Water Policy 12 (2010) 871–884

Tracking cooperation and conflict in international basins: historic and recent trends

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Abstract

This paper describes the use of media-reported events in the assessment of hydropolitical relations and investigates instances of conflict and cooperation over international water resources during the last 60 years. Specifically, two periods – 1948–1999 and 2000–2008 – are compared and assessed for trends in international hydropolitics. In many respects, the dominant trends of the 20th century have remained consistent through the period 2000–2008. Despite the rampant water crisis associated with resource degradation and imbalance between supply and demand, cooperation between riparian nations continues to far outweigh conflict related to shared waters. This holds true even in the contentious Middle East and Northern Africa (MENA) region, particularly during the most recent study period. The two most controversial issues in transboundary relations continue to be infrastructure and water quantity, a consistent pattern through both study periods. Positive interactions continue to be associated with joint management, flood control and technical cooperation, and the geography of conflict and cooperation remains relatively stable, with a mild increase in the importance of North America. Noteworthy changes include the increasing importance of water quality issues, and, while not documented through our methodology, a flurry of activity on transboundary groundwater.

Keywords: Conflict; Cooperation; Freshwater resources; International river basins; Transboundary

Background[1]

Despite the growing literature on water, conflict and cooperation in international river basins, currently no official or unofficial source is able to provide fully comprehensive, reliable and objective data about water-related interactions occurring regularly between nations around the world. In this era of heightened competition for limited water supplies, degrading water quality and threatened ecosystems,

[1] This section benefits from: Eidem *et al.* (2008).

doi: 10.2166/wp.2010.137

monitoring these relations is critical for the identification of significant international trends and for anticipating possible disputes between neighboring countries.

A number of political science datasets document interactions between countries through "event data"[2]. Originally developed by Charles McClelland in the early 1960s, event data complement traditional diplomatic history and enable researchers to undertake quantitative and statistical analyses of international politics (Yoffe *et al.*, 2004). In this context, several researchers have been compiling global datasets of various aspects of political conflict that contribute directly or indirectly to the study of conflict trends in shared river basins. These include, Azar's Conflict and Peace Data Bank 1948–1978 (COPDAB; Azar, 1980); Davies' Global Event Data System (GEDS) project 1979–1994; the International Crisis Behavior (ICB) dataset, collected by Wilkenfeld & Brecher (1997); Peter Gleick's Environment and Security Water Conflict Chronology (Gleick, 1993); Penn State's Correlates of War (Sarkees & Wayman, 2010) and the Issue Correlates of War (ICOW) project started by Paul R. Hensel in 1999 (Delli Priscoli & Wolf, 2009).

Although political scientists have been analyzing event data, natural resource scientists and managers have not necessarily utilized this resource when discussing conflict over natural resources. One hindrance is that political science databases are focused on diplomatic and militaristic behavior and they may not be well suited to environmental issues (Schrodt, 1995). Another limitation is that event datasets cover a number of interaction types (e.g. military, political, economic) and issue areas (e.g. trade, scientific exchange, border disputes) but many of them focus only on crisis events or, more specifically, on military interactions between nations and thus do not provide any information on cooperative events. Moreover, none of the existing event datasets code specifically for water resource issues and many are limited by the small number of countries included or the time periods covered. An exception to this is Gleick's Environment and Security Water Conflict Chronology, which collects information about conflict over water from different sources. Wolf (1998), however, points out that the conflicts described by Gleick are tensions, exacerbated relations and conflicting interests over water, but not state-level violence, at least not between nations or over water as a scarce resource. Moreover, in Gleick's categorization of "basis of conflict", water is generally categorized as a tool, target, or victim of warfare, and rarely as the cause of violence, and then only at the intra-national scale. Finally, Gleick compiles only conflictive events, not cooperative.

The International Water Events Database[3], developed and housed at Oregon State University (OSU), recently updated in collaboration with UNESCO-PCCP, is the only event database solely devoted to water-related interactions, both cooperative and conflictive, between nations on a global scale. It is an online searchable database that documents historical international water relations from 1948 and it defines events as instances of media-reported conflict and cooperation that occur within an international river basin, involving nations riparian to that basin and concerning freshwater as a scarce or consumable resource. Water quantity, water quality, or water as a quantity to be managed are included, while issues related solely to flooding or flood control, or water levels for navigational purposes are not (Yoffe *et al.*, 2003). Furthermore, since international river basins are the limiting parameter for the documented events, the database does not capture the increasing importance of international aquifers in transboundary interactions.

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[2] Schrodt (1995) explains that "event data are generated by examining thousands of newspaper reports on the day to day interactions of nation-states and assigning each reported interaction a numerical score or a categorical code. ... When these reports are averaged over time, they provide a rough indication of the level of cooperation and conflict between two states".

