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Hydropower and sustainability: Resilience and vulnerability in China's powersheds

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ABSTRACT

Large dams represent a whole complex of social, economic and ecological processes, perhaps more than any other large infrastructure project. Today, countries with rapidly developing economies are constructing new dams to provide energy and flood control to growing populations in riparian and distant urban communities. If the system is lacking institutional capacity to absorb these physical and institutional changes there is potential for conflict, thereby threatening human security. In this paper, we propose analyzing sustainability (political, socioeconomic, and ecological) in terms of resilience versus vulnerability, framed within the spatial abstraction of a powershed. The powershed framework facilitates multi-scalar and transboundary analysis while remaining focused on the questions of resilience and vulnerability relating to hydropower dams.

Focusing on examples from China, this paper describes the complex nature of dams using the sustainability and powershed frameworks. We then analyze the roles of institutions in China to understand the relationships between power, human security and the socio-ecological system. To inform the study of conflicts over dams China is a particularly useful case study because we can examine what happens at the international, national and local scales. The powershed perspective allows us to examine resilience and vulnerability across political boundaries from a dynamic, process-defined analytical scale while remaining focused on a host of questions relating to hydro-development that invoke drivers and impacts on national and sub-national scales. The ability to disaggregate the affects of hydropower dam construction from political boundaries allows for a deeper analysis of resilience and vulnerability. From our analysis we find that reforms in China's hydropower sector since 1996 have been motivated by the need to create stability at the national scale rather than resilient solutions to China's growing demand for energy and water resource control at the local and international scales. Some measures that improved economic development through the market economy and a combination of dam construction and institutional reform may indeed improve hydro-political resilience at a single scale. However, if China does address large-scale hydropower construction's potential to create multi-scale geopolitical tensions, they may be vulnerable to conflict – though not necessarily violent – in domestic and international political arenas. We conclude with a look toward a resilient basin institution for the Nu/Salween River, the site of a proposed large-scale hydropower development effort in China and Myanmar.

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1. Introduction

Large dams, perhaps more than any other large infrastructure project, represent a whole complex of social, economic and ecological processes. Today, countries with rapidly developing economies are constructing new dams to provide energy and flood

control to growing populations in riparian and distant urban communities. Meanwhile, countries that have a long history of dam construction are increasingly looking toward dam decommissioning because of changing environmental values and the economic cost of maintaining aging structures.

In the planning phase of dam development the disciplines of ecology, engineering and economics provide technical know-how to water resource developers. Furthermore, an extensive literature exists within the biophysical sciences and social sciences that identifies and evaluates the impacts of dams (Goldsmith and

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Hildyard, 1986; McCully, 2001; Scudder, 2005) (see also Tilt et al., *this issue*). However, when exploring socio-ecological systems it is imperative to acknowledge the connection between the landscape and thousands of years of human history in order to place the economic and environmental costs and benefits into context. Physical water control structures that provide energy and water security are often paired with governmental mandates, court decisions and laws governing their construction, ownership, and operation, as well as the distribution of benefits derived from the structures. In both the United States and China, the political and physical means of managing water are rendered highly inflexible by bureaucratic inefficiencies and advantaged interest groups. As Goldsmith and Hildyard noted two decades ago, “no dam is built in a political vacuum” (Goldsmith and Hildyard, 1986, p. 241). Geopolitical discourse that integrates scientific knowledge with political, social and ethical insight provides a way to more fully understand the system in hopes of promoting sustainable and equitable practices at all scales.

Drivers and impacts (both positive and negative) of dam development often lie outside the immediate watershed of the dam, which suggests the utility of a conceptual framework not necessarily aligned with watershed boundaries or neat and arbitrary political demarcations. Magee (2006b) offers the framework of a “powershed” to encompass the regions that politically and economically benefit from the energy produced, as well as to assess the basin that is being socio-ecologically impacted. This framework refocuses our analysis from the physical structure of the dam to the relations between actors being affected by them, i.e. the politics of cooperation and conflict.

In the last 30 years, attention to “hydropolitics” (Waterbury, 1979) surrounding freshwater resources has led to recent debates about the likelihood of violent conflict in the form of water wars (Dupont, 2001; Postel and Wolf, 2001; Shiva, 2002; Swain, 2001; Toset et al., 2000). Yet an evaluation of indicators of international water conflict conducted by Wolf et al. (2003) suggests that dams, as a single variable, are only weakly linked to water disputes. Dams or diversions on international transboundary rivers in the absence of socio-political agreements, though, did in fact create settings conducive to conflict. While empirical studies are still wanting at other scales (e.g., provinces, regions, states, powersheds), we suspect that positive political relations and institutional agreements among political entities decrease the likelihood of conflicts surrounding dams whose influence, economically and biophysically, crosses political boundaries within nations.

