Villamayor-Tomas, S., M. Avagyan, M. Firlus, G. Helbing, and M. Kabakova. 2016. Hydropower vs. fisheries conservation: a test of institutional design principles for common-pool resource management in the lower Mekong basin social-ecological system. *Ecology and Society* 21(1):3. http://dx.doi.org/10.5751/ES-08105-210103
Erratum: This paper was originally published with a date of 2015, the error was corrected on 18 January 2016.

Research, part of a Special Feature on Advancing Social-Ecological Research Through Teaching: Social-Ecological Systems Framework and Design Principles in Large Areas

Hydropower vs. fisheries conservation: a test of institutional design principles for common-pool resource management in the lower Mekong basin social-ecological system

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ABSTRACT. New methods have emerged for testing common-pool resource theory in large-scale environmental governance contexts. We aim to contribute to that scholarship by assessing the relevance of Elinor Ostrom's design principles in the lower Mekong basin (LMB). The recent dam-building trend in the LMB has revealed a trade-off between hydropower development and the conservation of migratory fish species. The need to internalize or avoid the negative externalities of hydropower dam construction poses a new challenge to the LMB governance system and its main management body, the Mekong River Commission. Our objective was to explain the emergence of the trade-off and the capacity of the governance system to address it. Elinor Ostrom's design principles and other variables provided by the Socio-ecological Systems Meta-analysis Database were first coded with regard to secondary data and then tested against the capacity for cooperation of the LMB governance system. The lack of sanctioning despite a strong monitoring system, and the existence of fuzzy governance boundaries in the context of a powerful outsider like China, were particularly relevant to understanding the current cooperation stalemate in the basin. Other variables such as scientific knowledge, triggering events, markets, resource spatial heterogeneity, and heterogeneity of interests were also relevant.

Key Words: *common pool resource theory; fisheries; hydropower; institutional design principles; lower Mekong basin; SESMAD; social-ecological systems*

INTRODUCTION

Here, we aim to contribute to a new effort initiated in the last years by scholars from different disciplines to test common-pool resource (CPR) theory on large-scale resource governance systems (Cox 2014, Fleischman et al. 2014*a*). For this purpose, we test Elinor Ostrom's design principles (Ostrom 1990). Empirically, the analysis focuses on the Lower Mekong River basin (LMB), a region internationally known for the cooperation struggles that the riparian nations are facing to balance a trade-off between hydropower development and fish production (Backer 2007, Schmeier 2009, Ziv et al. 2012). The research questions are: To what extent can Ostrom's design principles explain the current state of affairs in the LMB governance system? Does the case illustrate the relevance of other cooperation factors?

Many resource systems around the world are examples of CPRs, i.e., they are difficult to partition for private consumption and they can be depleted (Ostrom and Ostrom 1977). In CPRs, sustainable management is usually tied to cooperation problems and the "tragedy of the commons" (Hardin 1968). In the tragedy of the commons, CPR users do not have the incentives to self-restrain resource extraction because they cannot exclude others from the benefits of such effort, so the resource is overexploited and may collapse.

CPR theory emerged in the 1980s to highlight institutional, social, and physical factors that promote cooperation among local resource users (Agrawal 2001, Poteete et al. 2010). A central pillar of CPR theory is Ostrom's (1990) design principles for local resource management. The principles include the existence of clear resource and social boundaries, congruence between rules and local conditions, proportionality between the benefits and costs of cooperation, the participation of direct resource users in the decisions that affect resource management, effective monitoring and sanctioning, low-cost conflict solving mechanisms, external recognition of the right of resource users to self-organize, and multilevel division of labor at large scales (Cox et al. 2010).

The applicability of CPR theory to large-scale systems is an open question that some scholars have recently started to address (Cox 2014, Fleischmann et al. 2014*b*). Differences between local and large-scale contexts are numerous, including most prominently, the size and nature of actors involved (individuals vs. nation states), the chances of interest heterogeneity (higher at larger scales), the stronger influence of international geo-political affairs, and the greater difficulty of understanding resource dynamics at larger scales (Keohane and Ostrom 1995, Kerr 2007, Stern 2011, Araral 2014). However, the common-pool nature of resources and the associated appropriation and provision dilemmas are similar at both scales (Araral 2014). Thus, similar explanations of cooperation and sustainable management should apply (Keohane and Ostrom 1995, Stern 2011).