[3] Accessible at www.transboundarywaters.orst.edu/database/

In event databases that comprise a wide variety of information types, conflictive intensity is one of the most important classifications categories. Conflictive intensity corresponds to the action that actually occurred, from a verbal argument, to litigation, to violent protest or war. This ranking gives a measure of the intensity of interactions between and among stakeholders and provides a method to show behavioral changes over time (Shellman, 2004). It is important to note that while a series of events may pass through several conflictive intensities over time, the process does not necessarily evolve linearly. It may become cooperative at any point (Keltner, 1994).

Zeitoun & Warner (2006) point out that "the absence of war does not mean the absence of conflict" (p. 437) and that many water conflicts are largely silent owing to the imbalance of power between the riparians. Zeitoun & Mirumachi (2008) argue further that events are not exclusively either conflictive or cooperative, but rather usually have elements of both. To illustrate this, they develop the concept of water "interactions", where events are located along a matrix, with the *Y*-axis representing the level of conflict and the *X*-axis representing the level of cooperation. While we accept the general premise that they suggest, we assess conflict and cooperation separately here to aid in comparison of earlier work.

Experts agree that there are different levels or intensities of conflict. Previously, there has been less agreement about the specific identification of those levels or degrees of conflict or cooperation (Keltner, 1994). Thus, event data structures have evolved into expertly judged weighting systems and have been created and validated to measure intensity (Shellman, 2004).

Event information in the International Water Events Database is categorized by basins and countries involved, date of occurrence, issue area, an intensity scale to rank water-related news and detailed summaries of these events. The retrieval of water-related events from news sources and their classification according to the type and intensity of the reported interactions, lead to the creation of an events dataset that can be used for quantitative and qualitative analysis.

The use of event data at a global scale requires several caveats. Many water-related interactions occur without being reported by media; they simply may not be deemed newsworthy or be deliberately kept far from the media focus for strategic reasons. However, the analysis of whether and how water events are reported in the news offers useful hints about the level of cooperation/conflict around transboundary water resources. Hence, water events retrieved from written media can be used as an indicator of relations. By no means does this indicator pretend to cover all the ongoing interactions or to reflect all the nuances of the reported events, but it does strive to overcome some of the difficulties of getting information about the global formal and informal relationships among water-sharing countries. As stated by Delli Priscoli & Wolf (2009), "studies based on general datasets (rather than those based in water resources) only report statistical significance and should not be used to allude to causality. All statistical findings should *only* be used as intended, to point out *possible* sets of relations and likely directions for more focused case study approaches".

Moreover, many have questioned the use of popular media, with all of its biases and hyperbole, as a reasonable source of objective data. One important point about the coding process is that, regardless of how a given article is written, it is the *actions* of the parties that are actually coded. When coders focus on what one party actually did to, or with another party, the events can be reasonably evaluated.

During 2008, the Program in Water Conflict Management and Transformation (PWCMT) at OSU with the support of UNESCO undertook an update of the events stored in its online International Water Events Database with the objective of obtaining an overview of the most recent developments and trends in transboundary cooperation and conflicts around the world. The original International Water Events Database was created under the framework of the Basins at Risk project (BAR) and includes

approximately 1,800 water-related events. These events occurred between the years 1948 and 1999, involving 124 countries and 122 of the 265 existing and historical[4] international basins in 1999 (Yoffe *et al.*, 2003).

The latest update of the International Water Events Database presented in this paper covers the period 2000–2008, with 755 additional water-related events reported on 72 of 276[5] current international basins. The objective of this update was to contribute to the identification of recent common regional or global patterns and to identify the main sources of disputes or cooperation between countries. To facilitate the detection of the most recent trends, the events for the 2000–2008 period were analyzed separately from the dataset collected in the original project.

The present paper specifically focuses on international "water conflict", meant as the political stresses that result specifically between nations over shared water resources and not on the current severe global "water crisis" associated with declining water resources and increasing needs. These are two related but separate issues.

The present paper outlines the methodology used to update the International Water Events Database, describes and discusses the findings of the event update, compares its findings with those obtained from the data previously collected (1948–1999) and concludes with considerations about the future of international river basin cooperation in light of global changes.

Methodology

The methodology developed in the BAR project (Yoffe & Larson, 2002) was used as a starting point to retrieve and categorize events occurring in international river basins during the period from 2000 to 2008, in Africa, Asia, Europe, North America and South America.

The international basins to be scanned for new events were retrieved from the Transboundary Freshwater Dispute Database (TFDD) and the "Atlas of International Freshwater Agreements" (Wolf, 2002). The list of basins was used as a tracking mechanism to follow events and their corresponding developments, along with event dates, number of returned hits and related caveats.

The International Water Events listed up to the year 1999 were culled for possible news sources and keywords such as dam names, river basin organizations, treaty names, and so on. These newly generated keywords were combined with keywords, and water and cooperation/conflict terms previously identified by Yoffe & Larson (2002). The search queries were narrowed using a list of excluded terms elaborated upon by the same authors. Search efficiency was improved through the use of a range of relevant keywords, the exclusion of irrelevant terms (for example, keywords associated with maritime-related conflict or cooperation) and the use of Boolean indicators to rank-order search terms. Once the keywords were compiled, they were used to expedite the LexisNexis Academic search of 2,896 news sources (newspapers and news agencies publishing in English) worldwide.

