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Water resource development on the Ganges: moving beyond ambiguity

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Introduction

The Ganges River rises in the Himalayan border regions of China, Nepal and India and flows 2,500 kilometers (km) to Bangladesh and the sea. Fed by a complex interplay of glacial waters, surface flows and groundwater resources, the Ganges basin has economic, cultural, social and religious importance for its more than 500 million inhabitants (Crow *et al.*, 1995). For centuries, however, the utilization of water resources in the Ganges basin has been severely hampered by substantial seasonal variation in flows: the monsoon delivers about 80% of total annual rainfall in just three months of the year (mid-June through to mid-September) and the basin becomes drought-stressed during the dry season (Huda & Shamsul, 2001). As a result, large areas of the basin routinely suffer from both droughts and floods, resulting in significant human and socioeconomic losses. The allocation of the low flows of the Ganges during the dry season has been a major source of conflict between India and Bangladesh.

The challenges facing riparian countries along the Ganges can be addressed by integrated water resource development. Storage reservoirs can be built on the tributaries in the upper basin to hold a small portion of the vast monsoon runoff, in order to generate hydropower and augment low dry-season flow in downstream areas (Shibusawa, 1987; Khan, 1996; Onta, 2001). More than 30 sites in Nepal have been identified as offering suitable potential storage capacity for these objectives. Nine of these involve projects with gross capacity greater than 5 billion cubic meters (BCM) each; in combination they would provide total storage capacity of 110 BCM. This total is still only about 20% of the mean annual flow of the Ganges (about 500 BCM). In addition to hydropower generation and low-flow augmentation, these prospective reservoirs could also improve navigability along the length of the river and its tributaries.

Little progress toward such improvements has been made so far. Current storage in the whole basin is only 36 BCM. Less than 1% of potential hydropower capacity in Nepal, estimated at 83,000 MW, has been developed. Yet only 40% of Nepal's population has access to electricity and those who do have

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access experience chronic load shedding. Throughout the Ganges basin, slow progress in the utilization of water resources comes at a huge cost for millions of its residents, in a vast region where the poverty rate, the percentage of population that live on less than US$2 per day, is among the highest in the world.

Several rival explanations have been offered to account for this slow progress in water resource development. Scholars have held that the region's history of unilateral developments, the dominance of bilateral approaches to water conflicts, India's geopolitical power and the diverse and conflicting interests within each riparian country are among the main factors responsible for chronic failures in addressing water challenges in the Ganges basin. Although cooperation among riparian countries is imperative, these explanations seem to offer few grounds for optimism and reaffirm the likelihood that the basin's future development of water resources will continue to be slow.

We argue here that ambiguity about the hydrology, current water use and actual opportunities for development is also an important factor undermining the prospects for water resource development in the Ganges basin and may be the case in other international river basins as well. Although 'ambiguity' and 'uncertainty' have often been used interchangeably in the literature, they are dissimilar concepts and their differences have critical policy implications. Uncertainty refers to lack of precision in estimates when the problem structure is well defined; ambiguity, on the other hand, can be defined as a lack of clarity with regard to relevant variables and their functional relationships (Martin & Meyerson, 1988). We open our discussion below by explaining how ambiguity has led to the uneven path taken by riparian countries in dealing with water challenges in the Ganges basin and then offer some plausible remedies to overcome them.

Ambiguity and water resource development in the Ganges

Ambiguity is a typical feature of conflicts involving international river basins. Although it is often assumed that uncertainty presents major challenges to decision-making, ambiguity may have far more influence in shaping how decision-makers deal with complex problems. This is especially true for ill-structured problems that involve multiple decision-makers whose utilities are unknown and entail significant uncertainty about 'which concepts, rules and principles are necessary for the solution and how these should be organized' (Dunn, 2003).

