journal of peace RESEARCH

vol. 42, no. 1, 2005, pp. 47–65
Sage Publications (London, Thousand Oaks, CA and New Delhi) www.sagepublications.com
DOI 10.1177/0022343305049666

International Resource Conflict and Mitigation*

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Resource availability is frequently linked with historic and potential international conflict. Conventional wisdom holds that international resource conflict occurs in locations where growing resource demand and declining supplies are greatest. While relative scarcity is undoubtedly an element driving international resource dispute, a focus on supply and demand measures alone is insufficient to understand international conflict potential, because of the pervasive willingness of nations to construct regimes, structures, and frameworks – that is, institutions – for dispute mitigation. However, institutions for regulating the use of internationally scarce resources sometimes fail to develop, and when they do, they are not always sufficiently resilient to deal with changing political and resource environments. Thus, international resource conflict is most likely to occur where there exist both resource scarcity *and* insufficient institutional capacity to deal with it. In particular, conflict is most likely to emerge in those areas where (1) resource sovereignty is ill defined or non-existent, (2) existing institutional regimes are destroyed by political change, and/or (3) rapid changes in resource environments outpace the capacity of institutions to deal with the change. A mitigation strategy for potential international resource conflict is the construction of resilient resource management institutions, along with the improvement of existing institutions. To be most effective, these institutions should be clear in terms of resource allocation and quality control; be constructed with an intrinsic ability to adjust to changing political and environmental conditions; promote positive-sum solutions to resource problems; and incorporate structured conflict resolution mechanisms.

Introduction

The academic literature and popular press frequently link resources with historic or potential international conflicts and disputes, ranging from minor policy disagreements to outright violence (Galtung, 1982; Westing, 1986; Brundtland et al., 1987; Kaplan, 1994; Homer-Dixon, 1999; Renner, 1999). Oil, for example, has been deemed a significant factor in the 1991 Gulf War (Klare, 2000), while issues of water scarcity are often viewed as fueling continuing hostilities between Israel and its Arab neighbors along the Jordan River (Bulloch & Darwish, 1993). Further illustrations of the linkage between interstate conflict and resources can be found in the Caspian Sea (Chufrin, 2001) and Spratly Islands (Denoon & Brams, 2001), related to

* Background for this article was carried out under the US Agency for International Development's EPIQ program. The authors are grateful to Ken Baum of USAID and Doug Clark of the International Resources Group Ltd for their guidance, as they are to Nils Petter Gleditsch, Glenn Martin, and four anonymous reviewers for their close read and helpful comments. Address for correspondence: mark.giordano@cgiar.org.

oil reserves; between Indians and Bangladeshis, Americans and Mexicans, and among all ten countries of the Nile basin, concerning shared water supplies (Fradkin, 1981; Wolf, 1999); and over fisheries between Canada and the United States (DePalma, 1998), as well as between England and Iceland (Bailey, 1997). Furthermore, some authors have suggested that the importance of resources in international affairs and conflict may be increasing, not only because of declining supplies and growing demand, but also because of a shifting geopolitical environment. As put by Klare (2000: 403), 'with the cold war over and a new era beginning, resource competition will again play a critical role in world affairs . . . in some cases producing significant discord and crisis'.

For internationally engaged nations individually and the international community as a whole, an understanding of where, and if, future international resource conflicts are likely to occur may guide policy focus and allow for preventive diplomacy (Lund, 1996). We argue here that many of the factors frequently assumed to prompt international resource disputes and determine their location, in particular resource scarcity, in fact provide only a partial understanding of true causes. As a result, standard predictive measures of international resource conflict, such as declining supplies and increasing demand, are unlikely to prove satisfactory. In this article, an alternative methodology is offered for assessing the likelihood and location of future international resource disputes. The work begins by first illustrating the difficulty in using measures of resource supply and demand to predict even basic socio-economic outcomes, such as income, food availability, and price levels at the national scale – let alone locations at risk for future international resource conflict. An analysis of the reasons why resource availability is a poor predictor of conflict, focusing particularly on the role of institutions, is then undertaken. We introduce an alternative framework for assessing possible interstate resource conflict that suggests that the most likely locations are those in which institutional development is hindered, previously functioning institutions collapse, or change in resource conditions outpaces the ability for institutional adaptation. The article concludes by suggesting promising directions for future research and analysis.

Resource Scarcity and Socio-Economic Outcomes

There is a common assumption in the academic literature that international resource conflicts are primarily functions of resource supply and demand (Anderson & Snyder, 1997: 1). If resources are scarce relative to the demand for those resources, nations are more likely to conflict, since the imbalance will impinge on economic health or basic levels of human well-being. From this argument it follows that international resource conflict will escalate in the future, as human populations and their demands continue to expand while supplies of many basic resources decline in both quantitative and qualitative terms. Consequently, we should be able to predict the location of future international resource conflict by focusing on those areas where supply is falling, demand is increasing, or availability is reaching 'crisis' thresholds. In fact, the linkage between resource abundance, resource demand, and even such basic measures of well-being as national wealth, food availability, and price levels – let alone interstate conflict – is considerably less clear than often presumed.