A number of scholars have successfully applied CPR theory to understand water allocation and infrastructure provision in large river basins and have pointed to the importance of clear property rights, enforcement mechanisms, leadership, sustained stakeholder involvement, national governments' support, and appropriate cross-scale linkages and discussion platforms (Blomquist et al. 2004, 2005, Kerr 2007, Chen 2008, Heikkila et al. 2011, Schlager and Heikkila 2011). In addition, the scholarship on transboundary watershed governance and international environmental regimes has pointed to factors believed to contribute to international agreements and regime effectiveness. Some of these factors include cooperative political culture and transparency of decision making (Berardo and Gerlak 2012),

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magnitude of shared problems, political costs of inaction, occurrence of crises and breakthroughs in scientific understanding (Mitchell 2003), as well as enough time to build trust and translate intentions into management measures (Huisman et al. 2000). Clear and flexible rules for resource allocation, equitable distribution of benefits, sanctioning and conflict resolution (Wolf 2007), good understanding of problems at stake, low severity of shared problems, strong knowledge basis, low levels of environmental uncertainty, powerful pro-cooperation actors, depth and density of rules, and enforcement (Breitmeier et al. 2011) have likewise been identified as important.

The cooperation struggles among the LMB riparian countries became apparent with the construction of the first mainstream dam in the lower basin (the Xayaburi dam) by the government of Laos. The new dam and other 11 planned projects constitute a milestone in the history of economic cooperation in the region, but also threaten the fisheries and other resources in the basin, with unequal costs to the riparian countries. The need to internalize or avoid the negative externalities of hydropower development poses a new challenge to the LMB governance system and its main management body, the Mekong River Commission (MRC). In this context, we seek to understand the emerging trade-off between fisheries and hydropower development, and, with the help of CPR theory, also explain the capacity of the governance system to address it.

The case of hydropower development in the LMB is relevant for several reasons. First, it is one of the biggest and longest rivers in the world (4350 km long, a drainage area of 795,000 km^2, and 457 km^3 of annual water discharge), and runs through six countries: China, Myanmar, Laos, Thailand, Cambodia, and Vietnam. This makes the basin a good case in point to test CPR theory. Second, there is an interesting contrast between the economic and political heterogeneity within the group of riparian countries, and their ability to cooperate successfully for economic development (Schmeier 2009). Third, the stakes of hydropower development and fisheries conservation are very high in the LMB. Although the basin has considerable potential for hydropower development (ICEM 2010), it is also one of the most productive and biodiverse inland fisheries in the world (ICEM 2010, Pearse-Smith 2012). More generally, a number of authors have recognized that hydropower dams are an important challenge in governing transboundary rivers (Sadoff and Grey 2002, Yoffe et al. 2003).

The capacity for cooperation of the LMB governance system has been addressed by several authors (Backer 2007, Schmeier 2009, Will 2010, Boucher 2012; Heikkila et al. *unpublished manuscript,* http://web.isanet.org/Web/Conferences/FLACSO-ISA%20BuenosAires%202014/Archive/e5bb2629-b8c0-4711-889c-b8825baaff77.pdf). We aim to contribute to that body of literature by adopting a social-ecological systems approach, characterized by an ultimate interest in understanding social-ecological outcomes and trade-offs, i.e., not just cooperation (Ostrom 2009, van Poorten et al. 2011, Epstein et al. 2013, Evans et al. 2014, Fleischman et al. 2014*b*).

BACKGROUND

The history of the LMB governance system can be traced back to 1957 (Table 1). In 1995, the four LMB countries signed the Mekong River Agreement (MRA), which constitutes the basis for the current governance system (Sneddon and Fox 2006, Schmeier 2009). The system is administered by the Mekong River Council, the Joint Committee, and the MRC Secretariat. Among these, the MRC is the one most directly responsible for ensuring cooperation among the parties and the implementation of basin-wide policies that benefit all users.

