*

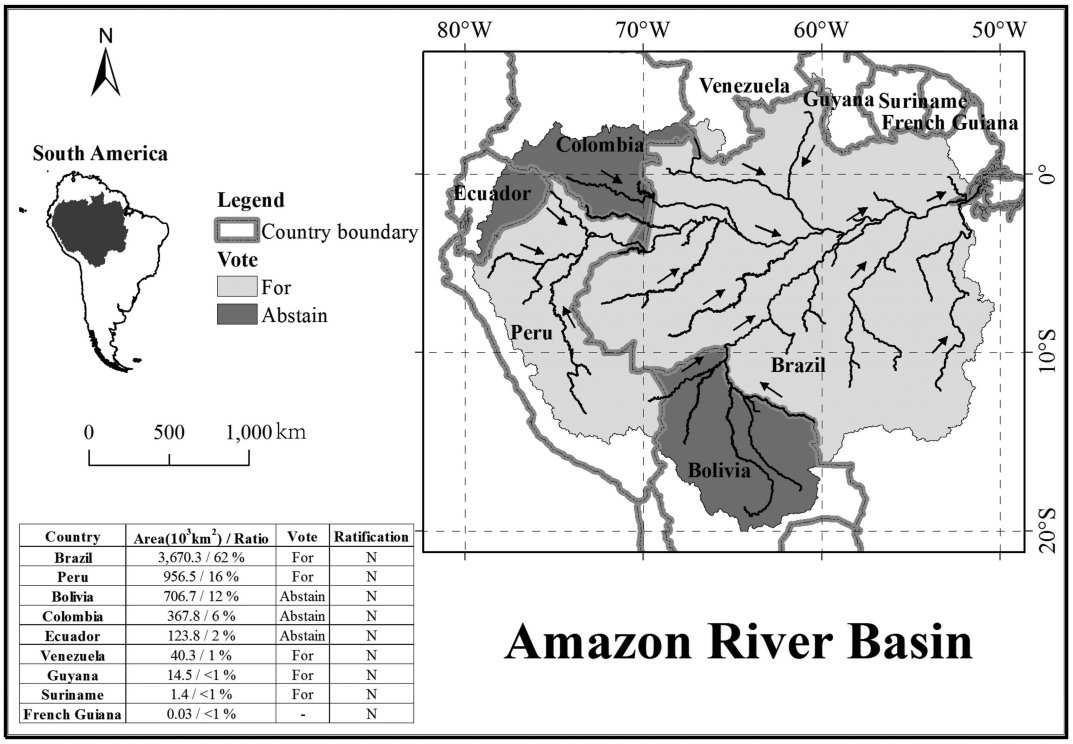
States absent (52)

Afghanistan
Bahamas
Barbados
Belize
Benin*
Bhutan
Bosnia and Herzegovina
Cape Verde
Central African Republic
Chad*
Comoros
Congo
Democratic People's Republic of Korea
Democratic Republic of the Congo
Dominica
Dominican Republic
El Salvador
Equatorial Guinea
Eritrea
Fiji
Gambia
Grenada
Guinea
Guinea-Bissau*
Iraq*
Kyrgyzstan
Lebanon*
Mauritania
Myanmar
Nicaragua
Niger*
Nigeria*
Palau
Republic of Moldova
Saint Kitts and Nevis
Saint Lucia
Saint Vincent and the Grenadines
Sao Tome and Principe
Senegal
Seychelles
Solomon Islands
Somalia
Sri Lanka
Swaziland
Tajikistan
The Former Yugoslav Republic of Macedonia
Togo
Turkmenistan
Uganda
Vanuatu
Yugoslavia
Zimbabwe

Note: Montenegro subsequently ratified, but did not exist at the time of voting.

Source: UN General Assembly Voting Record Search http://unbisnet.un.org:8080/ipac20/ipac.jsp?profile=voting&index=.VM&term=ares51229