In the first section of this paper we describe the complex nature of dams using the sustainability and powershed frameworks to holistically address geographical and political transboundary issues associated with dam development. We operationalize sustainability – both of institutions and ecological systems – along a continuum of resilience versus vulnerability. Employing a case study from China, the second section analyses the roles of institutions in China to understand the relationships between power, human security and socio-ecological systems in order to inform the study of conflicts over dams. The transboundary Mekong and Nu Rivers exemplify the need to transcend traditional political scalar boundaries in order to successfully identify and understand the role that hydropower development plays in the localized socio-ecological impacts of dam construction, the regional, asymmetric distribution of hydropower benefits, and international cooperation or conflict. While the complexity of hydropower development on China’s transboundary rivers is not necessarily unique, the fact that those rivers pass through as many as half a dozen countries underscores the need for a novel lens with which to examine the socio-ecological and political impacts of China’s hydropower development across political boundaries.

2. Conceptual and analytical frameworks

2.1. Hydro-political resilience and vulnerability

Within the framework of sustainability, concepts of “resilience” and “vulnerability” relate to the ability of biophysical systems to adapt to change (e.g., Gunderson and Pritchard, 2002). As the sustainability discourse has broadened to include human systems in recent years, research has also been increasingly geared toward identifying indicators of resilience and vulnerability within this broader context (e.g., Bolte et al., 2004; Lonergan et al., 2000; Turner et al., 2003). Simultaneously, dialog on “security” has migrated from traditional issues of war and peace to also begin incorporating the human–environment relationship in the relatively new field of “environmental security” (see United Nations Environment Programme (UNEP) and the Woodrow Wilson Center, 2004; Vogel and O’Brien, 2004). Politically, the imbalance of power among various actors – or of the *perceived* power of particular actors – in water resource development is a concern for those who are attentive to “human security.” In this paper we intend human security to be an inclusive concept focusing on the intricate set of relationships between environment and society as well as encompassing issues of internal stability and sub-acute tensions. These emerging discourses provide valuable insight into the study and management of water resources that are critical for both human and ecological systems.

The term “hydropolitics” came about as substantial new attention was being paid to the potential for conflict and violence to erupt over international waters. The term relates to the ability of geopolitical institutions to manage shared water resources in a politically sustainable manner, i.e. without tensions or conflict between political entities. “Hydro-political resilience” then, is defined as the complex human–environmental system’s (i.e. the institutions’) ability to adapt to permutations and change within these systems. “Hydro-political vulnerability,” on the other hand, is defined by the risk of political dispute over shared water systems (due to a lack of institutional capacity). On the relationship between change, institutions, and hydro-political vulnerability, Wolf et al. (2003) find that “[t]he likelihood of conflict¹ rises as the rate of change within the basin exceeds the institutional capacity to absorb that change.” The rate of change in the system and the institutional capacity, then, are two key factors in potential dispute settings.

More specifically, Wolf et al. find that very rapid institutional or biophysical changes that outpace the institutional capacity to absorb those changes lie at the root of most water conflict. On the physical side, rapid change outpaces institutional capacity in basins where there are unilateral development projects, unanticipated droughts or floods *and* the absence of cooperative regimes, such as treaties, river basin organizations (RBOs), or technical working groups, or when relations are especially tenuous over other issues. To complicate matters, an increasing rate of some physical changes with basins is being predicted as extreme weather events are becoming increasingly prevalent, making the spatial and temporal distribution of water resources less predictable (Oki and Kanae, 2006). This introduces additional uncertainty and variability for which current institutions (water law, treaties, river basin organizations) may not be prepared.

Like environmental change, socioeconomic and geopolitical systems may evolve rapidly or more slowly. Stress on socioeconomic and geopolitical systems occurs when changes in water demand due to rapid population growth, shifts in land use, or development of technology outpace institutional capacity. An

¹ Here, conflict ranges from strong displays of hostility to mild displays of dissatisfaction (Yoffe, 2001).