All incidents were ranked by intensity, using precise definitions of conflict and cooperation. The conflict–cooperation scale used in the International Water Events Database classification scheme was

[4] The Water Events Database includes events that occurred in two basins (one of each in the now unified Yemen and Germany) which are no longer international.

[5] This total reflects the updated number of international basins in 2008, as a consequence of the change of the borders in several parts of the world.

Table 1. Water event (BAR) intensity scale (modified from Yoffe *et al.*, 2003).

BAR value	BAR event description
−7	Formal declaration of war
−6	Extensive war acts causing deaths, dislocation or high strategic cost
−5	Small scale military acts
−4	Political–military hostile actions
−3	Diplomatic–economic hostile actions
−2	Strong verbal expressions displaying hostility in interaction
−1	Mild verbal expressions displaying discord in interaction
0	Neutral or non-significant acts for the inter-nation situation
1	Minor official exchanges, talks or policy expressions, mild verbal support
2	Official verbal support of goals, values, or regime
3	Cultural or scientific agreement or support (nonstrategic)
4	Non-military economic, technological or industrial agreement
5	Military economic or strategic support
6	International freshwater treaty; major strategic alliance (regional or international)
7	Voluntary unification into one nation

created by modifying the ranking system of the COPDAB, a pioneer database created in the 1960s (Azar, 1980). Its primary focus is international events and it includes a small section devoted to intra-national actions in highly conflictive countries. Its ranking system was modified by the BAR project to adjust for water resource management issues and concerns at the international level (Yoffe & Larson, 2002).

The events level of intensity was measured using the BAR Intensity Scale (Table 1), which reflects the type and intensity of cooperation or conflict with 15 numbers ranging from −7 (the most conflictive event, formal declaration of war over water) to +7 (the most cooperative event, voluntary unification into one nation over water). A zero BAR value represents neutral or non-significant acts. The event articles were further examined and appropriately coded, which included classification according to the issue addressed by the event (for example: irrigation, water quality, fishing).

Compared to the search protocol specified by Yoffe & Larson (2002), the approach applied for this event update is more refined in terms of search focus, but somewhat limiting in its capacity. The most significant difference between the approaches is the fact that in 2008 only one search engine was utilized (LexisNexis Academic search engine), rather than the use of the full suite of search engines referred to by Yoffe & Larson (2002), which included the Foreign Broadcast Information Service (FBIS)' World News Connection (WNC), Conflict and Peace Data Bank (COPDAB) and the Global Event Data System (GEDS) Project. Indeed, only two databases used by Yoffe & Larson (2002) had a suitable temporal coverage for the 2000–2008 events update: the World News Connection (http://wnc.fedworld.gov) and LexisNexis Academic databases. The other databases were not up-to-date and therefore could not be searched for events up to present times[6].

Once retrieved and coded, the news events about international rivers were analyzed to identify significant trends in terms of spatial distribution of the events (global and regional), BAR intensity values, issue types and cooperation tendencies in the most represented basins. For each of these aspects,

[6] The WNC was not considered a suitable research tool for this event update owing to its limitations in search function capability and the high returns of irrelevant articles that made our searches inefficient. Alternatively, the LexisNexis Academic search engine showed flexibility and search efficiency for our work.

comparisons were made with the findings of the 1949–1999 dataset. In the latter part of this paper, observable recent trends in transboundary water management led to deliberation over future tendencies in international water cooperation.

Findings

The news scanning approach retrieved 755 events for the 2000–2008 period. Most of the retrieved water-related events occurred in Asia, Europe and North America (Figure 1), with Asia standing out prominently, making up 434 instances or 58% of total events. In contrast, the Americas contribute only 13% (101 water-related events), with South America showing the lowest number of events (1%).

This distribution of events per continent is quite similar to that shown during the 1948–1999 study period (Wolf *et al.*, 2003a; Yoffe *et al.*, 2003), with the exception of the recent increase in the percentage of events occurring in North America and Europe and a slight decrease in events in the African continent (Figure 1).

The analysis of the BAR intensity values distribution for the 1948–1999 and 2000–2008 periods (Figure 2) indicates a clear trend towards cooperation over water that is more prevalent than conflict. Indeed, for the years 1948 to 1999, events with positive values on the BAR intensity scale far outweighed negative ones: of 1,831 events, 507 (28%) were conflictive, 1,228 (67%) were cooperative and the remaining 5% were neutral or non-significant (Yoffe *et al.*, 2003). Similarly, between 2000 and 2008, only 33% of the recorded events were classified as conflictive, while the remaining events were classified either as cooperative (63%) or neutral (4%) and the overall average BAR value was positive (+0.8).