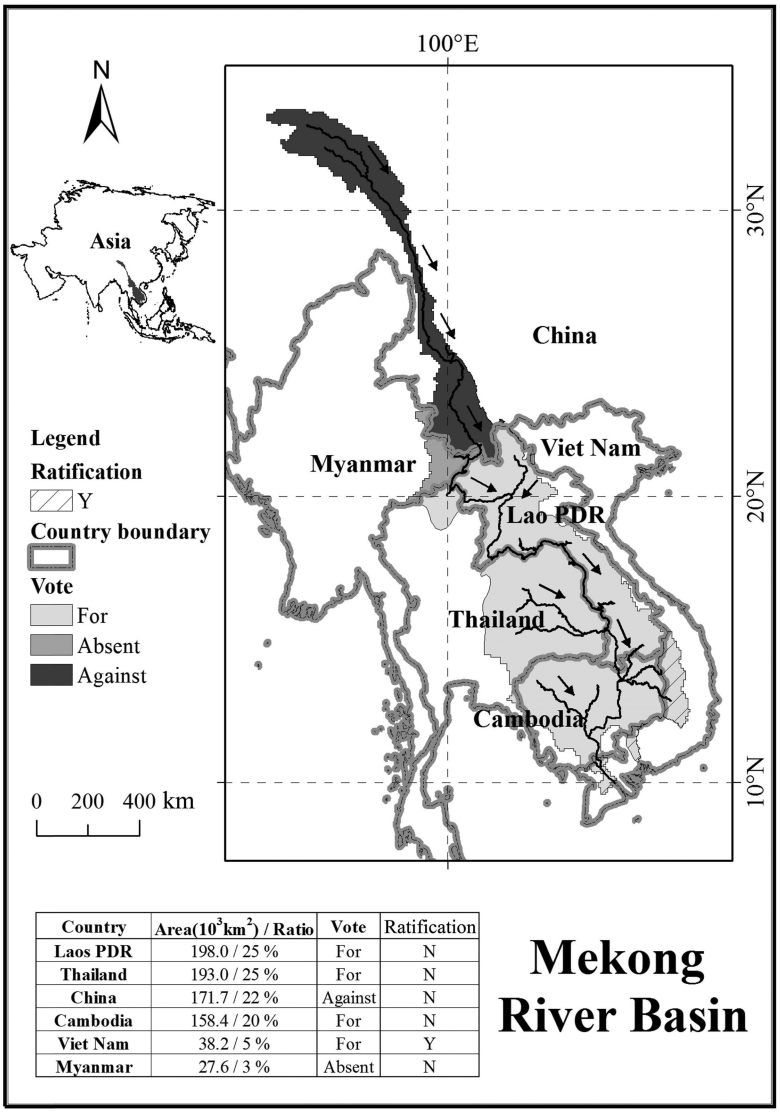
Appendix A2: Figures S1 to S12



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Brazil	3,670.3 / 62 %	For	N
Peru	956.5 / 16 %	For	N
Bolivia	706.7 / 12 %	Abstain	N
Colombia	367.8 / 6 %	Abstain	N
Ecuador	123.8 / 2 %	Abstain	N
Venezuela	40.3 / 1 %	For	N
Guyana	14.5 / <1 %	For	N
Suriname	1.4 / <1 %	For	N
French Guiana	0.03 / <1 %	-	N

The Amazon, the world's most environmentally significant transboundary watercourse with *c*.20% of the world's river flow, has no States ratifying the UNWC, exemplifying the lack of engagement with the UNWC in major transboundary basins. During voting, upstream States of Bolivia, Colombia and Ecuador all abstained, while middle and downstream States of Peru and Brazil voted in favour.

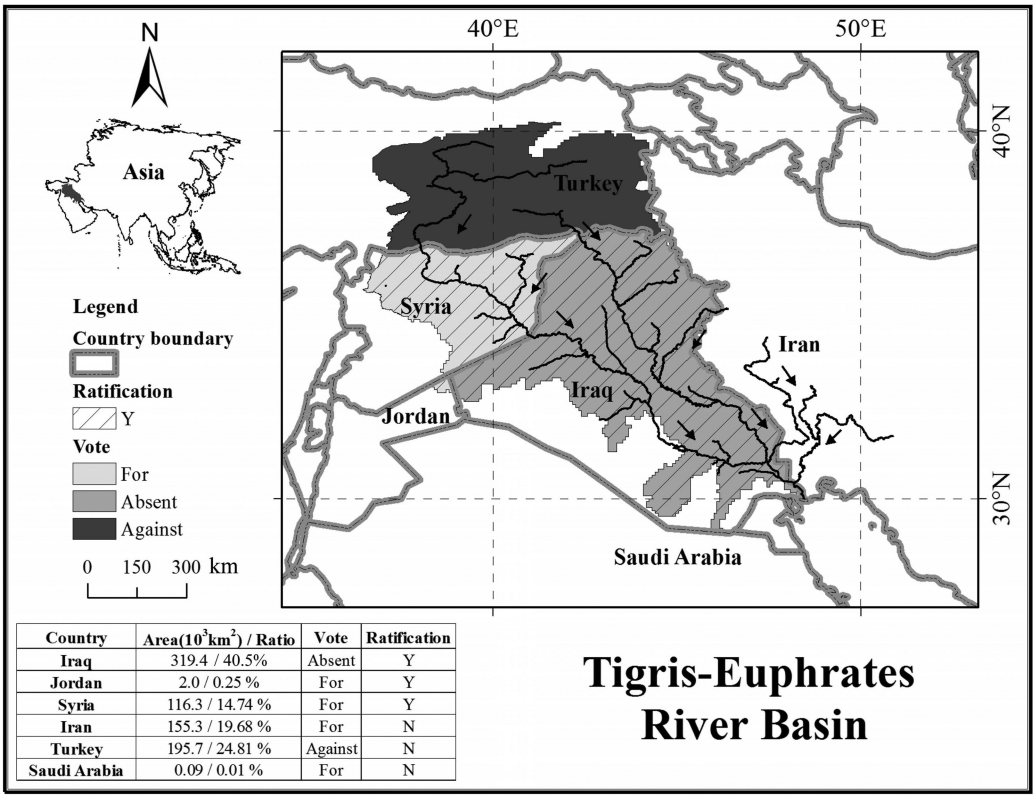
Fig. S1. Voting and ratification trends in the Amazon Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Laos PDR	198.0 / 25 %	For	N
Thailand	193.0 / 25 %	For	N
China	171.7 / 22 %	Against	N
Cambodia	158.4 / 20 %	For	N
Viet Nam	38.2 / 5 %	For	Y
Myanmar	27.6 / 3 %	Absent	N