Many development efforts undertaken in international river basins exhibit all these problems. There are five central reasons why solutions can be very hard to achieve. First, the interconnectedness of a river system and the myriad social, economic and environmental impacts, as well as their interactions, of decisions made over even one part of the system, are often beyond the reach of typical tools and methods employed in water resource planning. As a result, critical linkages are often unobserved or ignored, such that critical factors may not be taken into consideration at all.

Second, decisions about major infrastructure and treaties often have long-lasting impacts, well beyond the current generation of decision-makers, yet the choices that will be available to future generations and their preferences are unknown. It is easy, for example, to empathize with a negotiator's fear that a proposed major treaty could compromise the interests of future generations of his fellow citizens, when the treaty is designed to resolve immediate conflicts.

Third, it is common for experts to disagree about causal mechanisms or the magnitude of relationships based on the same set of data or evidence. The sources of such disparities are often unclear or intractable.

A fourth important source of ambiguity is unilateral strategic actions or reactions by individual riparian countries party to international water negotiations. Because of the high potential stakes involved, misrepresentation of key facts, restriction of access to key data and exaggeration of claims of various kinds are often employed among participants to gain perceived or real advantages in negotiations.

Fifth, there are often many stakeholders involved in the decision-making process, both domestically and internationally, and their objectives, preferences regarding different proposed scenarios, guiding constraints and potential reactions are often imperfectly recognized or unknown.

Given the high degree of ambiguity involved in international water negotiations, it should come as no surprise that water resource development in the Ganges basin has been largely the result of incremental, project-by-project activities within each of the riparian countries. The Government of India's decision to build the Farraka Barrage (completed in 1975) illustrates one common response to ambiguity. The Indian government made the decision to build the Farakka Barrage in order to maintain navigability of the Hooghly River by flushing out silt deposited in Kolkata Port and in order to ensure a saline-free water supply for Kolkata City (Crow & Singh, 2000), despite protests made by Pakistan concerning the resultant reduction in dry season flow to Bangladesh (until 1971 East Pakistan). Although doubts had been voiced about the effectiveness of the barrage in achieving its stated objectives, this was an internal Indian debate and was treated by planners as a matter of technical uncertainty.

Discussions were indeed held between the two countries before the decision, but India did not regard Pakistan as a partner in negotiation when making its decision to build the barrage (Crow *et al*., 1995). From the Indian perspective, inclusion of Pakistan as a negotiating partner would have created considerable ambiguity in terms of understanding and forecasting the full impact of the barrage on Pakistan, a 'reasonable' share of water for Pakistan and the likelihood of securing an agreement from Pakistan. India's unwillingness to confront such ambiguity, coupled with India's strong geopolitical position, led to unilateral development as the prevailing strategy. In retrospect, the substantial reduction of flow during the dry season as a result of water diversion at Farakka has caused socioeconomic and environmental losses for Bangladesh, although its intended effects on navigability of Kolkata Port and controlling salinity of the city's water are questionable (Rahaman, 2009). More important, the Farakka decision has created mistrust between India and Bangladesh, and trust is a key ingredient for cooperation in the future.

Ambiguity may also lead to costly delays in the construction of water resource infrastructure. The sharp contrast between Nepal's rich endowment of water resources and its actual achievement in harnessing these resources offers a case in point. Contributing to 45% of the flow in the Ganges basin and possessing some of the basin's best sites for hydropower generation, Nepal holds the key to large-scale infrastructure development projects and its cooperation is highly sought by both India and Bangladesh. There is little chance that Nepal would be made worse off by any initiatives in developing its water resources. But so far very little progress has been made in converting the country's enormous potential hydropower production into tangible measures to improve the livelihood of its people. The average gross domestic product (GDP) per capita is US$470 in Nepal, the lowest in the Ganges basin, and the proportion of the population with a standard of living below the poverty line is 31%.