Not only was the number of cooperative events since 1948 significantly higher than that of conflicts over water, but almost all of the negative events were classified in the first three least conflictive event categories (−1,−2 and −3). It is important to note that during the entire period covered by the database, there have been no listed events that registered −7 on the BAR intensity scale, a category reserved for formal declaration of war. However, some regions did display trends of conflict,

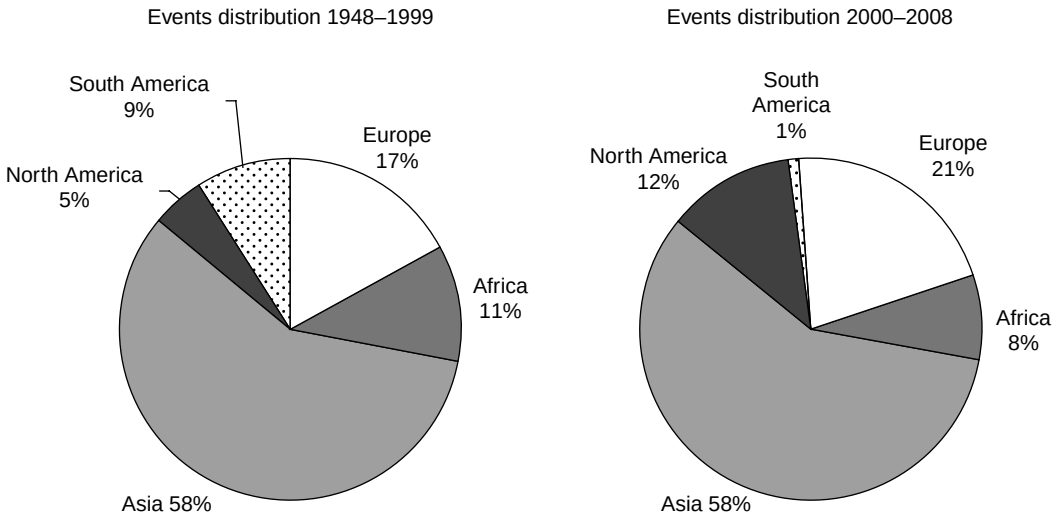

Fig. 1. Percentage events distribution by continents.

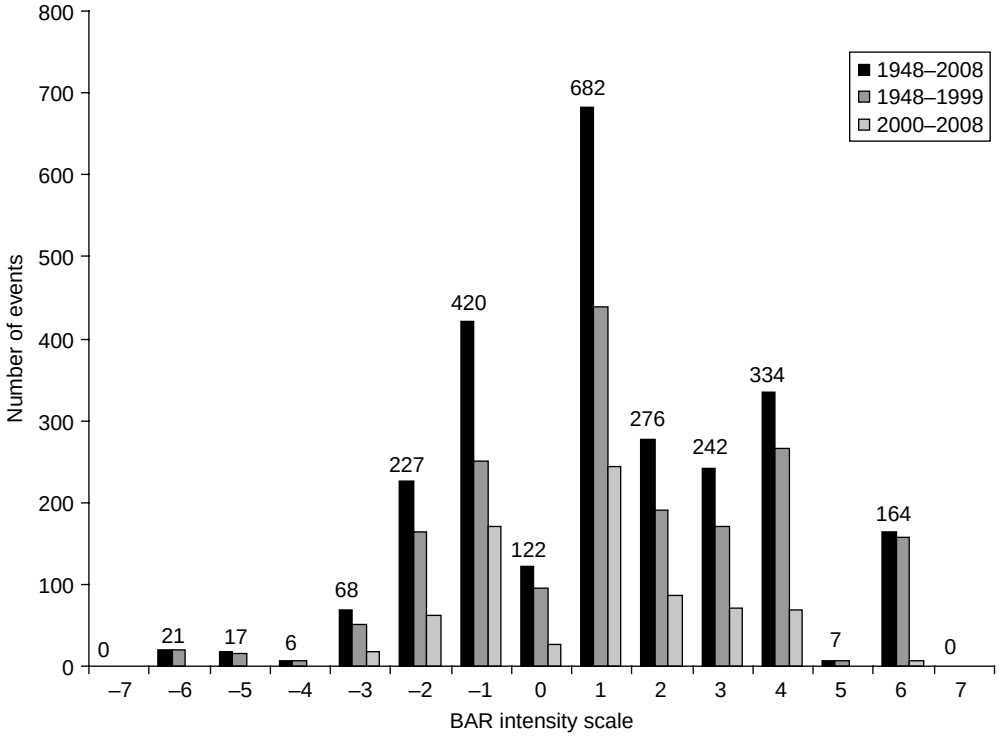

Fig. 2. Total number of events for the periods 1948–1999, 2000–2008 and 1948–2008 by BAR intensity scale.

for instance, between 1948 and 1970 the Jordan basin recorded 29 water events with a high negative intensity between −4 and −6.