The primary objective of the MRA was to support economic development and cooperation of member countries through sustainable management. In the framework of the MRA, five main procedures have been progressively formulated and implemented: (1) procedures for data and information exchange and sharing (implemented in 2001); (2) procedures for water use monitoring (implemented in 2003); (3) procedures for notification, prior consultation, and agreement (PNPCA; implemented in 2003); (4) procedures for the maintenance of flows on the mainstream (implemented in 2006); and (5) procedures for water quality (implemented in 2011; MRC 1995*b;* http://www.mrcmekong.org/about-mrc/). The MRC Strategic Plan, approved every five years (e.g., 2011–2015), sets the financial framework for the 12 key programs the MRC runs. Among these, four programs are central to the future development of fisheries and hydropower: the Basin Development Plan Program, the Fisheries Program, the Mekong Integrated Water Resources Management Project, and the Initiative on Sustainable Hydropower (http://www.mrcmekong.org/about-mrc/programmes/).

The Basin Development Plan Program identifies and prioritizes the projects to be implemented at the basin level (MRC 2013*c*). The Fisheries Program focuses on data generation and sharing, awareness raising, and the development of measures for sustainable fisheries management (MRC 2010*a*). Basin-wide Integrated Water Resource Management, successor of the Water Utilization Project since 2008, assists member countries with implementing integrated water resource management procedures and facilitates the implementation of the PNPCA with a Prior Consultation Review Report on planned hydropower dam projects (MRC 2010*c*). Finally, through the Initiative on Sustainable Hydropower, the MRC assists member countries in promoting sustainable forms of hydropower management and development (MRC 2010*b*).

The most controversial projects in the LMB are related to hydropower dam construction. The Xayaburi project proposed by Laos has unique significance. The dam is the first of a cascade of six dams upstream of Vientiane (Fig. 1). The project is driven by the Association of South-East Asian Nations (ASEAN) and Thailand, with the bulk of generated power being destined for Thailand. The plant has an installed capacity of 1260 MW and is designed to operate on a continuous mode. Among the six projected dams, Xayaburi was the first to be submitted for consideration under the MRC's PNPCA (ICEM 2010).

METHODS

We used methods similar to those developed in previous applications of the Social-ecological System Meta-analysis Database (SESMAD) approach to large-scale resource governance (Cox 2014). The SESMAD database is a relational database containing approximately 150 variables that have been associated with the sustainability of social-ecological systems (SESs). An SES is the basic unit of analysis considered in the SESMAD and is defined as a system containing at least one of the following components: an environmental commons, a

Table 1. Main events of the lower Mekong basin governance system and Xayaburi dam case. Sources: MRC (2010*e,* 2013*c*), Bangkok Post (2014), Heikkila et al. (2014), Worrell (2014); International Rivers, Xayaburi dam: http://www.internationalrivers.org/campaigns/xayaburi-dam; Wolf and Newton, *unpublished report:* http://www.transboundarywaters.orst.edu/research/case_studies/Documents/mekong.pdf.