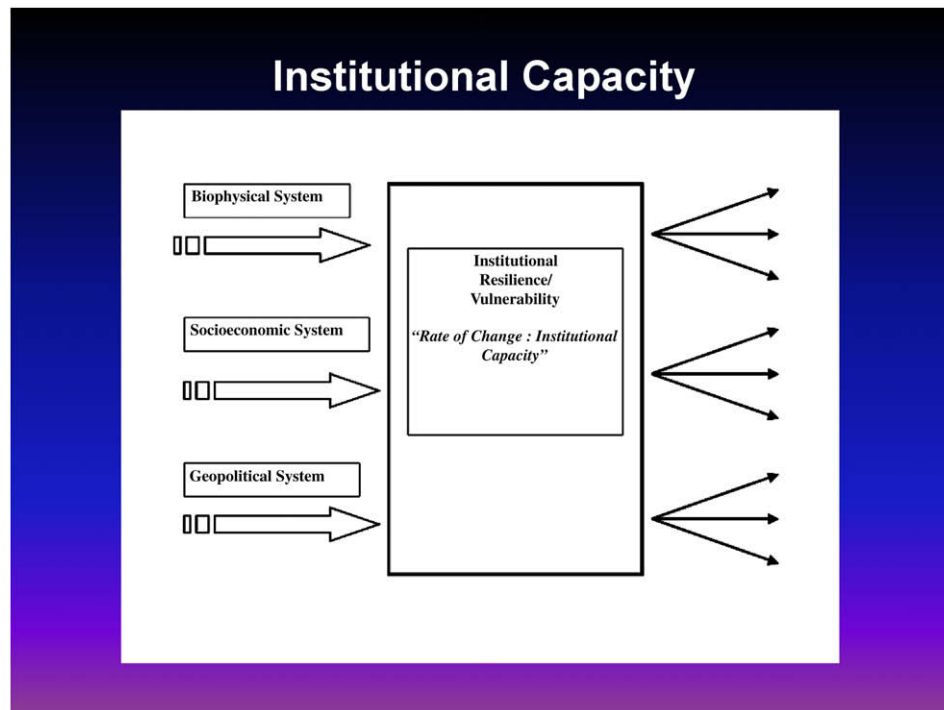


Fig. 1. Figures for McNally, Magee, & Wolf Systemic changes in the three pillars of sustainability are transformed by a resilient or vulnerable institution, resulting in different outcomes.

example of more rapid geopolitical change are “internationalized” basins, i.e., basins that include the management structures of newly independent states, but where comprehensive, transnational institutions governing water resources are lacking or, at best, frail. Such changes have resulted in disputes in areas formerly under British administration (e.g., the Nile, Jordan, Tigris–Euphrates, Indus, and Ganges–Brahmaputra), as well as in the former Soviet Union (e.g., the Aral tributaries and the Kura–Araks). These examples suggest that without the capacity to seamlessly adjust to new governance structures, conflict of one sort or another is likely to erupt.

In the second half of this paper we examine the case of China, where macro-institutional changes over the past quarter-century – namely, the transition from a state-run command economy to a market economy – have had relatively little impact on the structure and function of the country’s primary water governance bureaucracies such as the Ministry of Water Resources and the seven regional river basin commissions.² How these tensions play out with regard to dam development on transboundary rivers, and particularly on the mode of water governance the Chinese government chooses to implement in such cases, remains to be seen. Perhaps most important will be the degree to which such bureaucratic shuffling contributes to or detracts from institutional capacity to address and mitigate vulnerability at all scales, from local to transnational.

The general assumption of the relationship between water management and conflict then, as shown in Fig. 1, is that rapid change tends to indicate vulnerability while institutional capacity tends to indicate resilience. In addition, it shows that the physical and institutional rates of change need to be assessed in conjunction with each other for a more accurate gage of hydro-political

sustainability. Building on these relationships, Wolf et al. (2003) outline the characteristics of a basin that would tend to enhance resilience to change, including:

- international agreements and institutions, such as RBOs
- a history of collaborative projects
- generally positive political relations
- higher levels of economic development

In contrast, factors that would suggest a basin might tend toward vulnerability include

- rapid environmental change
- rapid population growth or asymmetric economic growth
- major unilateral development projects with asymmetric costs and benefits
- the absence of institutional capacity
- the potential for “internationalization” of a basin
- generally hostile relations among groups or nation-states within the basin

2.2. International resilience and the powershed

In the case of dams, it is often difficult to categorize changes in the system as being explicitly physical or institutional. Dams are maintained by various government and private entities while providing the public with the valuable resource of flood control (a public service), electricity, water supply and storage (either public or private). While the construction of new dams may constitute a rapid physical change, aging dams that regulate water flow may also threaten security of the riparian community. In the US, the economic benefits of hydropower or flood control may no longer justify the cost of repairing or rebuilding aging dams. The need for maintenance and monitoring of water control was emphasized in 2005 by levy breeches during Hurricane Katrina and the 2006

² Several scholars (Magee, 2006b; Xu, 2002; Yeh and Lewis, 2004) have analyzed the restructuring of the Chinese electric power sector (from ministry to state-owned enterprise to stock corporations), but the Ministry of Water Resources and its related institutions have seen much less reorganization.