Nepal's slowness to capitalize on its potential for water resource development also may be due in part to the ambiguity involved in cooperating with neighboring countries. While Nepal's determination to achieve maximum benefits from its water resources is admirable, there are formidable challenges to understanding and articulating just what achieving the 'maximum benefits' exactly

entails. Consider, for example, the proposed Kosi High Dam. What benefits would it provide to downstream riparian countries in terms of flood prevention and augmentation of low flow? What would be Nepal's fair share of the benefits from the construction of the Kosi High Dam? What price should Nepal charge its neighbors for the electricity generated from new hydropower facilities? The lack of clarity in answering these questions makes it difficult for Nepal to formulate sensible strategies in negotiation. Widespread criticism among the Nepalese over several of their country's cooperative projects with India in the past several decades has not only alerted Nepalese decision-makers to the danger of being on the wrong side of handling ambiguity, it has also bred a deep suspicion of any initiatives proposed by other riparian countries. Thus, although Nepalese policy makers' reluctance to engage in cooperative water resources development may be rational given the degree of ambiguity involved, the accumulation of lost benefits as time passes may harden the country's position in negotiations for development in the future.

Unlike Nepal, which apparently thinks that it can wait for the right moment to maximize the benefits from its water resources in the future, Bangladesh cannot afford the costs of delay. With 94% of its surface water resources originating outside its national boundaries, Bangladesh is the riparian most vulnerable to the deleterious effects of uncoordinated water development projects upstream. Since the Farakka Barrage began operation in 1975, Bangladesh has suffered a 50% decline in dry season flow from the Ganges (Mirza, 2004). Bangladesh has maintained that the construction of large storage reservoirs in Nepal can effectively regulate the Ganges to augment flow in the dry seasons in such a manner as to satisfy the needs of both India and itself, and Bangladeshi negotiators have insisted on the inclusion of Nepal in efforts to deal with water shortage problems. This inclusion of Nepal can be perceived as a step in the right direction from the perspective of integrated water resource development in the Ganges basin, but several critical questions remain unanswered. How much would it cost to build these large storage reservoirs? Who should pay for them? How much potential would these storage reservoirs have for augmenting low flow? Is there any trade-off between power generation and augmentation of flow in the dry season? The prospects of implementing development approaches advocated by Bangladesh are likely to remain elusive as long as there is a lack of clarity in addressing these questions.

Predictably, India's response to ambiguities involved in the trilateral approaches advocated by Bangladesh is to reduce the degree of ambiguity by insisting on bilateral solutions. This position is quite understandable from a strategic perspective, because inclusion of Nepal in India's negotiations with Bangladesh may legitimize Bangladesh's claims to share benefits derived from large-scale projects in Nepal and might complicate India's own negotiations with Nepal. It is also justifiable from a technical perspective, because bringing in a third party would increase the degree of complexity in addressing the ambiguity involved. On the other hand, although India's approach to ambiguity by either avoiding it (unilateral development) or reducing it (bilateral solutions) may have served the nation's interests well in the past, its limitations in furthering basin-wide infrastructure development are becoming increasingly apparent. India, too, may have no choice but to join other riparian countries in confronting this ambiguity head on.

Ambiguity is among the major factors that have undermined the potential for water resource development in the Ganges basin. Failures to address ambiguity have not only led to unilateral developments and the predominance of bilateral solutions to water conflicts, but have also given rise to contradictory beliefs about the basin that could shape discourse in the future.

Moving beyond ambiguity

The articles comprising this special issue of *Water Policy* represent a small step toward unraveling the ambiguities involved in water resource developments in the Ganges basin, some of the most troubling of which have been identified above. It is our hope that that this special issue will contribute to a better understanding of the dynamics of the river basin from a system-wide perspective.