Date	Event
1957	Riparian states negotiate a draft charter for the Committee for Coordination of Investigations of the Lower Mekong under the auspices of the United Nations Development Program; signature brings Mekong Committee into legal existence
1970	1970–2000 Indicative Basin Plan proposed tributary and mainstream development of 180 projects for irrigation expansion and hydropower
1978	Invasion of Cambodia by Vietnam; Mekong Committee becomes a three-member Interim Mekong Committee without representation from Cambodia
1986	Water Quality Monitoring Network Program implemented, with water quality monitoring at permanent monitoring stations
1987	Complete revision of indicative basin plan from 1970, with an investment plan for 1987–2000
1991	Cambodia rejoins as full participant after peace settlement, but Committee remains legally interim
1992	Greater Mekong Subregion, including China, Laos, Myanmar, Thailand, and Vietnam, initiated with the help of the Asian Development Bank
1995	Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (Mekong Agreement) signed by Laos, Vietnam, Thailand, and Cambodia; Mekong Committee becomes the Mekong River Commission (MRC)
2000	Initiation of Water Utilization Program through MRC, funded by the Global Environmental Fund and World Bank
2001	Launch of Basin Development Plan first phase; Procedures for Data and Information Exchange and Sharing adopted by MRC
2002	Agreement with China signed on sharing river waterlevel data with MRC
2003	Procedures for Water Use Monitoring and Procedures for Notification, Prior Consultation, and Agreement (PNPCA) adopted by MRC
2006	Launch of Basin Development Plan 2 and Basin Development Strategy; Procedures for the Maintenance of Flows on the Mainstream adopted by MRC
2008	Thailand and Laos agree on construction of three dams to retain enough water for each side's villages' use year-round
2009	MRC Council approves key principles and approach to prepare the Integrated Water Resources management-based Basin Development Strategy
2010	MRC Strategic Environmental Assessment of hydropower on the Mekong mainstream completed and report published
2011	Adoption of Integrated Water Resources Management-based Basin Development Strategy results in approval of the Basin Development Plan for 2011–2015 by MRC Council; Procedures for Water Quality adopted by MRC; launch of Fisheries Program for 2011–2015
Xayaburi Hydropower Project events	
October 2010	Laos government submits Xayaburi Dam project to MRC' PNPCA process; Prior Consultation Process initiated by MRC
April 2011	No consensus in MRC Joint Committee; agree that a decision on the prior consultation process be tabled for consideration at the ministerial level
May–October 2011	Laos government hires Pöyry Energy to review the project's compliance with the Mekong Agreements; Laos government gives Thai developer Ch Karnchang the go-ahead to resume work (June); project is found to be "principally in compliance" (August); Electricity Generating Authority of Thailand signs agreement with Xayaburi Power Company to purchase electricity; Cambodian and Vietnamese governments not notified (October)
December 2011	MRC Council meeting agrees further impact studies are necessary before further construction can proceed
January 2013	MRC expresses concern about social effects and environmental risks associated with construction of the Xayaburi hydropower dam
March–April 2014	Laos informs Vietnam that Xayaburi dam is 30% finished; Thai villagers file a court case to halt construction of dam

governance system, or an actor group. An environmental commons is an environmental resource or pollutant that is collectively used, produced, or shared by one or multiple actor groups. An actor group comprises individuals, organizations, or nations that have developed a set of institutional arrangements to govern an environmental commons or interact with the commons in other meaningful ways. A governance system is a set of institutional arrangements such as rules, policies, and governance activities that affect interaction between one or more actor groups and an environmental commons. The database also comes with a coding book with definitions of variables and possible value options.

The distinction of different SES components was useful here to draw the boundaries of our analysis. The possibility of identifying multiple instances of actor groups and environmental commons in the system triggered productive discussions about the analytical advantages and disadvantages of different models of the case.

Fig. 1. Map showing the locations of mainstream dams in the Mekong basin as of 2014. Source: http://www.MeltdowninTibet.com, © Michael Buckley.

After identifying both analytical and data availability considerations, we agreed to focus on the group of riparian nations (actor group component), the MRA regime (governance system component), and water flow (environmental commons component). We focused on testing Ostrom's design principles but were also open to evidence regarding the role of other variables. The SESMAD coding book was instrumental for that purpose because it includes clear operationalizations of the design principles, as well as of other variables from CPR theory and other theories.

We selected the Mekong case with three criteria in mind. It had to be a case of large, transboundary river management; there had to be a transboundary governance system in place; and there had to be sufficient secondary data available. The Mekong case fulfilled all of these criteria and additionally was interesting for the reasons explained in the introduction.

Data were collected through content analysis of published studies on the case. Secondary sources included peer-reviewed publications and grey literature published by reputable organizations such as the MRC and the World Wide Fund for Nature. Additionally, we used data from primary sources, e.g., the text of agreements, reports produced by public organizations involved in river management, and raw data produced by the MRC. New sources were sampled until no significantly new information was obtained with the last source, following the methods of Glaser and Strauss (1999).

We modeled the case according to the SESMAD components on the base of the collected data. Different sets of SESMAD variables were assigned to pairs of coders who first each coded the variables independently and in a subsequent round compared those codes with his or her partner. Each coder kept track of quotes from the texts so that both coders could review and interpret the data together in case of disagreement. Then, the codes and unsolved disagreements were shared with the rest of the group for final approval.