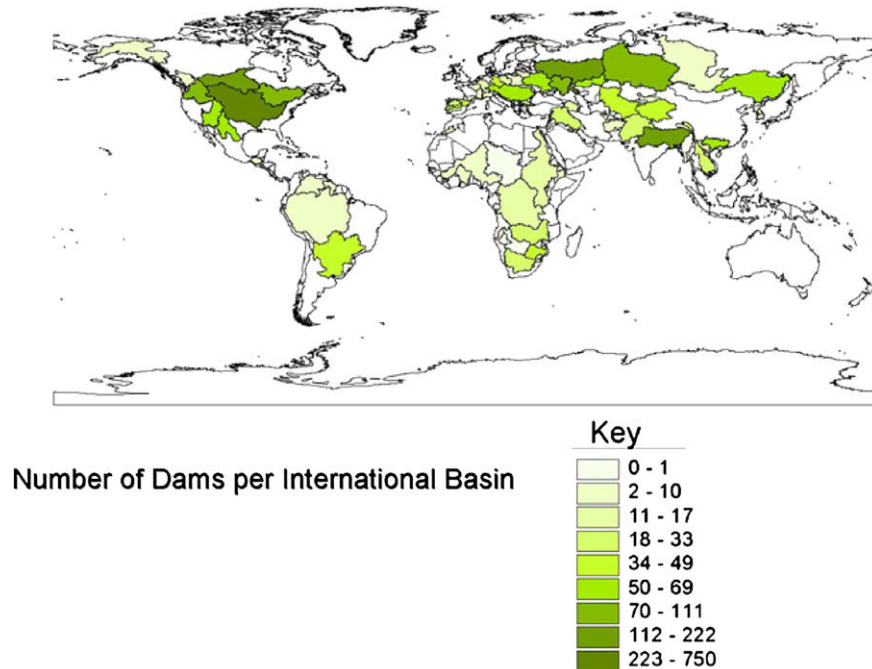


Fig. 2. Dams in international river basins. Source: Wolf et al. (2003).

failure in the Kaloko Dam in Kilauea, Kauai, in Hawaii. Along with keeping a dam compliant with existing safety criteria, there are legal liability issues involved in the event of a sudden uncontrolled release of water. The potential for loss of human life can be especially devastating in terms of economic and political impacts (Hepler, 2006).

Besides the difficulty in classifying a dam and its related effects as either physical and institutional drivers (or both) of conflict, additional challenges arise in categorizing the spatial extent of a dam's influence. As shown in Fig. 2, Wolf et al. (2003) use the watershed or basin to define the scale of analysis for international water conflicts. Analogous to this approach, Magee (2006b) suggests the framework of a "powershed" to encompass the regions that are politically and economically benefiting from the energy produced and assess the basin that is being socio-ecologically impacted. In his study of large-scale hydropower projects in remote parts of southwestern China's Yunnan Province, Magee found that although the projects are frequently billed as tools for poverty alleviation and local economic development in Yunnan, in reality the majority of power will be transmitted to load centers hundreds of kilometers away on China's highly populous, economically vital, and power-short southeastern coast. Local employment benefits do accrue to an extent during the construction phase of the projects, but once they become operational, they hardly demand large quantities of moderately skilled labor of the type most readily available in that part of China. Magee defined the powershed as a way to better capture the link between urban industrial centers in Guangdong Province and rural hydropower stations in Yunnan, along with the opposing flows of capital and electricity between those two places. The framework allows us to conceptualize transboundary geographical and political issues associated with dam development from a new perspective while maintaining a focus on the institutions *within and across* political boundaries that allow these actors to adapt to changes within the socio-ecological system.

Socioeconomic and physical changes that raise energy and water security concerns have traditionally been addressed by constructing large-scale hydro-modification structures (dams, channels, levies). As a country develops, personal and industrial

water demand tends to rise, as does demand for previously marginal agricultural areas. While this can be somewhat balanced by more access to energy- and water-saving technologies, new water resources are often exploited before water conservation measures are put into place. In mainland Southeast Asia, for instance, the Mekong River has been the object of a wide range demands from various types of users for centuries; such conflicting demands have become more salient in recent years (Sneddon and Fox, 2006; Wolf et al., 2003). Existing, ongoing, and proposed hydropower development by regionally dominant China on the upper Mekong has generally been construed as in conflict with downstream demands for fish habitat protection, shipping, and agriculture.³ Institutionally, the Mekong River Commission (MRC), of which neither China or Myanmar (the upstream riparians) is a member, is frequently portrayed as defending the interests of its member states (Cambodia, Laos, Thailand, and Vietnam) against the "unilateral" development schemes of non-member China. Yet the Electricity Generating Authority of Thailand (EGAT) is a joint investor in two of the Chinese dams, and the MRC's newest strategic plan embraces the possibility of hydropower development on the main trunk of the Mekong, something it had not done previously. China's upper Mekong (lower Lancang), then, lies within the powershed of Thailand, and stands to become even more enmeshed in it as efforts to extend and strengthen transboundary power grids throughout the Greater Mekong Subregion proceed. Given Thailand's political and economic clout compared to its less-developed downstream neighbors, coupled with the unrivaled importance of China in the region, it seems plausible that the MRC, while durable, may find its effectiveness challenged as it seeks to balance increasingly disparate demands on the Mekong.