From a regional perspective, the majority of the events between 2000 and 2008 were recorded in South Asian basins, followed by Eastern Europe, North America, sub-Saharan Africa and the Middle-Eastern-North African (MENA) region. This is similar to the regional distribution displayed during the previous 50-year period, when MENA, South Asia, Eastern Europe and sub-Saharan Africa were the most represented regions.

The data found for the recent event update indicate positive average BAR values for all regions. This finding is especially encouraging for the MENA region. Indeed, until 1999 this was the sole region presenting predominantly negative events (average BAR lower than −1). After the year 2000, in the MENA region, positive events (64%) outweighed negative ones (32%) and the average BAR value was positive (+1.1).

When events are broken into issue type (Figure 3), we find that the distribution by issue observed in the past for infrastructure and water quantity is also maintained for the 2000–2008 timeframe. In fact these two issues are often closely related and make up the majority of the water instances, contributing 51% of the overall recorded events.

Infrastructure and water quantity seem consistently to represent the most conflictive aspects of transboundary water management and the most updated data suggest a slight increase in the weight of negative events in recent times (Table 2). Indeed, during the 1948–1999 period, infrastructure and water quantity, even though the most controversial issues, had a majority of positive events (61% and 59% of the

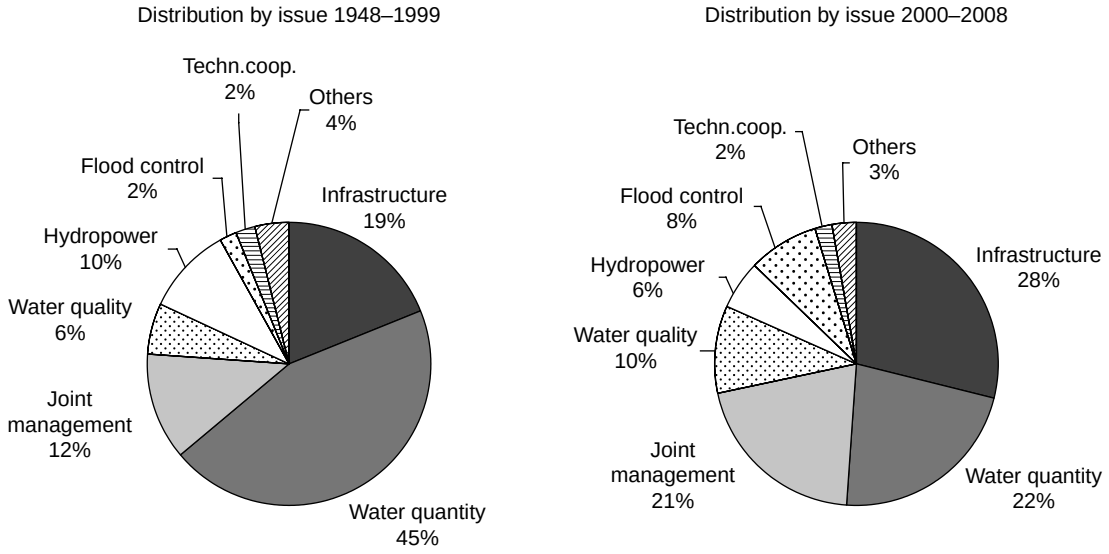

Fig. 3. Distribution of events by issue type. Joint management refers to events that report generic interactions related to water management and that do not refer to any specific issues (e.g. creation of a joint committee for water management in general, expression of will to collaborate, celebration of meetings).

non-neutral events for each of those issues, respectively). From 2000 to 2008, negative events related to these issues accounted for 50% of the significant (non-zero BAR value) events related to both issues (Table 2).

Water quantity remains a significant issue, but has diminished in overall significance and approaches to it that, at least in theory, require a high degree of cooperation between riparian countries (e.g. joint management and infrastructure development/management) appear to have increased in prevalence.

Joint management, water quality and flood control issues have increased in numerical importance during the 2000–2008 period. Joint management is the third most represented issue for the entire period studied, with a clear predominance of collaborative events. While showing cooperative tendencies, joint management, water quality and hydropower seem to shed light on more conflictive interactions during 2000–2008, as displayed by a decrease in the percentage of positive events for each of these issues (Table 2). Conversely, the percentage of cooperative interactions in flood control and technical cooperation has increased over the same period.

Table 2. Percentage of positive ("cooperation") and negative ("conflict") events for each set of issue type and time period (e.g. Water quantity and 1948–1999). Percentages are calculated over the total number of significant (non-zero) events for each one of these sets.