The analysis was accomplished in two steps. First, we used pattern matching (Yin 2014) to test Ostrom's design principles. Pattern matching compares an empirically based pattern with a theoretically predicted one; if the patterns coincide, the results can be used to argue in support of the theory, and vice versa (Yin 2014). Second, we focused on the additional data collected to explore the relevance of other variables.

RESULTS

We first characterize the current state of hydropower development and fisheries production on the lower Mekong River and highlight the trade-off between them. We then outline the results of the coding exercise.

Outcomes

The LMB is one of the most active regions of hydropower development in the world. Four trends favor an expansion of hydropower in the basin, namely an increase in regional cooperation, trade, and planning; strong national desires to diversify fuel sources; and the international trend to reduce greenhouse gas emissions for the power sector (ICEM 2010). On the mainstream Mekong River, 11 dams are planned, including the Xayaburi dam (MRC 2011*b*). These dams can increase the 2600 MW capacity of the existing 26 tributary dams by 14,700 MW, with Laos producing 70% of the basin's energy and Cambodia 20%, including 85 planned tributary dams (Tables 2 and 3). The potential of all the planned projects is estimated to cover approximately 15% of the combined electricity demand of Vietnam and Thailand in 2020 (MRC 2011*b,* San 2015).

Table 2. Number of dams in the lower Mekong basin. Source: MRC (2011*b*).

Country	Mekong	Tributaries				
	Planned	Existing	Under construction	Planned	Total	Grand total
Cambodia	2	1	0	11	12	14
Laos	9†	11	9	71	91	100
Thailand	0	7	0	0	7	7
Vietnam	0	7	5	3	15	15
Total	11	26	14	85	125	136

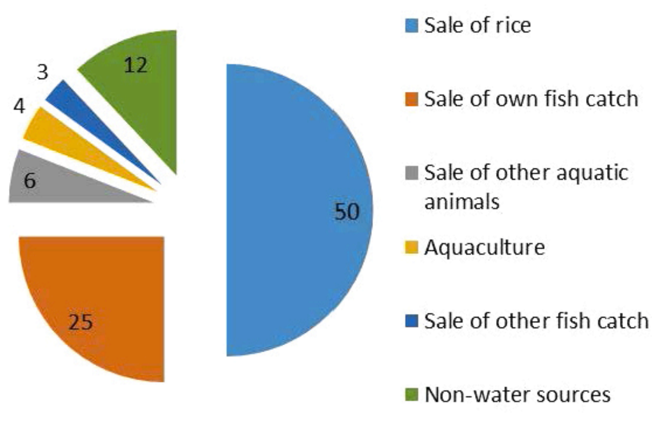
†Including two dams on the border with Thailand.

Table 3. Energy generation capacity of dams in the lower Mekong basin (MW). Source: MRC (2011*b*).

Country	Mekong Planned	Tributary Existing	Tributary Under construction	Tributary Planned	Tributary Total	Grand total
Cambodia	4280	1		1309	1310	5590
Laos	10,417	738	2764	6847	10,349	20,766
Thailand		745			745	745
Vietnam		1204	1016	363	2583	2583
Total	14,697	2688	3780	8519	14,987	29,684

The Mekong contains the largest freshwater fishery on the planet and is second only to the Amazon in fish biodiversity. It has a productivity of approximately 2.1 million tonnes/yr, which represents 22% of the world's fisheries production (ICEM 2010), and an estimated total value of USD 3.9–7.0 billion/yr (MRC 2010*d*). Fish is important for regional food security, both in terms of consumption and cash income. Approximately two-thirds of the LMB's population is involved in the Mekong fishery at least seasonally, and sales of fish catch account for 25% of household income in rural areas (Fig. 2). The importance of fish sales as an income source varies among countries. In Cambodia and Laos, fish sales is the main source of income for 40% of the population, whereas in Thailand and Vietnam, the figure reaches only 10% (MRC 2010*b*). Fish is also the main source of protein for the LMB's inhabitants, with 70% of Laotians and 40% of Cambodians depending on fish for subsistence (MRC 2010*d*).