The biophysical and institutional context of the Salween River (Nu River in China) one watershed to the west of the Lancang/

³ Political obstacles and lack of data sharing have largely prevented any basin-wide research into the extent to which upstream dams may modify sediment transport, dissolved gases, and flow regimes downstream (see, for instance, He et al., 2006).

Mekong system, is quite different. Not surprisingly, this has different implications for the sustainability/resilience analytic. Like the Lancang/Mekong, the Nu/Salween originates in China's Qinghai-Tibet plateau. After leaving China's Yunnan Province, it flows into Myanmar and along the Thailand/Myanmar border before emptying into the sea. In many developing countries, economic stability is of primary concern; positive political relations with other states and long-term institutional or ecological resilience are secondary. Such is the case in Myanmar, where hydro-development on the Nu is not unwelcome at the central state government level. Indeed, Chinese developers have already entered into agreements with the military government in Myanmar to jointly develop projects on the Myanmar portion of the river (2007). China is without a doubt Myanmar's strongest ally, providing significant amounts of aid (military and otherwise) to a country that is otherwise a pariah on the international stage. Such positive political relations and collaborative river development projects, then, suggest a degree of resilience in Sino-Myanmar water governance regimes. The magnitude of resilience is qualified because there are no formal institutions such as the Mekong River Commission or comprehensive plan (or even an apparatus to design and implement one) yet in existence for the Nu/Salween system. Formal institutions are important for two reasons. First, hydropower-led development schemes that fail to take into consideration the livelihood and ecological demands on the river may give rise to conflicts on a sub-national level, especially since many parts of the watershed are populated primarily by ethnic minorities whose ties with the central government are already fraught. And second, the economic and political power imbalance between China and Myanmar leaves informal agreements vulnerable to potential rapid changes in the political relations between the two nations.

Even in cases where a dam effectively regulates a river, providing a reliable means of transportation and irrigation, changing economic, social and political values may influence an interest group's dependency on dam services. An example of this can be seen in relationships between farmers and environmentalists in the Columbia River watershed in North America. Wheat farmers on the Columbia River in the US northwest, historically at odds with advocates for salmon, have changed positions on dam removal of the four lower Snake River dams. In the past, farmers maintained a political advantage over environmental advocates, but a more recent political shift in favor of salmon conservation has led to fears that the operations of the Columbia River dams could be determined by a federal judge if regional managers cannot come up with a plan to successfully protect salmon (Barrenger, 2007). In the case of the Snake River, political drivers – specifically, the desire to retain some degree of localized control over dam operations, even if it means a net loss in acre-feet available for irrigation – are proving to be stronger motivators of farmers' actions than is the desire for the irrigation infrastructure provided by the river. More generally, this serves as an example of how physical structures can maintain temporary stability but are not designed to be resilient in the face of changing social, economic and political values. Instead, institutions such as laws, implementing organizations, and exchanges of data and expertise must be designed and implemented with adaptability in mind and with a clear recognition, to the greatest extent possible, of the myriad stakeholders who stand to gain or lose from various forms of riparian development.

3. How resilient are China's powersheds?

3.1. Reforms for stability or resilience?

Past empirical studies on resilience and vulnerability have focused on international water conflicts. By extension we suspect that positive political relations and institutional agreements

decrease the likelihood of conflicts surrounding dams *within* nation-states and their respective powersheds. Vulnerability assessments conducted at a broad (e.g., watershed) scale may determine that constructing dams in areas of low economic activity, low population density and little political influence constitute the most rational political policy from the perspective of the national government. However, such a perspective stems from development mechanisms that are more focused on short-term stability than on long-term resilience. That is, the quantifiable short- to medium-term economic benefit expected to accrue from the dam trumps longer-term, less readily quantified values such as institutional or biophysical resilience. Thus, it is important that the scale of the vulnerability assessment be appropriate to account for the numerous stakeholders and interests involved in hydro-development projects. The powershed scale allows us to apply the same criteria to international and national players. We will show how this is the case in China a place where local, region and international resilience can be investigated on two transboundary rivers at different stages of development.

In China, the complexity of decision-making on large-scale hydropower projects belies common misperceptions of the Chinese state behaving as a monolithic actor on major development projects. When we shift our unit of analysis from the national to the powershed scale, we see that new dam projects in China involve national-level power companies and their provincial subsidiaries, regional power grids, supra-regional yet sub-Ministerial basin (watershed) commissions, and governmental units at many levels, not to mention increasingly vocal and legally-grounded citizen groups.⁴ Moreover, strong interprovincial linkages between energy resource providers in western China and load centers in coastal and eastern China, coupled with national development programs such as the Great Western Development Campaign and the West-East Electricity Transfer, add yet another level of complexity to decisions on energy projects, and underscore the importance of thinking outside the usual analytical "boxes" based strictly on political or ecological boundaries. Indeed, it may be more useful to think of a powershed first as an ensemble of *processes* (investment, design, construction, generation, consumption) and then as the ensemble of associated places.