The myriad problems of Bangladesh, for example, where the physiologic density (population per unit of arable land) is 3,600 persons per square mile, are often blamed on both the current population level and its relatively high (1.9%) growth rate (data from

de Blij & Muller, 2002). As a result, international and domestic agencies invest large shares of their development funds earmarked for Bangladesh on population control in an effort to slow the decline in per capita land and other resource availability (Ahmad, 1992). In fact, the physiologic density of Bangladesh and other poor, 'over-crowded' nations is substantially lower than those in many wealthier nations including Japan, South Korea, Taiwan, Germany, and the Netherlands, and no clear statistical relationship exists between income levels and physiologic density among nations in general.[1] Thus, agricultural land availability, a variable often intimately associated with basic welfare, in fact reveals itself to be a poor predictor of national economic outcomes.

While the absolute availability of land may not, by itself, predict economic outcomes, it is true that human populations continue to grow from unprecedented levels, presenting major challenges for food supplies. In the last quarter-century, humankind has *added* more people to the planet than existed in 1900 (Population Reference Bureau, 1999). With the growth in human population has come a decrease in land available for agricultural expansion, both because most suitable lands have already been appropriated and because cities, roads, and other structures increasingly cover the landscape. Many modern writers (Ehrlich, 1968; Brown & Kane, 1994; PBS, 2002) have used these observations, along with concepts from Malthus (1798) and carrying capacity models from biology, to predict impending food crises. Despite the apparent logic behind such arguments, the historic evidence suggests that the global food situation has improved, rather than declined, in the face of population growth (Simon, 1996; Lomborg, 2001). For example, global food availability, both in total *and per capita*, has increased since 1960[2] while prices, which serve as markers of food scarcity, have declined.[3]

While the potential of future agricultural innovation may be debated, evidence from the global food system clearly shows that general predictions of coming resource shortages, and hence conflict, cannot be based solely on supply and demand measures. Of course, one cannot infer from the fact that global food output has kept pace with global population that food problems do not exist in particular locations. Any assessment of food needs is by nature scale dependent, and large segments of the world's population continue to face food problems, sometimes resulting in horrific famine, at local and regional scales. However, scholars from a variety of viewpoints and disciplines (e.g. Watts, 1983; Sen, 1984; Simon, 1996) have consistently pointed to political systems rather than human population levels, the natural environment, or resource availability as the proximate cause of these smaller-scale emergencies.

Though no global crisis in renewable food resources has yet to emerge, one might reasonably expect to see rising scarcity levels for non-renewable resources, any use of which is, by definition, unsustainable. Even here, however, the case for causal linkages between simple supply and demand measures and outcomes such as price is less than straightforward. For example, the price of oil, a resource critical to our modern

[1] A simple linear regression of physiologic density (logged) on per capita gross domestic product (logged) results in an R^2 of 0.001 (data from de Blij & Mueller, 2002).

[2] Food availability proxied as 'major meats' and 'major grains' using data from FAOSTAT (2004). While output of both has increased more rapidly than population since 1960, growth in meats has been especially striking, especially in the light of its high input requirements vis-à-vis grains.

[3] Nominal US producer prices for the three main global grain crops, wheat, rice and corn, were taken from FAOSTAT (2004) for 1965 through 1995, from IWMI (2002) for 1996 through 2000, and from the IMF (2004) for 2001 through 2003 and deflated using the Implicit Price Deflator provided by the Bureau of Labor Statistics (2004).

economies and perhaps most closely associated with international resource conflict, has shown no clear trend over the last 50 years, despite rapidly increasing utilization, and is nearly unchanged from levels 100 years ago (Simon, Weinrauch & Moore, 1994). Similar trends can be seen in the demand and prices of mineral resources (see Cook, 1999).

If resource supply and demand cannot be linked to socio-economic outcomes at the national scale, what about direct linkages between resource scarcity and international resource conflict? Water now holds the preeminent position in the literature as the resource most likely to lead to international conflict. Increasing demand, decreasing supplies, and declining quality have all been given as factors behind impending 'water wars' (Starr, 1991). Despite such assertions, few scholars have looked beyond anecdotal evidence to produce empirical studies of the linkages between water scarcity, or the scarcity of any other resource, and international conflict (Diehl & Gleditsch, 2001). Many of the water-related studies that do exist focus their work on the most hostile international river basins, including the Nile, Jordan, Tigris and Euphrates, and Indus (Elhance, 1999; Lowi, 2000), and do not consider in their analysis the generally cooperative experience of the world's 259 other international river basins (Giordano & Wolf, 2002). One of the few empirical analyses attempting comprehensive coverage of the world's basins (Yoffe, Wolf & Giordano, 2003) found no correlation between levels of conflict and cooperation over internationally shared freshwater systems and any measure of supply. The same study also called into question the common belief (Klare, 2001) that water conflict is most likely to occur in arid regions, such as the Middle East and North Africa, casting further doubt on the utility of supply and demand or 'stress' measures (such as those based on Falkenmark, 1986 or Ohlsson, 1999) in predicting international water conflict. Another study (Toset, Gleditsch & Hegre, 2000), focusing on water and international conflict in general, that is, not necessarily conflicts related specifically to water, found only mild correlation and questioned the extent to which the relationship was related to water scarcity.