Trends in the Mekong Basin show that at the top of the watercourse, China voted against the UNWC. Myanmar, possibly for wider geopolitical reasons, was absent from the vote. The remaining downstream States of Viet Nam, Thailand, Lao PDR, and Cambodia all voted for the UNWC. Only Viet Nam, at the end of the watercourse, has ratified to date.

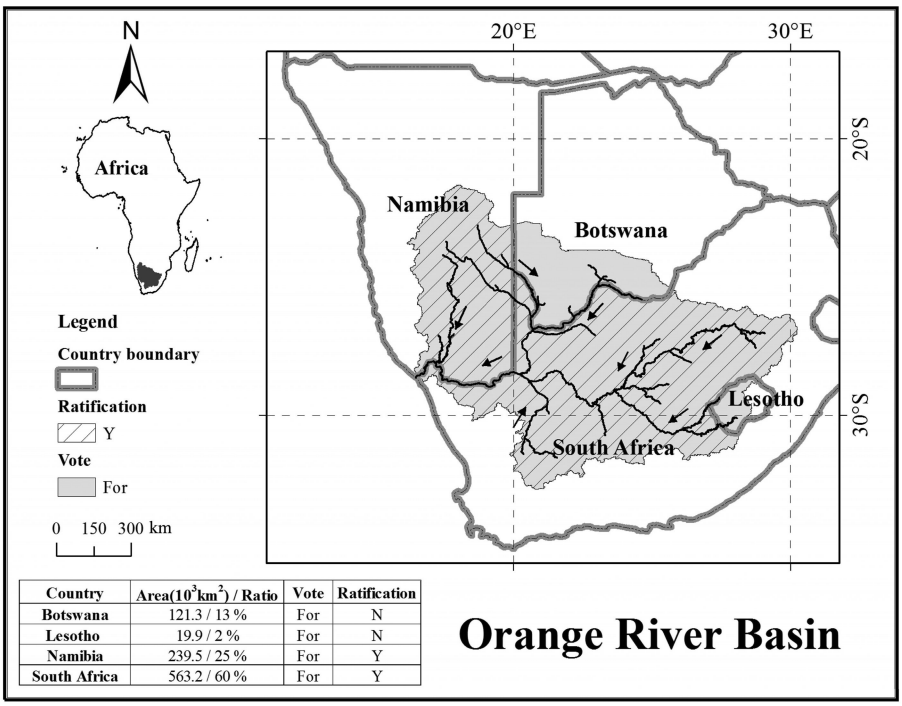
Fig. S2. Voting and ratification trends in the Mekong Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Iraq	319.4 / 40.5%	Absent	Y
Jordan	2.0 / 0.25 %	For	Y
Syria	116.3 / 14.74 %	For	Y
Iran	155.3 / 19.68 %	For	N
Turkey	195.7 / 24.81 %	Against	N
Saudi Arabia	0.09 / 0.01 %	For	N

The Tigris-Euphrates Basin exemplifies clearly defined behaviours. The key upstream State, Turkey, voted against. Iran, playing a more minor upstream role, as well as Syria (downstream to Turkey) both voted for. Iraq abstained,possibly due to the political isolation of the extant regime. Subsequently, both Syria and downstream Iraq have ratified the UNWC, fitting with their circumstances as dependent on external water inflows.