Climate change is likely to have a significant impact on the utilization of water resources in the Ganges basin, but there is considerable ambiguity regarding the nature of this impact and its implications for prospects of cooperation between riparian countries. Although attention and emphasis have often been placed upon the negative impact of climate change in the future, such as increasing frequency and severity of floods or intensifying water shortages, the increasing need to contend with its effects may also open up new opportunities for international cooperation in water resource management. Employing a version of the Water Evaluation and Planning model, Sharma & deCondappa (2013) assess the potential contribution of glacier and snow melt to the flows of the Ganges basin in the context of climate change, as well as potential opportunities that might arise from an increase in these upland waters. Their findings suggest potential opportunities to exploit this additional available water through construction of a number of storage reservoirs that could be used locally or within trans-boundary agreements between India, Nepal and Bangladesh, to capture this extra water just at the end of the dry season, when flows from glaciated areas become noticeable and water demand from agriculture and the domestic sector is at its peak. The authors also show how using the extra melt water flows for augmentation of the groundwater resources through regional 'managed aquifer recharge' programs could become an attractive option for intensive and sustainable use of groundwater resources in the agriculturally important regions of the basin.

Although disagreement among experts about the potential impact of climate change is a frequent source of ambiguity for water development planning in the Ganges basin, Jeuland *et al.* (2013) present an analysis, based on basin-wide hydrological and economic modeling, which suggests that despite uncertainties, projections for precipitation derived by the Intergovernmental Panel on Climate Change do not exceed the range of natural variability. These and other findings are shown to aid in unraveling the ambiguity surrounding the effects of development of upstream dams on reducing peak flows – the source of a crucial debate between Nepal, where the dams would be located, and downstream riparian countries. The authors conclude that whereas the potential for hydropower production is substantial, large upstream dams may have only limited ability to reduce peak flows, as annual flow from tributary rivers farther downstream greatly exceeds the storage capacities of these upland projects. Although the authors' findings provide evidence suggesting enhanced water availability in dry seasons as a result of additional upstream storage, as well as better regulation of annual flows as a result of upstream dams, their analysis points to an important source of ambiguity that has not been addressed hitherto in the existing literature: lack of clarity regarding the relative value of this water for irrigation in the Ganges basin, or for low-flow augmentation in Bangladesh, under conditions of climate change. Much attention has been focused on large-scale projects that entail considerable ambiguity at present, but their analysis points to the importance of greater adaptive capacity and of 'soft' solutions that have not received sufficient attention in discussions of solutions for water conflicts in the Ganges basin.

One such 'soft' solution is highlighted in Battacharya *et al.* (2013), which describes the impact of management practices on flooding in the Sundarbans caused by climate change. Based on detailed study of the morphology and tidal environment of the Sundarbans estuaries, their research reveals

that while tidal estuaries constrained by embankments in the Sundarbans have failed to prevent channel erosion that has undermined embankments, causing mass failure, breaching and subsequent flooding during surge events, innovative management practices have modified this process of erosion. The practice of severing tributary channels from the main channel by using flap sluices has in many cases reduced tidal flow in the main channels to the degree that the channels are not only accreting rather than eroding, but are capable of accommodating future sea level rise without erosion. The authors conclude that management responses to prevailing and predicted future sea levels must vary according to inherent differences between three classes of estuaries: oversized estuaries, equilibrium estuaries and undersized estuaries.

Embankments are often justified on the ground that they will provide flood protection and enable an additional annual crop to be grown. Instead, the analysis of Somanathan (2013) suggests that the alleged increase in crop production resulting from embankment appears to have been based on a false presumption relating to development of adaptive capacity. A natural experiment conducted in 18 villages along the Kosi river discovered that the gross value of crop output in the regularly flooded villages is higher, or at least no lower, than that in the control villages, even though three out of four of the regularly flooded villages in the study are located inside embankments and therefore are highly exposed to seasonal and concentrated river flooding. Mean wages of agricultural and casual workers in the regularly flooded villages proved to be no lower than in the control villages and the same pattern held for measures of schooling, health, wealth and household amenities. Somanathan concludes that the capacity to adapt to predictable floods appears to be higher than is often presumed.