Measures of International Resource Conflict

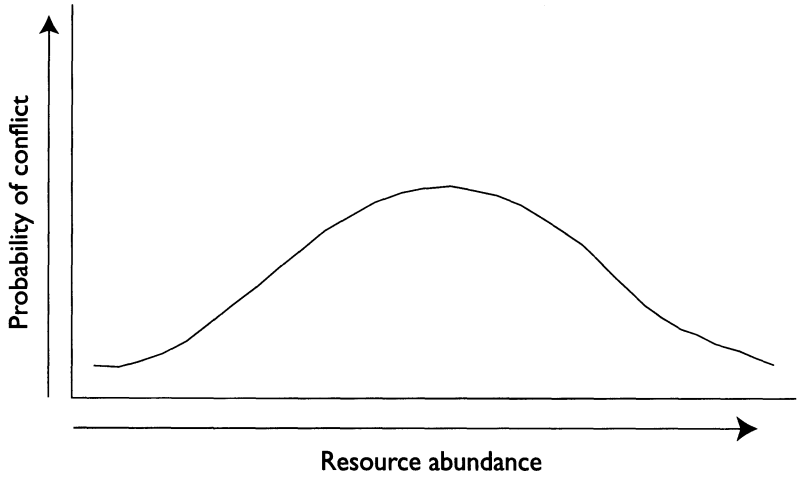
Why do measures of absolute resource abundance and demand, by themselves, fail to predict socio-economic outcomes or price trends at the national scale, and why are those measures, therefore, unlikely to be useful predictors of international resource conflict? There are at least three primary reasons. First, the relationship between resource scarcity and social outcomes, including conflict both national and international, is likely to be non-linear. Much of the literature linking resources to conflict suggests that conflict occurs where resources are relatively scarce. While rarely if ever articulated, there is a non-trivial notion behind this idea that resource conflict *does not occur* where resources *are absent*. Conflicts over diamonds and timber are assumed to take place, for example, in the countries that possess diamonds and timber (Klare, 2001), *not* in countries that *do not* possess diamonds and timber. (This is not to say that countries without those resources might not become involved in any conflict, but simply that the conflict is unlikely to occur in the resource-less country.) While there is no reason to conflict over non-existent resources, there is also little incentive to conflict when resource availability is low, because the expected payoff from even a successful confrontation is minimal in terms of resources gained. As resource availability rises, however, the potential benefit, in terms of obtaining resources, from conflict begins

to rise and with it the probability of conflict. However, at some point resource abundance reaches such a level that its marginal value begins to decline, reducing the payoff from even successful confrontation. When the resource exists in such quantity that all demand can be met at zero marginal cost (i.e. the resource is not scarce in the economic sense), the payoff from, and probability of, conflict again approaches zero. Thus, the relationship between scarcity and probability of conflict is not some linear function of resource availability or demand, but rather follows a non-linear path such as that depicted in Figure 1.

The relationships shown in Figure 1 are at least partially borne out through analysis of the seemingly opposing views that have now emerged in the connection between resource availability and conflict at the national scale. While some authors suggest that intra-national conflict is correlated with scarcity (Barbier & Homer-Dixon, 1999; Barbier, 1999; Homer-Dixon, 1999; Homer-Dixon, 2000), others maintain that it is relative abundance of resources that is more likely to incite conflict (see e.g. Ross, 1999; Le Billon, 2001; de Soysa, 2002a,b; Collier et al., 2003). The 'resource curse' hypothesis put forth by these latter authors states that countries well endowed with natural resources are at greater risk of internal conflict for a variety of reasons, including exposure to price shocks, corruption, availability of finances for rebel groups, and incentives for succession (Collier et al., 2003: 126). While the views of the two schools seem to be in opposition, it is also quite possible that both the resource scarcity and resource abundance arguments are correct and that, in part, the difference in outlook is related to the direction from which the problem, and the resource abundance/conflict curve, is approached.

The second factor explaining the failure of resource endowments to be good predictors of socio-economic outcomes concerns the nature of resource availability and scale.

Figure 1. Hypothetical Resource Abundance/Conflict Curve



Where resources do not exist, or exist in low quantities, resource conflict is unlikely, because the potential payoff from conflict is low. As resource availability rises, the potential payoff from conflict rises and with it the probability of conflict. However, when abundance reaches some level, the resource's marginal value begins to decline, reducing again the probability of conflict.

Japan has a similar population to Bangladesh and less agricultural land available per capita, yet Japan has been able to thrive economically, while Bangladesh remains one of the world's poorest countries. A major difference between the two nations is that one, Japan, has been able to transform the human and physical assets it does possess into internationally valuable products that it can exchange for resources it holds in short supply, such as agricultural commodities and oil. The other nation, Bangladesh, has failed in this endeavor. The comparison between Japan and Bangladesh highlights the notion that countries can 'virtually' import even essentially non-tradable resources, such as land and water, in the form of food or other commodities, so long as political and economic environments are supportive. Allan (2002), for example, estimates that each ton of wheat trade involves a virtual transfer of the 1,000 tons of water involved in the average production process. Because of the possibility of both actual and 'virtual' resource trade, the true scale of resource supply and demand facing a particular country is unlikely to be national, weakening the applicability of national statistics in predicting resource conflict.