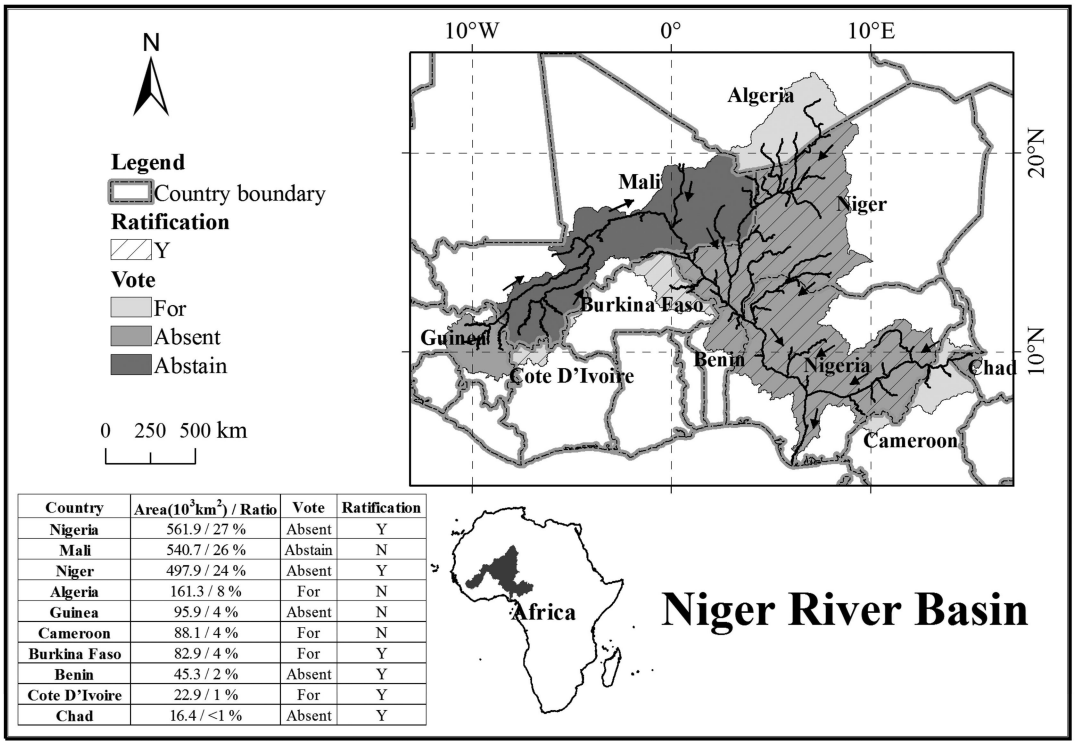
Fig. S3. Voting and ratification trends in the Tigris–Euphrates Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Botswana	121.3 / 13 %	For	N
Lesotho	19.9 / 2 %	For	N
Namibia	239.5 / 25 %	For	Y
South Africa	563.2 / 60 %	For	Y

The Orange River Basin comprises four SADC States (with most of the flow derived from Lesotho). Despite SADC membership, it provides a further case of hydrologically disaggregated UNWC behaviour regarding ratification. While all four riparian States voted for the UNWC, only the two downstream States of South Africa and Namibia have ratified to date.

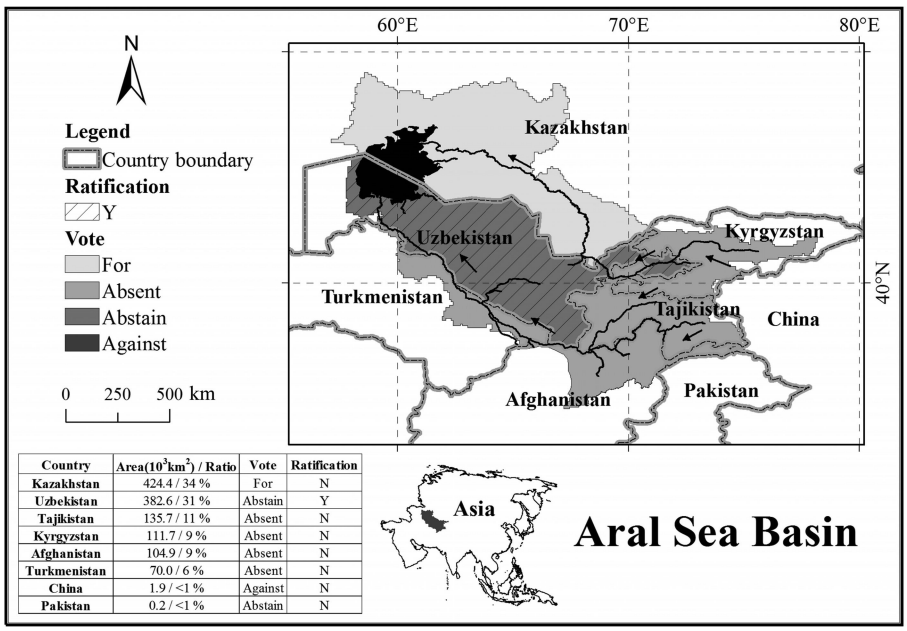
Fig. S4. Voting and ratification trends in the Orange Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Nigeria	561.9 / 27 %	Absent	Y
Mali	540.7 / 26 %	Abstain	N
Niger	497.9 / 24 %	Absent	Y
Algeria	161.3 / 8 %	For	N
Guinea	95.9 / 4 %	Absent	N
Cameroon	88.1 / 4 %	For	N
Burkina Faso	82.9 / 4 %	For	Y
Benin	45.3 / 2 %	Absent	Y
Cote D'Ivoire	22.9 / 1 %	For	Y
Chad	16.4 / <1 %	Absent	Y