	1948–1999		2000–2008	
Issue	Cooperation (%)	Conflict (%)	Cooperation (%)	Conflict (%)
Infrastructure/development	61	39	50	50
Water quantity	59	41	50	50
Joint management	94	6	86	14
Water quality	76	24	65	35
Hydropower	95	5	78	23
Flood control	84	16	97	3
Technical cooperation	98	2	100	0
Others	77	23	62	38

When considering the distribution of the issue types among continents, we observe that events related to the use/development of infrastructure and to water resources quantity have dominated the interactions in Asia and Europe, where they sum up 62% of all the 2000–2008 continent events. In the same period of time, water quantity issues showed significant weight in North America (54% of the continent events) and Africa (16%). In Africa, Europe and Asia, joint management issues played an important role (66%, 18% and 18%, respectively). Water quality issues were significant in North America (20%) and Europe (25%). In particular, in Europe interactions related to water quality and flood control dominated all the continent events (46% in total).

The number of recorded events per basin is very unevenly distributed, ranging from 0 (no new events were found) to 189 for the Indus river basin. Of the 72 international basins that had at least one event during the period 2000–2008, 14 international basins had more than ten events recorded (Table 3). Among these, the majority are primarily located in Asia and North America.

Only three basins accounted for 55% of the total recorded events. These were the Indus, Danube and Ganges–Brahmaputra–Meghna basins; with 189, 116 and 110 events, respectively. In these three basins the BAR values ranged from −3 to +4, indicating that the interactions have been both cooperative and conflictive (Table 3). The Indus has an average BAR value close to zero (0.01) and about an equal number of cooperative and conflictive events, while the other two basins show positive averages and a clearer majority of positive events. The only two basins that had more than 10 events and a negative average BAR value are both located in North America (Nelson–Saskatchewan and Colorado), while the basins where interactions seem to have been more collaborative than conflictive (BAR average >1) are: Jordan (1.5), Aral Sea (1.4), Tigris–Euphrates/Shatt al Arab (1.3), Danube (1.28), Mekong (1.1), St. Lawrence (1.1) and the Nile (1.0).

The Aral Sea basin had the highest percentage (88%) of cooperative events, followed by the St. Lawrence (81%) and the Danube basins (77%). Among the most contentious basins, according to the retrieved news events, were the Colorado, the Nelson–Saskatchewan and the Rio Grande river basins, with 92%, 58% and 57% negative events, respectively.

Table 3. Number of recorded events, average BAR value, max BAR value, minimum BAR value, percentage of cooperative events and conflictive events (over the total number of events for the basin) for basins having more than 10 events recorded between 2000 and 2008. Neutral events are not included in the analysis of cooperative and conflictive events above.

River basin	No. of events	BAR average	Max BAR value	Min BAR value	Cooperation events	Conflict events
Indus	189	0.01	4	−3	51%	49%
Danube	116	1.28	4	−3	77%	23%
Ganges–Brahamaputra–Meghna	110	0.82	4	−3	71%	29%
Nile	29	1.03	4	−3	66%	34%
Nelson–Saskatchewan	26	−0.23	3	−3	42%	58%
Rio Grande (N. America)	23	0.26	6	−3	43%	57%
St. Lawrence	21	1.10	4	−1	81%	19%
Jordan	19	1.53	4	−2	72%	28%
Aral Sea	17	1.41	6	−1	88%	12%
Mekong	16	1.13	4	−1	73%	27%
Helmand	16	0.75	4	−3	56%	44%
Tigris–Euphrates/Shatt al Arab	15	1.33	6	−3	71%	29%
Amur	14	0.86	4	−1	62%	38%
Colorado	12	−1.17	1	−2	8%	92%

When comparing the basins with the highest number of events in the 1948–1999 and 2000–2008 periods, there is a significant coincidence in names of the most represented basins (11 out of 14 are the same) but interesting differences in the level of cooperation suggested by the recorded events (Table 4).

Table 4 shows that there has been an increase in the percentage of cooperative events in only four basins (Jordan, Tigris–Euphrates/Shatt al Arab, Danube and the Ganges–Brahamaputra–Meghna). The data from the remaining basins represented in the most recent update suggests a shift towards less cooperative relationships. This tendency is especially clear in the Colorado, Rio Grande (N. America), Amur and Mekong basins. Moreover, the Nelson–Saskatchewan basin, appearing for the first time in the database, presents only 42% of events as cooperative. At the same time the Aral Sea has maintained a similar and very positive record over the two studied periods.

Wolf *et al.* (2003a) divided the period 1948–1999 into three periods where events showed similar trends in terms of BAR intensity. These authors observed that during the periods 1948–1970 (called period 1) and 1987–1999 (period 3) the average number of cooperative events per year was significantly lower than in the period 1971–1986 (period 2). Indeed, the percentage of positive events over the total events was 64% and 60% for periods 1 and 3, and 82% for period 2. Wolf *et al.* (2003a) related the two less cooperative periods to the internationalization of basins owing to the break-up of empires, notably the British Empire in the 1940s and the USSR in the late 1980s, which seemed to have had a direct influence on the increase of conflicts recorded in the BAR event database. The analysis of water events between 2000 and 2008 suggests that the less cooperative trend that started in 1987 (period 3) has not yet concluded, since positive events on average counted for only 63% of the total events during that period of time. Overall, this pattern shows consistent variability in the balance between cooperation and conflict, but most significantly, cooperative incidents still dominate over conflictive ones by consistently making up over half of the total water-related events.