Finally, and most importantly, is the fact that individual resources exist as only a small part of broader resource systems (Firey, 1960) in which supply and use outcomes are a result of the interaction of resource endowments, culture, technology, and institutions (Hayami & Ruttan, 1985). As a result, the relative abundance of any individual resource is only a partial determinate of the socio-economic outcome in any particular time or place. Furthermore, the interactions of the various elements within a given resource system are themselves mutually reinforcing. This has been demonstrated by Perkins (1969), in the specific case of China, where a tenfold increase in population over the period 1368–1960, far from creating a national food crisis, was shown to have driven improvements in land productivity and increased agricultural output. In other contexts, Boserup (1965), Tiffen, Mortimore & Gichuki (1994), and Southgate (2001) have argued that changes in relative population/resource abundance could be primary factors in agricultural innovation, both technical and institutional. Going a step further, Hayami & Ruttan (1985) showed, among other findings, that differences in national rates and paths of technological and institutional innovation could, in fact, be explained partially as a function of differing national resource endowments. In other words, technology and institutions can develop to compensate for low or diminishing endowments of particular resources, a possibility many past prognosticators of impending resource crises and conflicts, by focusing their logic on a static understanding of supply and demand, failed to appreciate.

This broader view of resource systems also helps to explain other seemingly incongruous resource outcomes. Despite recent events, long-held fears that we will run out of critical non-renewable resources, such as oil, have not been reflected through rising prices, both because new technologies have been developed to reduce the cost of extraction and increase efficiency in use as demand increased and because market institutions have allowed production input mixes to shift in response to changing prices. The ability of technologies, institutions, and, perhaps, cultures to change and adapt to declining absolute supplies also provides insights into why fears that Israel would meet with disaster after its water supplies were 'fully' allocated in the 1960s have proved unfounded (Kay & Mitchell, 2000). The threat of declining water supplies in Israel and other water 'stressed' countries may have promoted the introduction of innovative water-saving techniques and encouraged trade regimes that allow the import of

water-intensive products at the expense of local production. In fact, arid areas, where the historic experience with water scarcity is longest and the benefits from resilient management structures are greatest, may be more prepared to cope with water pressures than better-watered areas (Wolf, 2000).

A New Paradigm

The previous sections have argued that, while international resource conflict may be related to resource availability and demand, a simple knowledge of supply and demand conditions, in and of itself, is insufficient to predict potential international resource conflict. This is partly because the relationships between relative resource abundance and conflict are neither straightforward nor easily measured in national statistics and, more importantly, because individual resources exist as part of larger resource systems in which institutions can mitigate the potential role of scarcity or abundance in international conflict. Institutions can vary widely and may have formal legal structures or remain an informal collection of rules, such as a set of commonly observed customs within a 'community' (Stevens & Jabara, 1988). In the international resource arena, institutions range from customary practices among neighboring states to multilateral resource conventions and treaties.

While specific definitions may vary by discipline, institutions can be broadly described as:

> the rules of a society or of organizations that facilitate coordination among people by helping them form expectations which each person can reasonably hold in dealing with others. They reflect the conventions that have evolved in different societies regarding the behavior of individuals and groups relative to their own behavior and the behavior of others. (Hayami & Ruttan, 1985: 94)

Clear evidence of the role of institutions in diffusing international resource conflict can be seen in the case of freshwater systems. The construction of large dams is frequently cited as a factor exacerbating tensions over international waters, as impoundments created by upstream riparians can disrupt the flow and volume made available to downstream users. However, Yoffe, Wolf & Giordano (2003) found that while the construction of large dams could increase conflict levels between states, this was true only for internationally shared basins in which no water management treaties had previously been signed. International basins with large numbers of dams and treaties, even if those treaties did not deal directly with dam-related issues, were in fact no more conflictive than basins with no or low numbers of large dams. Thus, institutional capacity was able to ameliorate conflict and tension that might otherwise have occurred as a result of dam-generated water supply changes.

The ability of institutions to mitigate conflict is further strengthened by their propensity to develop and evolve in response to changing resource conditions. In particular, increasing resource scarcity (Anderson & Hill, 1975) and changes in productivity and technology (Demsetz, 1967) can prompt the development and evolution of international resource management institutions. This outcome is clearly evidenced in the historic record of international resource treaties. The history of international water law, for example, dates at least to 2500 BC, when the two Sumerian city-states of Lagash and Umma crafted an agreement ending a water dispute along a tributary of the Tigris River (Wolf, 1998). Since that first agreement, an additional 3,600 international water treaties, the vast majority of which concern navigational issues, have been signed (FAO, 1984). However, as the demand for consumptive uses of water has expanded over the past century, owing to population, agricultural, and industrial pressures, a growing number

of agreements address water as a limited and consumable resource, apart from navigation or other uses. Furthermore, changing value systems and growing scientific knowledge have fostered an evolution in treaty content towards issues of water allocation and quality, environmental integrity, and groundwater (Giordano & Wolf, 2002). Similarly, Giordano (2002) found that fisheries treaties have progressed over their 500-year history, from a focus on congestion in fishing sites to allocation of catch and designation of management rights and responsibilities, again in response to changing scarcity, values, and knowledge.