The two main upstream States of the Niger Basin, Guinea then Mali, have not engaged with the UNWC, absenting and abstaining respectively, and not ratifying. The key downstream States of Niger (highly dependent on external flows) and Nigeria, both absent from the original vote, have subsequently ratified, following the hypothesized patterns of engagement. The remaining riparian States of Benin (absent), Burkina Faso (in favour), Cote D'Ivoire (absent), and Chad (absent) have all ratified, however, they contribute small flows to this basin and have interests in other basins. Algeria is also hydrologically insignificant to the Niger and voted for the UNWC. Cameroon, upstream on the significant Benue tributary, voted for the UNWC but has not ratified.

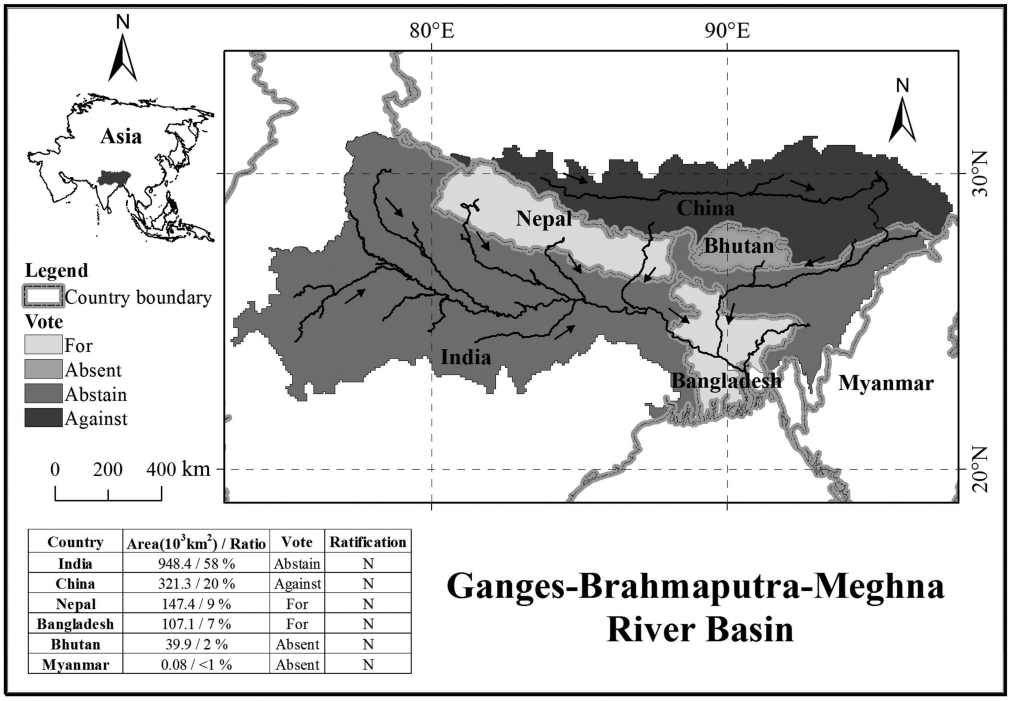
Fig. S5. Voting and ratification trends in the Niger Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Kazakhstan	424.4 / 34 %	For	N
Uzbekistan	382.6 / 31 %	Abstain	Y
Tajikistan	135.7 / 11 %	Absent	N
Kyrgyzstan	111.7 / 9 %	Absent	N
Afghanistan	104.9 / 9 %	Absent	N
Turkmenistan	70.0 / 6 %	Absent	N
China	1.9 / <1 %	Against	N
Pakistan	0.2 / <1 %	Abstain	N

The Aral Sea Basin has one riparian voting for the UNWC, Kazakhstan and one ratifying the UNWC, Uzbekistan. Both these States are downstream. The remaining upstream States of Afghanistan, Kyrgyzstan, Tajikistan and Turkmenistan were absent.