As noted briefly in the previous section, the spatial distribution of benefits accruing from large-scale hydropower development in western China often favors the urban and industrial load centers in coastal and eastern China, which are the major recipients of hydroelectricity. In China as elsewhere, the socioeconomic losses and impacts of resettlement associated with dam construction disproportionately burden the rural poor, and create especially intense pressures on women (Braun, 2005). Yet just as higher levels of economic development tend to enhance resilience in international basins, we expect the same may improve community resilience on the local scale. As a corollary, where the distribution of benefits within the powershed is asymmetrical, we may expect to find tension and a tendency toward decreased overall resilience of communities to deal with institutional and environmental change.

As China's economy continues to grow, ever greater amounts of electric power are predicted to be exported from resource-rich but

⁴ In China, the administrative level or rank of an individual or an organization is fundamentally important in determining that the individual's or organization's ability to interact with government officials of different ranks. Thus a representative of a "national" power company, such as one of the five formed from the former Ministry of Electric Power, will have much greater political clout, and command much more influential audiences, than would a representative of a provincial or municipal subsidiary. Provinces, for instance, hold the same rank as Ministries. While central commissions generally outrank Ministries, the seven basin commissions technically rank below the Ministry of Water Resources yet on many topics hold decision-making sway over the Ministry.

infrastructure-poor western China to resource-poor but development-frenzied eastern China. The Western Development Campaign, instituted as part of the Tenth Five-Year Plan (2001–2005), prioritized infrastructure development in China's west as a means of facilitating resource extraction to continue fueling the country's economic development, especially in its eastern regions. Related policies encouraging the transfer of hydroelectric power from western rivers to eastern load centers have given the green light to develop such resources on grounds that national development and economic stability will benefit.

Additional reforms have been implemented with economic *stability* (not resilience) in mind; a major component of these reforms in recent years has focused on restructuring former state-owned enterprises (SOEs) and government. For much of the period from 1949 to the present, these Soviet-style industrial behemoths have been loss-making enterprises and recipients of frequent bailouts from China's banks; yet a paramount function of the SOE sector has been to provide cradle-to-grave social benefits (housing, sustenance, medical care, and education) for its employees and their dependents, thus helping guarantee social *stability*. Such company-based welfare, however, is being challenged by newer, leaner, and more competitive production models in China's so-called socialist market economy with Chinese characteristics.

In the realm of dam-building, the most important actors in China's large-scale hydropower development are the five electric power companies that were calved off the former State Power Corporation of China, which itself was created from the assets (and, to a large extent, personnel) of the former Ministry of Electric Power.⁵ Though these development corporations are officially recognized as "stock companies," their legacy as part of a former ministry gives company leaders important access to key decision makers in the Chinese central government, such as in the Energy Bureau of the National Development and Reform Commission.⁶ Additionally, even though these companies are listed on Chinese and international stock exchanges, they are not fully privatized; the Chinese central government continues to hold controlling interest in the companies. Power sector "reforms," then, may have simply resulted in a case of old wine in new bottles, with central government priorities regarding dam-building still easily transmitted from the highest levels of development planners down to the construction companies themselves.

Two practical outcomes of institutional restructuring are particularly relevant to this study, and to the notions of resilience versus vulnerability. First, there is considerable uncertainty among individual decision makers throughout the would-be hydropower governance bureaucracy, which is compounded by recent revisions in the Water Law of China. That is, bureaucrats in the Ministry of Water Resources, the seven trans-provincial watershed commissions, local (provincial and below) water and electric power authorities, and other agencies are generally unclear about where their jurisdiction over large hydropower projects and international waterways begins and ends. Second, and related, this uncertainty among decision makers also makes the negotiation of any durable and resilient international agreement on utilization of shared (transboundary) water resources, whether within China or between China and neighboring countries, especially problematic. Approaching questions of development on transboundary rivers

from the perspective of a powershed allows us to capture dynamics ranging from domestic bureaucratic politics to regional power imbalances that may have otherwise been overlooked in an analysis focused on nation-states alone.

3.2. Access to the political process and positive relations

Economic reforms in China have increased the overall level of economic development and provided citizens greater ability to participate in market mechanisms. Reforms have also revealed the weaknesses in the state-run economy, but China's market economy has brought with it new and trenchant problems of its own such as lack of long-term livelihood guarantees, inadequate regulatory framework for labor and environmental issues, and prioritization of short-term economic development over longer-term ecosystem health and human security concerns. In other words, local resilience sacrificed for China's interest in being a robust international economic power.