Indicators for Regions at Risk

The mere fact that institutions *may* evolve to mitigate international resource conflict in the face of declining resource supply or rising resource demand, does not mean that they *will* evolve, or that they will evolve rapidly enough to avert all resource crises or conflicts. For example, work has been done to show that, in some circumstances, particularly within the context of the developing world, an 'ingenuity gap' that hinders the development of conflict-mitigating institutions can exist (Barbier, 1999; Barbier & Homer-Dixon, 1999; Homer-Dixon, 2000). Thus, an understanding of the potential for resource conflict and conflict mitigation requires an understanding of both resource supply and the institutional capacity available for managing that supply. As a result, international resource conflict is most likely to occur where (1) an institution does not yet exist to manage internationally shared resources that are, or that will become, scarce; (2) such an institution existed but was damaged or destroyed by political or other change; or (3) such an institution exists, but sudden changes in resource demand or supply, either in terms of quantity or quality, outpace the present capacity of the institution to deal with the modified resource environment. We now provide a more concrete examination of the locations and circumstances under which these three conditions are likely to occur.

Non-Existent Institutions

The failure of specific institutions to evolve for the governance of certain international resources stems from three general problems. First, there are many areas of the earth's surface for which general political sovereignty has yet to be determined or is in dispute and whose resources retain an unclaimed, and contestable, status. Second, even where sovereign boundaries have been established, there is a class of resources, known as transboundary or 'fugitive' resources (e.g. fluvial water, migratory wildlife), that, by their nature, cross the territorial boundaries that have traditionally defined sovereignty. As will be discussed below, the multi-jurisdictional nature of these mobile resources makes the creation of institutions for their management problematic. Finally, 'pool' resources such as oil reserves and groundwater, though typically immobile, may lie across the boundaries of states and have characteristics such that use by one nation, within its own sovereign boundary, may impact the availability or quality of the resource for neighboring states. As a result, the nature of pool resources, like transboundary resources, complicates the construction of international management regimes.

Ill-Defined Sovereignty Regions in which sovereignty is not clearly defined represent perhaps the most obvious locations of institutional inadequacy with respect to international resource management. While most of the earth's land area has been divided among sovereign states, there are still significant portions of the earth's surface over which territorial rights have yet to be

established or that remain in dispute. These regions include long unclaimed areas (e.g. the high seas), areas with disputed sovereign boundaries (e.g. between India and Pakistan in Kashmir, and between China, Indonesia, Malaysia, the Philippines, and Vietnam in the South China Sea), and areas in which sovereign boundaries have yet to be strictly defined (e.g. between Saudi Arabia, Yemen, and Oman). These regions, if not already in conflict, are likely locations of future conflict because of the possibility of resource discovery and changes in extraction technology that could make the use of currently unknown or uneconomic resource reserves profitable.

An example of how failure to establish territorial sovereignty might lead to resource conflict can be seen in the case of oceans. Sovereignty over the seas and the resources they contain was generally considered unnecessary until at least the early 17th century, based in part on the belief that marine resources were inexhaustible (Christy & Scott, 1965). This belief has clearly proven false, and coastal nations have responded by extending their national boundaries further from shorelines (Buck, 1998) and by entering into literally hundreds of treaties dividing the ocean's fishery resources (Giordano, 2002). Despite these efforts, national control of large areas of the world's oceans is unclear with respect to both fisheries and mineral extraction. In particular, sovereignty has not been defined for most of the world's ocean resources in the water, seabed, and subsoil beyond 200 (sometimes extended to 350) nautical miles from shore. If ocean fisheries continue to decline, valuable mineral resources are found in deep water, or technologies change to make currently unprofitable oceanic resource extraction feasible, these areas will be especially subject to future international conflict.

This has already been the case in the South China Sea. Sovereignty over the South China Sea's resources has long been in question (Denoon & Brams, 2001), in part because of discrepancies in the interpretation of the United Nations Convention on the Law of the Sea (UNCLOS, 10 December 1982 21, I.L.M. 1261) that defined the 200-mile limit. Questionable sovereignty, however, was initially insufficient to incite conflict among the five nations (six if the Republic of China is considered separately from the People's Republic of China) with competing claims. Rather, significant territorial disputes began only after it was discovered that oil deposits might exist in the vicinity of the South China Sea's Spratly Islands. Since then, a number of states involved in the dispute have increased their naval and commercial presence, leading to threats of, and sometimes outright, aggression (Chang, 1990). Analogous events occurred in areas of ill-defined sovereignty between Argentina and Chile in the 19th century related to nitrates (leading to actual hostilities) and in the later 20th century related to Antarctic ice access. We can expect similar problems should oil be discovered near the undefined borders of the Arabian peninsula or in any other area with disputed or as yet undefined sovereign boundaries.

Transboundary Resources Even where sovereign boundaries have been precisely established, additional international resource management institutions are generally needed when transboundary resources are present, because transboundary resources, by definition, violate the borders on which sovereignty concepts have traditionally been based. International transboundary resources possess at least three characteristics that make them particularly vulnerable to conflict. First, nations have an incentive to overexploit transboundary resources, because the benefits of use accrue entirely to the consuming country while the costs, in terms of

decreased or degraded supplies, are shared by all countries through which the resource may eventually pass. This asymmetric matching of costs and benefits results in an increased likelihood of overuse by each country and perceptions that use by other parties is unfair or inappropriate. Second, the reasonable fear that other nations will overuse the transboundary resources that enter their territories can lead to a 'use it or lose it' mentality, further encouraging overexploitation. This fear has led to overcapitalization in resource extraction technologies, for example, in the assembly of large and fast fishing fleets designed to maximize short-term catch (FAO, 1999), placing further pressure on resource stocks. Third, forming agreements between states over transboundary resources is complicated, as the nature of resource movement and national geographies can pre-define nearly intractable negotiating positions by involved states. In the case of transboundary rivers, for example, upstream users generally tend to favor the 'doctrine of absolute sovereignty', which maintains the absolute right of a sovereign to use the waters flowing through its territory, whereas downstream users, where water development schemes have the longest history, tend to favor allocation based on the 'doctrine of absolute riverine integrity', which holds that all riparian territories have a right to use, undegraded, the waters naturally in their province.