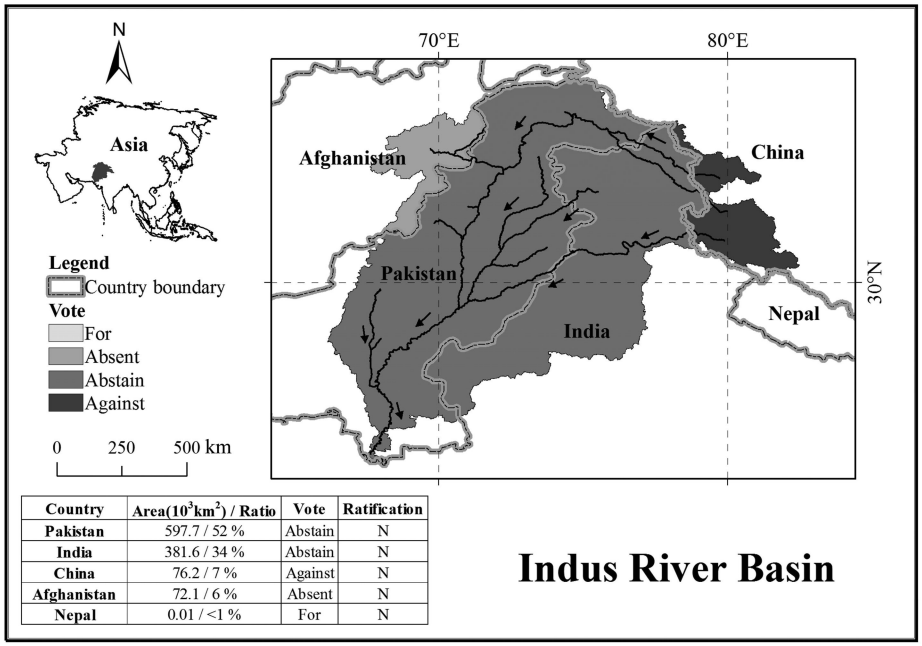
Fig. S6. Voting and ratification trends in the Aral Sea Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
India	948.4 / 58 %	Abstain	N
China	321.3 / 20 %	Against	N
Nepal	147.4 / 9 %	For	N
Bangladesh	107.1 / 7 %	For	N
Bhutan	39.9 / 2 %	Absent	N
Myanmar	0.08 / <1 %	Absent	N

The Ganges-Brahmaputra-Meghna Basin has a population of at least 630 million people (FAO, 2011), making it one of the world's most significant river basins from a social and economic perspective. Downstream Bangladesh voted for the UNWC, along with upstream Nepal (for reasons unknown). Midstream India, upstream of Bangladesh, abstained. Bhutan was absent. Upstream China voted against the UNWC. No State has ratified the UNWC to date.

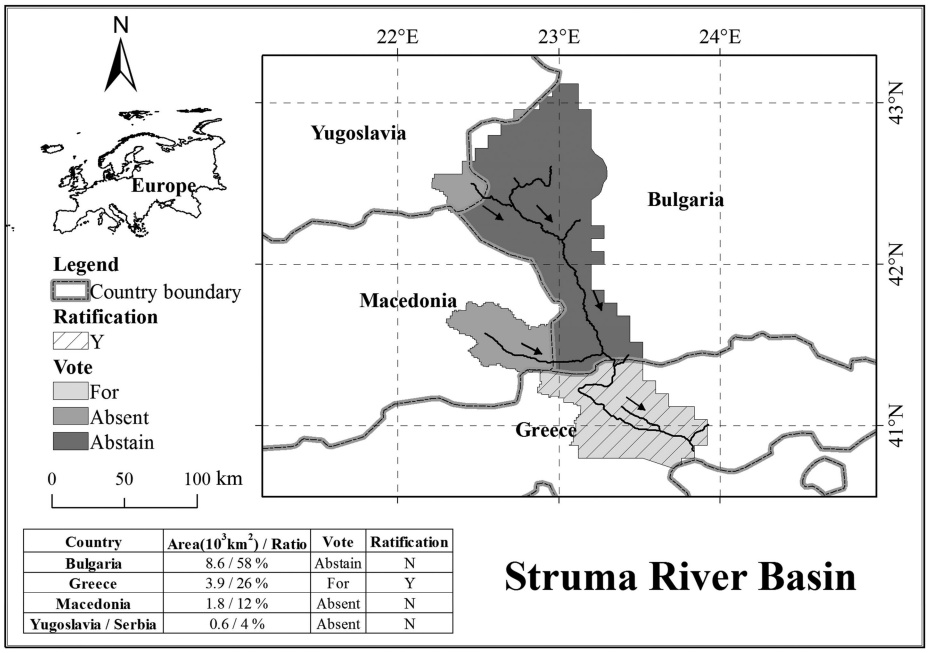
Fig. S7. Voting and ratification trends in the Ganges–Brahmaputra–Meghna Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Pakistan	597.7 / 52 %	Abstain	N
India	381.6 / 34 %	Abstain	N
China	76.2 / 7 %	Against	N
Afghanistan	72.1 / 6 %	Absent	N
Nepal	0.01 / <1 %	For	N

The Indus River Basin is characterized by an absence of engagement among most of its four riparians. Upstream Afghanistan was absent from the vote, upstream China voted against, while India (upstream of Pakistan, downstream of China) and downstream (of India) Pakistan (upstream and downstream of Afghanistan) abstained. The Indus also illustrates the lack of support for the UNWC by key regional superpowers. No basin State has ratified.