China's current leadership seems to be cognizant of the dangers of trading long-term institutional and ecological resilience for short-term economic gains. President Hu Jintao has emphasized the importance of "harmonious" development, recognizing not only the tensions caused by China's growing gap between wealthy and poor, but also those caused by ever more numerous and serious environmental and related human health concerns that are increasingly leading to mass incidents and social instability. Of the most pressing of environmental concerns is freshwater, both in terms of quality and quantity. Current estimates are that approximately one-third to one-half of China's population lacks reliable daily access to safe drinking water.

Social instability resulting from environmental degradation highlights the importance of positive political relations between those who stand to be most affected by the dams and those most able to change project outcomes to reduce impacts. Related to this is the generally low level of public access to the political process, and the fact that in many of the areas where dams are sited in China, local governments are the primary, if not the only, source of information regarding such projects, thereby limiting villagers' ability to realistically assess the potential outcomes. Research has confirmed that governments are most receptive to the needs of economically and politically advantaged groups; this holds true for decisions regarding the management of water resources. Yet in democratic societies inequities resulting from are tempered by officials' desire to be reelected by the public majority. Not surprisingly, the dynamics in non-democratic societies may yield different outcomes even when the physical components of the riparian system are similar.

Case studies in China that mapped the networks involved in the governance of large-scale multinational water projects suggest that some mega-dam construction projects embody the inequalities inherent in globalization and that development decisions are frequently not attuned to local needs, concerns, and assets (Bakker, 1999; Fox, 2000; Magee, 2006a; Padovani, 2004). In China, the Three Gorges (Yangtze River) and Lancang (upper Mekong) River dam projects have been criticized for disorganized resettlement of residents near the dams (Chen and Li, 2003; Magee, 2006a; Padovani, 2004). In the case of the Manwan dam, the first on the mainstream of the Lancang-Mekong, resettled residents complain that promises of compensation have been broken, as has the promise of affordable electricity to local communities. This is partially the result of high-cost of infrastructure necessary to connect high-voltage output from power stations to lower-voltage local grids. These problems persist despite the fact that the Manwan dam has been functioning since 1993 (Magee, 2006a). As with large dam projects elsewhere around the world, public participation in decision-making is seen as key to resolving these and related

⁵ The restructuring of MEP to SPCC occurred in 1996–1997. In 2002, five corporations – China Guodian Corporation, China Huadian Corporation, China Huaneng Group, China Power Investment Corporation, and China Datang Corporation – were subsequently created from SPCC.

⁶ The NDRC, formerly the State Planning Commission, continues to wield considerable influence in large-scale development decisions.

issues. According to one Chinese dam expert, large infrastructure projects are frequently given favorable consideration and hastily approved, whereas those individuals most immediately affected – the migrants – “lack the right to participate in decisions about their own fate” (Chen and Li, 2003, p. 545).

Politically disadvantaged, non-economic interests may find that appeals to international trade partners or global organizations may provide an access point to national policy decision processes that otherwise would have been difficult or impossible to attain (Howlett and Ramesh, 2003). In Brazil for example the Xingu River indigenous tribes appealed to the global community to raise awareness and protest a proposed dam that would supply water to the world's largest producer of soybeans. In China, a small number of activists opposing the lack of transparency in decisions about the Nu (upper Salween) River dams have made numerous appeals to sympathetic national bureaucracies such as the State Environmental Protection Agency (SEPA) or to international organizations such as The Nature Conservancy and the United Nations. The fact remains, though, that discrepancies in political power frequently polarize dam developers and locally affected communities, especially in countries lacking democratic institutions, making it very difficult for the latter to influence the decisions or behavior of the former. We hasten to note, though, that even the hands of established democracies such as the United States are not clean when it comes to large dams; much of the dam-building in the first half of the 1900s in the US was done hastily and through top-down decision-making, with little consideration of effects on local communities.

4. Conclusion

As China's presence becomes increasingly present on the world stage due to its economic and political clout, so, too, do the implications of China's breakneck development for environmental sustainability and social stability. Construction of large dams on southwestern China's transboundary rivers has become one of many focal points of media attention in the region and around the world. Such coverage has primarily focused on the following perceived or actual concerns: (a) the unilateral development of dams on the upper (Chinese) reaches of the rivers; (b) the lack of consideration of the social or ecological impacts to nearby and downstream communities; (c) the fact that China, as a non-member of the region's most long-lived basin institution, the Mekong River Commission, does not have to vet its plans with MRC members. More recently, plans to build a 13-dam hydropower cascade on the Chinese stretch of the Nu/Salween River have become the target of opposition by activists, academics, and other concerned individuals both inside and outside China.