As a result of these factors, there has been only limited success in developing institutions for international transboundary resource management. Notably, more than half the world's 263 international river basins lack any type of cooperative management framework, and only 62 basins have been identified with water quality treaties (Giordano, 2003). Furthermore, of those basins with water treaties, approximately two-thirds have three or more riparian states, yet less than 20% of the accompanying agreements are multilateral (Giordano & Wolf, 2002). Efforts to construct frameworks for the management of other international transboundary resources, such as the atmosphere, the ozone layer, and acid rain, are all relatively recent, and there is still considerable question as to the potential success of current international management efforts, a problem highlighted by the recent withdrawal of the United States from the Kyoto Protocol.

International 'Pool' Resources International 'pool' resources are those relatively immobile resources that lie across the boundary of two or more nations. Examples include 'fossil' groundwater, the water of lakes, and oil.[4] Similar to transboundary resources, the use of an international pool resource by one nation can impact availability of the resource for other nations. For example, the pumping of underground oil and gas reserves is known to 'draw' the resource from adjacent areas and has been cited as a factor in Iraq's decision to invade Kuwait in the 1991 Gulf War (Sifry & Cerf, 1991) and in tensions between Germany and the Netherlands. Similarly, cross-boundary groundwater supplies are vulnerable to 'well interference', in which pumping in one location reduces volume and pressure in another (Anderson & Snyder, 1997). The growing understanding of the existence of underground resource reserves and the dynamics of extraction may increasingly lead to feelings that a nation's resources are being 'stolen' by other extracting nations. Unfortunately, there is a limited history of

[4] Lake water that straddles international boundaries might sometimes be better considered a transboundary resource, since flow patterns may move the water, and the pollutants it can carry, across boundaries. Similarly, groundwater, because of its flow and potential to carry pollutants, might in some cases better be considered as a transboundary resource. The issue of whether to consider such resources as transboundary or common pool depends primarily on the time scale under consideration.

international agreement on codification of rules for the use of international pool resources. As a result, it appears that the potential for conflict over international pool resources, at least in the near to medium term, is likely to grow, as technologies for extraction improve and oil and groundwater reserves are increasingly accessed.

The Collapse of Institutions

A second condition increasing the likelihood of international resource conflict occurs when existing rules for use suddenly change with a collapse of traditional order. Such a result is especially likely when resources that were once managed under a single government become 'internationalized' as a result of boundary or sovereignty changes. For example, while the Caspian Sea has long been known to have substantial oil reserves, direct international competition for the region's resources – and the construction of pipelines to move those resources – increased substantially when the collapse of the Soviet Union changed the number of nations bordering the sea from two to five and left offshore drilling rights less than clear. In the case of freshwater resources, there has been a marked increase in internationalization in recent years, with the number of transboundary basins rising from 214 in 1978 (United Nations, 1978) to 263 in 2002 (Giordano & Wolf, 2002) and still more growth following the recent independence of East Timor. Most of the increase in numbers has been due to changing political boundaries. Significantly, Yoffe, Wolf & Giordano (2003) found that both the incidence and intensity of international water resource conflict tend to rise in the wake of internationalization of river systems, such as occurred after the breakup of colonial regimes after World War II and the Soviet Union in 1989. However, cooperation levels seemed to rebound once a new order was established.

Inflexible Institutions

Finally, just as sudden changes in institutional regimes can lead to international resource conflict, so too can sudden changes in the physical environment, when existing institutions are not sufficiently resilient and flexible to deal with that change. For example, Yoffe, Wolf & Giordano (2003) found no correlation between international conflict over water at the basin level and the abundance of water in the basin or basin level climate. In other words, arid, 'water stressed' basins were no more likely to be conflictive than basins with more substantial water availability. Instead, conflict levels tended to increase when there was a substantial drought- or flood-induced change in availability for a given year. The likely explanation of this finding is that institutions and rules tend to evolve to govern 'normal' or slowly changing conditions, but that those institutions are challenged when sudden change occurs.

Clearly then, while institutions are important in mitigating international resource conflict, their mere presence is insufficient to prevent all discord. For example, fixed allocations were used to divide the waters of the Colorado river between the USA and Mexico in a 1944 treaty (USA/Mexico, 1946). Unfortunately, the allocations were calculated on flows in an especially wet year, and when discharge levels later dropped, a dispute emerged between the two countries (Mumme, 1993). Analogously, the Frazier River Convention (184 L.N.T.S. 305) used absolute numbers, rather than harvestable catch, to allocate salmon numbers between the USA and Canada and eventually broke down as the fishery declined. The water-sharing provision of the 1994 Treaty of Peace between Israel and Jordan similarly failed to include drought provisions, resulting in political and economic tensions when water availability declined in 1999.