Table 4. Comparison between the number of events and percentage of positive events (over the total number of events) during the two study periods (1948–1999 and 2000–2008) in the 14 most represented basins in the most recent events update. Those basins that appeared among the top 14 basins in both timeframes are in *italic*.

	Number of events		Cooperative events (%)	
River basin	1948–1999	2000–2008	1948–1999	2000–2008
Indus	59	189	59	51
Danube	172	116	55	77
Ganges–Brahamaputra–Meghna	148	110	68	71
Nile	78	29	76	66
Nelson–Saskatchewan	0	26	–	42
Rio Grande (N. America)	8	23	75	43
St. Lawrence	22	21	91	81
Jordan	250	19	44	72
Aral Sea	29	17	90	88
Mekong	87	16	94	73
Helmand	7	16	71	56
Tigris–Euphrates/Shatt al Arab	202	15	48	71
Amur	23	14	87	62
Colorado	16	12	69	8

Discussion and conclusion

The analysis of the BAR intensity values of events between 2000 and 2008 leads us to conclude that, despite the current global water crisis, tendencies towards international cooperation over water are more prevalent than conflict. This confirms similar trends observed in the events for the period from 1948 to 1999 (Wolf *et al.*, 2003a; Yoffe *et al.*, 2003). However, the comparison of trends observed during the periods 1949–1999 and 2000–2008 suggests a more recent tendency toward less cooperative interactions between countries. Interestingly, this tendency is not detected in the MENA region. During the previous 50-year study, events in that region were found to be predominantly negative but in the most recent years cooperation has outweighed conflict.

Infrastructure and water quantity, two issues often closely related, seem consistently to be the most conflictive aspects of transboundary water management. The analysis of incidents of these issue types indicates an increase in the weight of negative events in recent times. Similarly, joint management, water quality and hydropower, although showing cooperative tendencies, have shown a slight decrease in the percentage of positive interactions. In contrast, flood control and technical cooperation have increased their share of positive events during the period 2000–2008.

When comparing the relative relevance of each issue type during the two periods studied, it is interesting to observe that water quantity diminished in overall significance while joint management and infrastructure/development appear to have increased in prevalence at the same time. This may indicate a shift towards an increased need for cooperation to face water quantity problems since both water management and the development/use of water infrastructure suppose, at least in theory, a high degree of cooperation between riparian countries.

Compared with past events, water quality seems to be gaining an increasing importance in the interactions between countries over transboundary water, especially in North America and Europe. This trend is not surprising because when competition over water increases, water quality is a determining factor in the amount of water that is effectively available for a specific use. Events related to joint management represent a significant share of the total events, especially in Africa, Asia and Europe. This seems to reflect a flurry of activity around a more coordinated water management scheme. In Africa and Asia this could be due to progress in the set-up or refinement of international agreements, while in Europe this could be related to new obligations for better international cooperation established by the recent European Union Water Framework Directive (EC, 2000).

Almost all the negative events recorded for the period 2000–2008 were classified in the descriptive range of mild verbal expressions of discord in interaction through diplomatic–economic hostile actions. These are numerically classified as -1 to -3 on the BAR intensity scale. Furthermore, the results indicate that vast extremes of conflict or cooperation between nations, such as extensive war causing death, dislocation or strategic costs or voluntary unification into one nation, have not been exhibited by nations over water-related matters. This confirms the observation of Wolf *et al.* (2003a) that even if water can act as an irritant in the relationship between countries, no wars over water have been recorded in recent times. History and current research suggest that risk of conflict as a means of water management and dispute resolution is unlikely.

When comparing the 1948–1999 and the 2000–2008 studies, it is striking that the list of the most represented basins, regardless of their order, are patterned in such a way to suggest that the geographical focus of water cooperation has not significantly changed. The only noteworthy change in this sense is an

increase in the presence of Northern American rivers among the most represented basins, showing a predominance of mild conflicts (e.g. legal suits) on water rights or treaties.

The evolution of the percentage of positive events in the 14 world basins with the highest number of events during the 2000–2008 period suggests a shift towards less cooperative interactions. Only four basins (Jordan, Tigris–Euphrates/Shatt al Arab, Danube and the Ganges–Brahamaputra–Meghna) have recorded an increase in the percentage of positive events, while the others have followed the opposite pattern.

In the 2000–2008 update, the coverage of South America water events was particularly limited. This may be related to the fact that the events search was performed on international and local news sources published in English. This implies that our events retrieval could not capture those events reported only in the local language of the different basins. However, most countries surveyed have local English-language press, so we assume that if any international interactions of significant importance and duration occurred in any part of the globe, they would be captured by that local media written in English, or in the international press. Hence, the selected search language may have prevented the recording of some interactions, but the overall results of the study still reflect major water-related events over shared waters worldwide.