We chose to focus our analysis on powersheds involving China for several reasons. First, large-scale hydropower is almost universally considered renewable and sustainable in China. The current leadership's emphasis on sustainable and scientific development, along with its renewable energy targets for the coming decades, stand to more than double the existing installed hydropower generating capacity by 2020; as such, robust analyses of the degree of sustainability of these projects, operationalized through the metrics of vulnerability and resilience, are sorely needed. Second, Chinese dam developers have begun exporting hydropower expertise to neighboring areas such as Mainland Southeast Asia, opening the door for significant Chinese involvement in projects on the main stem of the Mekong and other rivers throughout the region. At the moment, such involvement is limited to technical analyses and feasibility studies, but it is likely that Chinese loans, construction expertise, and equipment will eventually come into play. Through this research and related work in the future, we hope to make some headway in contributing to, or at the

very least understanding, the yardstick by which a particular project is deemed sustainable or not, through analyses of vulnerability versus resilience throughout the powersheds in which new power stations are situated.

In this paper, we have attempted to demonstrate the utility of the notions of resilience and vulnerability in operationalizing the less tangible concept of sustainability. Sustainability is often criticized for being too ambiguous, or for lacking clarity as to what is to be sustained and by whom (economic development versus ecological services, for example). Resilience and vulnerability, however, provide a means for assessing the degree of adaptability of a system, be it ecological or socioeconomic (or, more likely, a combination of both). We briefly explored the application of these concepts to water resources management institutions in China, focusing on large-scale hydropower development projects on the Lancang (upper Mekong) and Nu (upper Salween). Due to the transboundary nature of these rivers, and the history of geopolitical tensions in the area, it is important that water resource governance regimes be designed and maintained in a manner conducive to institutional and ecological resilience in order to best ensure an equitable distribution of costs and benefits throughout the powersheds of the dams. In the case of the Lancang-Mekong, we pointed several key challenges faced by the Mekong River Commission, the longest-lived regional water resources governance regime. The nature of the challenges facing the MRC – not least of which, the fact that neither China nor Myanmar is a member – may mean that the organization, while stable, will not necessarily be resilient in the face of rapid changes in the biophysical or socioeconomic/institutional realms, particularly the wide range of users and their related demands on the river. One watershed to the west, we see that the Nu/Salween, while currently lacking a governance institution such as the MRC, benefits on an inter-state level from shared interests in hydropower development, rather than more divergent demands, thus suggesting a higher degree of resilience and lower degree of vulnerability at the nation-state level. Questions of vulnerability, however, become much more manifest at the scale of sub-national regions, many of which are rural and dominated by ethnic minorities lacking political and economic clout.

Interestingly, the current climate of circumspection surrounding the Nu River hydropower development plans – the proposed 13-dam cascade was halted in 2003, and at present there is only tentative approval of a scaled-down version of four dams (Magee and McDonald, forthcoming) – may provide an opportunity for establishing a truly resilient transboundary water governance institution for that watershed. Some aspects of the Chinese socio-political context that would be highly conducive to a resilient institution include:

1. High rates of economic development (though significant geographic disparities persist);
2. Rapidly evolving legal system that gives increasing legitimacy to complaints involving natural resources (over-exploitation, pollution, etc.);
3. Increasingly vocal and legally grounded citizen groups;
4. Amicable and stable political relations with the Myanmar government, despite some tensions potentially arising out of China's condemnation of the Myanmar government's violent suppression of peaceful protests in fall 2007;
5. China's and Myanmar's participation as dialogue partners in the Mekong River Commission may provide insights into designing and operating a more successful institution;
6. Fewer riparian countries (three) on the Nu/Salween means that shared goals between China and Myanmar to exploit hydropower resources on the river are more likely to be convergent than disparate goals of the six riparian countries on the Lancang/Mekong.

At the same time, any institution designed to promote socio-economic, geopolitical, and biophysical resilience in the Nu/Salween will need to address the following factors that might tend to promote vulnerability:

1. Asymmetric economic development throughout the powershed of the proposed Nu dams, particularly the difference in local conditions near the dam sites as compared to more homogenizing but less useful indicators such as per capita GDP;
2. Rapid institutional change (due to political and economic reforms) in China;
3. Rapid environmental change, including changes in flow volumes resulting from the impact of climate change on the glaciers that feed the Nu and other Southeast Asian rivers;
4. Potential for renewed instability in Myanmar.

While it is far beyond the scope of this paper, and the expertise of its authors, to design the “right” type of institution that would lead to best-practice-based management of such an important transboundary waterway as the Nu/Salween, we do hold out hope that such an institution is within reach. Furthermore, we believe that using the metrics of resilience versus vulnerability to operationalize sustainability, and the analytical lens of the powershed to better assess costs and benefits outside the immediate area of the watershed or arbitrary political boundaries, may prove useful tools in envisioning such an institution.

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