Among riparians in the Ganges basin, a widely held belief is that dams in Nepal would produce large downstream benefits for India, as well as for Nepal itself. This has created expectations of commensurate compensation. Nepal's continuing reluctance to capitalize on its potential for water resource development despite this general optimism may be in part due to perceived ambiguity involved in cooperating with neighboring countries. This ambiguity may arise from lack of clarity regarding the impact of interdependence in water resource planning. It is often argued that the true benefits of cooperative water resource development in international river basins are undermined by failure to consider interdependencies during water resource planning. In a study reporting results from the Ganges Economic Optimization Model, Wu *et al*. (2013) argue that *over*-estimation of interdependence may likewise impede progress in cooperation. Their analysis finds that constructing large dams on the upstream tributaries of the Ganges may, in fact, have much more limited effects on controlling downstream floods than previously thought and that the benefits of low-flow augmentation delivered by storage infrastructures are currently, in fact, low (though modernization of irrigation systems in India and Nepal could alter this). A better understanding of actual and prospective effects of interdependence not only changes the calculus of the benefits and costs of different scenarios of infrastructure development, but might also allow riparian countries to move closer to benefit-sharing positions that are mutually acceptable.

Experience outside the region may also shed light on unraveling ambiguities that hamper water resource development in the Ganges basin. To date, Nepal has avoided entering into an agreement with India to develop its hydropower resources, as it has feared becoming involved in an unbalanced arrangement whereby India might secure an unfair advantage. Dhakal & Jenkins (2013) show that experience with the Chukha dam in Bhutan can serve as a real-life example of how such a power purchase agreement might be structured so as to yield a result advantageous to both parties. The power purchase agreement framework for the 336 MW Chukha Hydel Project in Bhutan demonstrates the transfer of risks, management of risks and sourcing of finance in exchange for the sharing the

economic rents associated with such projects. India undertook the costs and risks of constructing the hydroelectric dam and power plant in exchange for a reduced purchase price of electricity from the completed facility. Analysis shows that although India is now in a position to exercise monopsonic power in this electricity market, it remains possible to honor an agreement for sharing risks and returns between India and the Himalayan countries that is beneficial to all stakeholders.

Water conflicts in the Ganges basin mainly arise from conflicting interests among nation states, but there are also often many stakeholders involved in the decision-making process within each country. Their competing interests can be a source of water conflicts as well and lack of clarity in understanding their objectives, preferences over different scenarios, constraints and potential reactions can present significant challenges to decision-makers charged with preparing for international cooperative efforts. Mullick *et al.* (2013) present a case in point, focusing on the complexity of dealing with competing off- and in-stream demands in the allocation of water resources along the Teesta River in Bangladesh. With AQUARIUS, a generalized hydrologic–economic optimization model, they show that maximizing economic benefit by allocating flow to irrigation results in compromising the goal of environmental protection, whereas upholding in-stream flow constraints for environmental protection would result in significant economic losses of irrigation benefits. Such conflicts are common in river basins and their analysis helps to articulate the trade-offs between competing interests, a critical and imperative step toward addressing ambiguities involved at broader scales. The findings of this study suggest that certain allocation criteria, such as marginal benefits of sectoral water uses, can be used to address the trade-offs.

The final contribution to this collection, Sadoff *et al.* (2013), provides a summary of the Ganges Strategic Basin Assessment, the most comprehensive, ambitious effort to date in the search for clarity in answering fundamental biophysical, economic and social questions that currently characterize the ambiguities involved in sustainable development of water resources in the Ganges basin. For example, can upstream water storage control basin-wide flooding? Can upstream water storage effectively augment low flows downstream? Are there good alternatives or complements to reservoir storage? What is the magnitude of potential economic benefits from multipurpose water infrastructure and what are the trade-offs between different water uses? Is infrastructure the best strategy for protecting communities from floods? Is it possible to control sedimentation in the Ganges? The authors' analysis challenges some of the most widely shared perceptions concerning the potential for large-scale water resource developments in the basin and points to a need to broaden the search for possible solutions to water conflicts along the Ganges.

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