In the near future and as resources permit, it is hoped that the methodology described in this paper will also be extended to other languages, so that even more events can be captured. Moreover, owing to the increasingly important role of groundwater in the world economy, future upgrades of the events search protocol will include terms that allow us to retrieve incidents over transboundary aquifers.

International aquifers can range in surface area from several hundred square kilometers to tens of thousands of square kilometers and the international community is paying increasing attention to their role in transboundary relationships. While there have been several attempts to analyze the legal status of aquifers in international law and treaties (e.g. Matsumoto, 2002; Puri, 2003; Eckstein, 2004; Burchi & Mechlem, 2005; Jarvis *et al.*, 2006), the most detailed work regarding the spatial distribution and characteristics of transboundary groundwater is being carried out by the International Shared Aquifer Resources Management (ISARM) program. In 2006 ISARM published a first inventory of transboundary aquifer systems (Struckmeier *et al.*, 2006), which represents the first step necessary to undertake a systematic global events search on international groundwater.

Understanding the updated events dataset combined with the entire International Water Events Database is not simple. Take for example the Indus, Danube and Ganges–Brahmaputra basins: we find these basins to be prime examples of locations where both conflictive and cooperative events are documented. These contrasts represent different events, possibly different issue areas and may even represent different geographic points within a given river basin. It should be noted that basins are not static. Issue areas are affected by changing circumstances, deeming basins dynamic and ever changing. A combination of issue areas within a basin adds to the complexity of shared waters. Although the figures represented in this paper do not show the details of each particular event, even under the simplest scenario one can imagine a region where, over time, a point of contention can move between reconciliation and conflict as circumstances change.

The BAR project attempted to correlate conflictive or cooperative tendencies with a number of parameters that are often identified as indicators of water conflict (e.g. water stress index, gross domestic product, population density). A major finding from this analysis suggested that these were only weakly linked to dispute, while very rapid changes, either in the institutional setting or in the physical system, were at the origin of most water conflicts during the 1948–1999 period. This led to the conclusion that the internationalization of basins and the unilateral development of new water projects, coupled with the

absence of cooperative regimes, could be the most significant indicators to look at for any consideration about future trends. However, even these indicators, which have proved to follow consistent patterns in the past, cannot give definitive answers to questions about where the future "hot spots" of international waters cooperation will be.

Among those basins flagged as "at risk" based on these two key indicators (Wolf *et al.*, 2003a), only the Ganges–Brahmaputra and Mekong have recorded a significant number of events between 2000–2008 and cooperation has outweighed conflict in both basins. This confirms the idea that "basins at risk" is a fluid concept, with the actual basins changing constantly (Wolf *et al.*, 2003b). The recent start of processes of conflict mitigation in most of the basins originally named "at risk" has directed international interaction in those basins towards cooperation, while new basins are now showing signals of increased hydropolitical stress (Wolf *et al.*, 2003b).

It is clear that further study of international interaction surrounding shared waters is needed and perhaps no simple answers can be given to the questions asked by policy makers or society. The analysis of water events during the past 60 years shows the absence of intense international water-related conflicts. This should by no means be interpreted as a lack of need for enhanced management of shared waters. At the same time, the events analysis suggests that, even when riparian countries are strongly confrontational on many issues, it is still possible for them to cooperate on water-related matters. Although cooperation may be biased by other unsolved underlying problems, it can help to provide countries with interim solutions.

Through a continued effort to keep the International Water Events Database current, further research will assist in better understanding conflict and cooperation over international freshwater resources. Transforming our collective awareness may improve relationships between competing water users by bolstering our ability to strategize, anticipate, address and mediate.

Acknowledgements

The work described in this paper has been undertaken with the generosity of UNESCO's PCCP Program. This paper is an up-dated version of a publication prepared for UNESCO-PCCP (from Potential Conflict to Cooperation Potential) as a side publication for the World Water Assessment Programme (UNESCO-WWAP) in March 2009 (by De Stefano, L., de Silva, L., Edwards, P. & Wolf, A. T. (2009), Updating The International Water Events Database, Paris, UNESCO-WWAP). The authors thank Léna Salamé (UNESCO) for her helpful comments and continuous support. Coders at OSU -- Marloes Bakker, Jehan Jabareen, Carolyn Jackson, Kendra Hatcher, Elina Lin, Amy McNally, Olivia Odom and Yoshiko Sano -- deserve special mention and gratitude for tirelessly plowing through thousands of documents to help tell the story described here. The authors are also grateful to Patrick MacQuarrie, manager of the Transboundary Freshwater Dispute Database, for his support in the data retrieval and to two anonymous reviewers for their insightful comments and suggestions.

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Received 18 March 2009; accepted in revised form 17 July 2009. Available online 2 April 2010