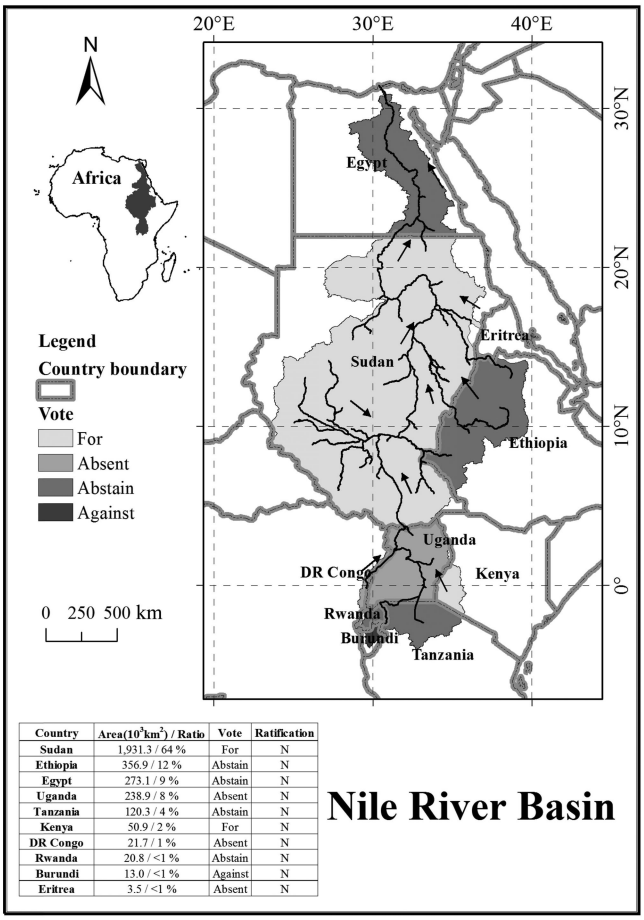
Fig. S8. Voting and ratification trends in the Indus Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Bulgaria	8.6 / 58 %	Abstain	N
Greece	3.9 / 26 %	For	Y
Macedonia	1.8 / 12 %	Absent	N
Yugoslavia / Serbia	0.6 / 4 %	Absent	N

The Struma's downstream riparian Greece voted for and ratified the UNWC. Upstream, Bulgaria abstained and Macedonia was absent. Serbia was not in existence in its present form at the time of the vote. The basin exhibits the hypothesized downstream bias for UNWC support. All States are UNECE signatories, and Greece and Bulgaria are EU members.

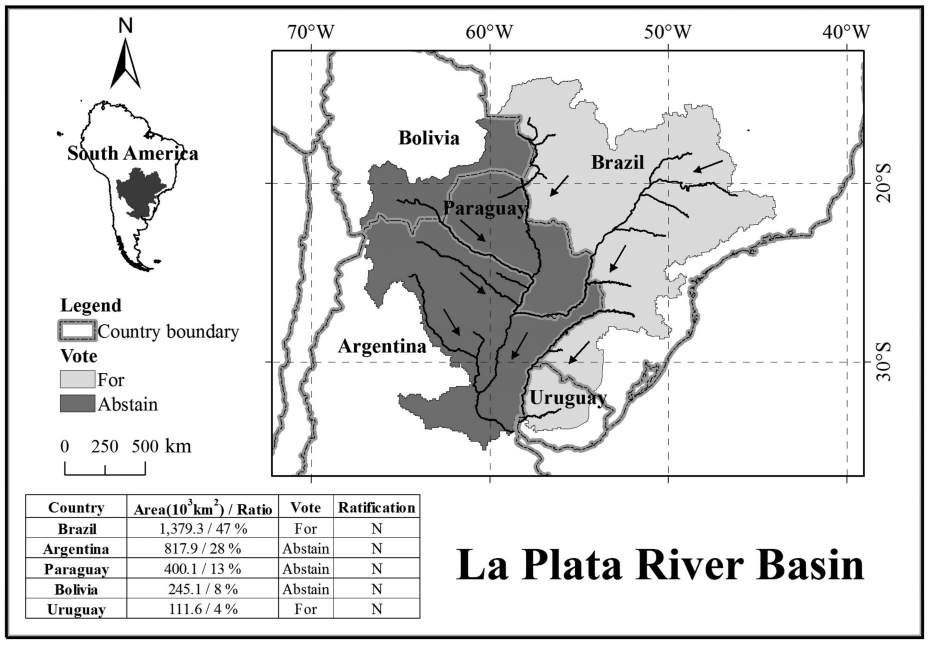
Fig. S9. Voting and ratification trends in the Struma River Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Sudan	1,931.3 / 64 %	For	N
Ethiopia	356.9 / 12 %	Abstain	N
Egypt	273.1 / 9 %	Abstain	N
Uganda	238.9 / 8 %	Absent	N
Tanzania	120.3 / 4 %	Abstain	N
Kenya	50.9 / 2 %	For	N
DR Congo	21.7 / 1 %	Absent	N
Rwanda	20.8 / <1 %	Abstain	N
Burundi	13.0 / <1 %	Against	N
Eritrea	3.5 / <1 %	Absent	N

Two Nile riparians voted in favour of the UNWC, the upstream State of Kenya and the lower State of Sudan. The remaining States of Egypt, Ethiopia, Tanzania, Rwanda and Uganda all abstained. Eritrea and the Democratic Republic of Congo were absent. Upstream Burundi voted against the UNWC. The Nile has a complex and contested web of treaties. Nevertheless, there are some elements for the hypothesis, namely Sudan as a major downstream supporting State, with non-support elsewhere and upstream opposition by Burundi.