The salient point is that predictions of international resource conflict and efforts at mitigation must focus not only on the existence of institutions to manage scarcity, but also on how well those institutions are able to cope with changing, especially rapidly changing, political or resource environments. As stated, some institutions, like those just described, have failed as conditions changed. Others, however, such as the 1960 Indus Water Commission between India and Pakistan, have proved to be remarkably resilient over time in allocating or protecting internationally shared resources, even in the midst of outright war (Alam, 2002; Giordano, Giordano & Wolf, 2002). Thus, an important factor in understanding resource conflict is understanding the characteristics that make up resilient institutions.

'Successful' Institutions

While institutions can relieve the social, political, and environmental stresses associated with resource scarcity, their ability to mitigate international resource conflict is in part dependent on their structure. The underlying factors that promote institutional success – in terms of the institution's ability to resolve or avert conflict – are indeed complex and can vary across resource type and setting. However, a review of the international environmental conflict mitigation literature in general, and the experience of international water law in particular (Giordano & Wolf, 2002), offers broad guidance in understanding critical factors in predicting long-term institutional success.

First, successful institutions tend to utilize clear language concerning resource allocation and quality control. The importance of clarity has been succinctly put by Keynes with reference to the 1982 United Nations Convention on the Law of the Sea: 'When it comes to deciding where the baseline for measuring the territorial seas should be, all such features must be examined closely and rules laid down to accommodate them. This is far from a trivial matter. Unless the position is made clear, disputes may arise, wars may be fought and lives may be lost' (quoted in Maling, 1989: 10–11). Despite the importance of clear language, nation-states tend to favor the creation of 'open-ended' resource institutions with symbolic, but substantively void, commitments (Utton, 1973; see Giordano, 2003, for a discussion of this tendency in international water law). While perhaps a positive first step towards formal resolution of international resource management problems, the longer-term value of such agreements is questionable in the face of resource crises, especially those caused by rapidly changing conditions.

Second, clarity in language must be matched with a degree of institutional adaptability. The environment, technologies, and value systems all change over time. For institutions to be effective in the long run, then, they must be able to adapt not only to variations in the resources themselves, but also to the changing knowledge base and social systems of the resource users (Dietz, Ostrom & Stern, 2003; Stern et al., 2003). As was demonstrated earlier, even simple measures such as the incorporation of allocation regimes based on percentages of useable or harvestable stocks, rather than absolute quantities, can make the difference between a successful tool for resource conflict mitigation and failure.

Third, allocating benefits is more productive than allocating the resource. Traditional resource institutions have tended to concentrate on the physical distribution of single resources. While such arrangements can be effective, they can create only zero-sum outcomes. Alternatively, agreements that distribute benefits from resource use can produce positive-sum solutions that have a higher value to concerned parties and, therefore, a higher propensity for long-term resilience. An example of such an institution is

the 1950 agreement between the USA and Canada on the Niagara (CTS 1950/3). This treaty does not simply allocate absolute quantities of water, but rather provides greater flow over the famous falls during 'show times' of summer daylight hours, when tourist dollars are worth more per cubic meter than the alternative use in hydropower generation. Similarly, institutions that create linkages across issues to create a 'basket of benefits' (Giordano & Wolf, 2002) may offer a broader base upon which to negotiate initial institutional creation (Martin, 1995) and provide more flexibility in solving problems when changing conditions create disagreement. One such example can be seen in the 1998 Agreement on the Use of Water and Energy Resources of the Syr Darya Basin,[5] in which the Kyrgyz Republic exchanges water management for fossil fuels from Uzbekistan and Kazakhstan.

Finally, even when seemingly 'strong' institutions are established, new issues or problems may arise, sparking disagreements between the involved states. To withstand new sources of tension, institutions must have clearly defined conflict resolution mechanisms in place. The USA and Canada, for example, have instated several prominent management bodies, including the International Joint Commission (IJC), established as part of the 1909 Boundary Waters Treaty (CUS 312). In the treaty, the IJC was granted substantial authority to resolve transboundary water resource disputes between the two states. This conflict resolution mechanism has resulted in the settlement of several disputes between the USA and Canada over such issues as the development of the Columbia River and the construction of the High Ross dam.

Future Directions

As described in the preceding sections, predicting international resource conflict, isolating its causes, and developing mechanisms for its alleviation or prevention are complex. Accurate assessment of potential conflict requires not only an understanding of resource demand and supply issues, but also an understanding of the presence and capability of related resource management institutions. Mitigating international resource conflict involves a profound understanding of the factors that contribute to long-term institutional success. While we have presented a framework for assessing regions and resources at risk of future international conflict, there are a number of promising avenues for future research that could not only better our ability to understand where conflict might take place, but also guide strategies for conflict mitigation and avoidance.

Assigning Sovereignty over Resources

A primary challenge to the prevention of international resource conflict is devising rules and institutions to allocate resource use and other rights between states. Some resources, in particular transboundary and pool resources, defy traditional definitions of national sovereignty and, therefore, require methods of allocation beyond those of territorial demarcation. An example of one such method is the use of a 'nation of origin' principle for the establishment of use rights to anadromous fish, including many salmon species. The principle holds that fish that travel across maritime boundaries belong to the nation in whose waters they were born and was codified in the Law of the Sea Treaty (21 I.L.M. 1261) and other agreements, such as the Pacific Salmon Treaty between the USA and Canada (1469 U.N.T.S. 357).[6] Research into the effectiveness and potential transferability across resource types of similar

[5] Text available at http://www.transboundarywaters.orst.edu.