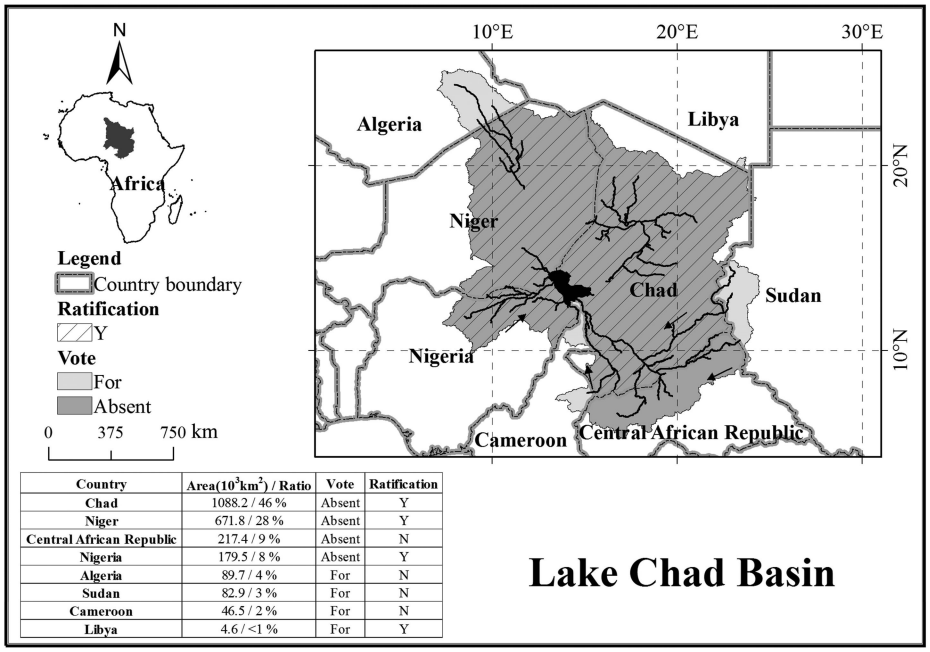
Fig. S10. Voting and ratification trends in the Nile River Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Brazil	1,379.3 / 47 %	For	N
Argentina	817.9 / 28 %	Abstain	N
Paraguay	400.1 / 13 %	Abstain	N
Bolivia	245.1 / 8 %	Abstain	N
Uruguay	111.6 / 4 %	For	N

The complex La Plata Basin includes the Parana River, which has the Paraguay River as a major tributary, and the Uruguay River, both meeting in the Rio de La Plata,which is bordered by Argentina and Brazil. Upstream Brazil voted in favour, readily explained by its downstream position in the uniquely important Amazon basin. Upstream Bolivia and Paraguay abstained. Downstream Uruguay voted in favour. Downstream Argentina abstained. With the exception of Argentina abstaining, voting in the basin broadly supports the hypothesis. No States have ratified.

Fig. S11. Voting and ratification trends in the La Plata River Basin.



Country	Area(10^3km^2) / Ratio	Vote	Ratification
Chad	1088.2 / 46 %	Absent	Y
Niger	671.8 / 28 %	Absent	Y
Central African Republic	217.4 / 9 %	Absent	N
Nigeria	179.5 / 8 %	Absent	Y
Algeria	89.7 / 4 %	For	N
Sudan	82.9 / 3 %	For	N
Cameroon	46.5 / 2 %	For	N
Libya	4.6 / <1 %	For	Y

Three downstream (lakeshore) States, Chad, Niger and Nigeria, of this seriously threatened lake were absent at the vote but subsequently ratified, with downstream (lakeshore) State Cameroon voting for and the upstream (major contributing) State Central African Republic absent, fitting the hypothesis of downstream engagement vs upstream disengagement. Desert States Algeria (voting for) and Libya (voting for and ratifying) make no hydrological contribution, and Sudan (voting for and downstream on the Nile) makes a minimal contribution. Due to the hydrological insignificance of Algeria, Libya and Sudan in this basin, and Sudan's primary concern with the Nile, their voting trends do not have weight in the Lake Chad analysis.

Fig. S12. Voting and ratification trends in the Lake Chad Basin.