[6] The rationale of the 'nation of origin' is that the country controlling the breeding habitat is in the best position to manage the habitat and should enjoy the economic benefits, via increased harvest, of proper management.

new thinking could yield valuable insights into the creation of new treaties and other types of international resource management regimes.

Institutions and Conflict Mitigation

At the international scale, the development of resource management institutions is complicated by the fact that there are no overarching legal bodies to set and enforce rules and conduct. Instead, solutions must be voluntarily negotiated between sets of sovereign nations whose opinions concerning the type and existence of institutions may differ as a result of factors ranging from geographic location to level of economic development to political ideology. To encourage greater resource collaboration, the international community has devised, and in some cases codified, generalized principles of international resource management from which states can draw in the development of cooperative frameworks. For some resources, in particular ocean fisheries, these principles have been successfully utilized in specific bilateral and multilateral conventions (Giordano, 2002). Cooperative frameworks created for the management of other resources, like international waters, however, have largely developed independently of existing international principles (see Giordano & Wolf, 2002). Research into how and under what conditions generic, systematized rules are likely to be adopted by concerned states could help focus the international communities' efforts at fostering the creation of cooperative resource management institutions.

Scale and Role of Trade

As alluded to above, international trade is one possible means for alleviating national or regional resource scarcity. Even for essentially non-tradable resources, such as water and land, 'virtual trade' in the commodities for which resources are valued as a production input can reduce effective national scarcity levels (Allen, 1998, 2002). If trade can be used to reduce scarcity, then technological solutions to particular resource constraints become relatively less important than open trading regimes and overarching political stability. Further, interdependence through trade relations has been shown to generally reduce the potential for interstate conflict (Oneal & Russett, 1999), and so increases in virtual trade may have cooperation benefits at multiple levels. At the same time, however, a reliance on world markets brings with it additional risks and institutional challenges owing to the possibility of unilateral policy changes that suddenly disrupt or stop trade flows, as was the case with oil and grain in the 1970s and early 1980s. Similarly, exogenous disruptions to trade regimes brought on by war or other political turmoil can suddenly alter control over and access to resource supplies. A research agenda that examines the benefits and risks of trade as a solution to resource scarcity concerns might enhance our understanding of where trade might offer an effective alternative to technologically driven solutions, and in which regions and for which resources the risks of trade dependency are greatest.

Learning from National Experiences

Despite the long history of water and wildlife treaties, the experience with international resource management institutions is negligible in comparison with the vast depth and breadth present at national, sub-national, communal, and familial scales. The experience in shared resource management at these finer scales may offer valuable lessons for management at the international level (and vice versa), especially as globalization and the ever-increasing interdependency among the world's nations makes international interaction over resources increasingly common (Keohane & Ostrom, 1995; Ostrom et al., 1999). In addition, cross-scale analyses may

highlight linkages between local, national, and international resource relationships and the institutions that govern them, further elucidating the nature and causes of and options available for mitigating conflict (Ostrom et al., 1999; Giordano, Giordano & Wolf, 2002; Young, 2003).

Identifying 'New' Resources at Risk

The general prescription presented here has been to create institutions for unmanaged, scarce resources shared by sovereign nations and to strengthen those existing institutions in need of repair. While this may help us mitigate conflict over currently scarce and at-risk resources, such as freshwater and fisheries, it does not readily identify potential future sources of tension. As population, the environment, and value systems change, resources that are currently in abundance may decline and some not currently considered 'resources' become valuable. New frameworks for assessing such change might be established to help monitor evolving resource systems and alert us in advance to potential risks and institutional needs.

Conclusion

The connections between resource supply and demand and international resource conflict are much less straightforward than commonly assumed. As a result, conventional resource scarcity metrics, by themselves, are unlikely to serve as useful predictors of future international resource conflict. Instead, we suggest here that international resource conflict is most likely to occur where there exist both resource scarcity *and* insufficient institutional capacity to deal with that scarcity. In particular, we argue that conflict is most likely to emerge in those areas where resource sovereignty is ill-defined or nonexistent, where existing institutional regimes are destroyed by political change, and/or where rapid changes in resource environments may outpace the capacity of institutions to deal with the change.

This broader understanding of the factors behind international resource disputes not only assists in predicting where conflict might occur, but also provides insights into promising avenues for mitigating potential conflict. Clearly, institutions can provide a significant means for conflict mitigation and should be encouraged in many areas where they are currently lacking. However, to be effective, international resource management regimes should be clear in terms of resource allocation and quality control; be constructed with an intrinsic ability to adjust to changing political and environmental conditions; promote positive-sum solutions to resource problems; and incorporate structured conflict-resolution mechanisms. Thus, a mitigation strategy for potential resource conflict is the construction of resilient international resource management institutions along with improvement of some existing institutions.

Finally, concern over international resource conflict in the realm of high politics is a relatively recent phenomenon, and the research presented here only begins to address the political complexities of international resource management. New opportunities for mitigating international resource conflict may come to light through additional research on alternative definitions of resource sovereignty, international community involvement, and lessons from cross-resource and cross-scale management studies. Further research and attention to these and other issues associated with international resource conflict may have the added benefit of encouraging greater political support for finding cooperative solutions to shared resource problems, preferably before crises emerge.

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