Fig. 2. Proportional income sources of rural residents in the lower Meking basin corridor. The Mekong corridor encompasses 15 km on either side of the mainstream. Source data from MRC (2010*d*).



The outcome of interest that we used as a measure of cooperative success is the state of the fisheries, as threatened by hydropower development. Accordingly, we focused on fishery assessments and estimations that target the effects of dams. Additionally, we looked at the governance process that characterizes the Xayaburi dam affair to assess the effectiveness of the LMB governance in promoting cooperation. Hydropower development also threatens the agricultural sector; however, the effect is expected to be considerably lower than for the fisheries (ICEM 2010). In addition, the development of hydropower itself can be used as a measure of cooperation success among the riparian countries (i.e., cross-country investments and energy trade agreements); however, we decided against adopting this measure because it fails to capture the negative externalities over other water uses.

Currently, the fisheries throughout the basin are reporting declining catches (MRC 2010*d*), although this could be due to catches growing slower than the population (Baran and Myschowoda 2008). More importantly, approximately 87% of the species in the LMB are migratory, and thus are vulnerable to past and future dam building (Dugan et al. 2010, MRC 2011*b,* Grumbine et al. 2012, Ziv et al. 2012). Specifically, the planned mainstream dams threaten 16% of the mainstream species with extinction, which compose 35% of the harvest species (ICEM 2010). This will amount to estimated losses of 26–42% in fish catches, while reservoir fisheries in the dams will only compensate for 10% of the loss in capture fisheries (ICEM 2010).

In 2010, Laos's government submitted the Xayaburi Dam project to the MRC's Notification, Prior Consultation, and Agreement process. The MRC Joint Committee did not reach consensus and decided in April 2011 to address the case at ministerial level. In 2011, Laos hired an engineering consulting firm to evaluate the Xayaburi Dam's compliance with MRC environmental standards (The Economist 2013). The favourable assessment of the firm encouraged the Laos government to claim accomplishment of the Prior Consultation requirement and to proceed with the construction works (MRC 2011*a*). Completed in December 2011, the MRC's assessment concluded that the Xayaburi Dam would not fully comply with the MRC standards (International Rivers, Xayaburi dam: http://www.internationalrivers.org/campaigns/xayaburi-dam). Thus, the MRC recommended a 10-yr moratorium and the construction of smaller dams on tributaries. Despite the MRC's conclusions, Laos continued the construction works. By 2014, 30% of the project had already been completed (Worrell 2014).

Coding of variables

As a preliminary step to the analysis, we coded the design principles by assigning them values. For this purpose, we followed the SESMAD coding book, which includes a question and a set of potential values for each variable (Table 4). According to our review, the case scores high for some of the principles. Monitoring (see DP4 in table 4) is high; the LMB system enjoys a long-standing water quality, hydrological, and meteorological monitoring system and a set of procedures for information sharing and notification among the member states. External recognition (DP 7 in table 4) is also high, as measured by the political and financial support provided by international and regional organizations to the LMB governance system. The nested enterprises principle (DP 8) is also fulfilled; the LMB governance system is structured into a series of governing bodies at the basin and national levels that coordinate with each other for different governance purposes. Other principles are also present but not strong enough or wide enough in scope. Commons boundaries (DP1) are clear as there is good knowledge of the limits of the basin and the location of dams and fish hotspots; however, the China's Dialogue Partner status keeps open a unilateral stance on river basin. Also, The

Table 4. Coding and relevance of Ostrom's design principles in the lower Mekong basin case.

SESMAD[†] variables	SESMAD value	Explanation
Commons boundaries (DP1[‡])	Clear boundaries	Good knowledge of the limits of the upper and lower Mekong basins (UMB and LMB, respectively), mainstream river, and tributaries, and of the locations of dams and fish hotspots. This has helped to unveil and assess the hydropower-fisheries trade-off but has not prevented some controversy over impact estimations
Actor group boundary clarity (DP1)	Clear boundaries	Political boundaries of riparian nations within the LMB (vs. the UMB) are well known. This facilitates the assignment of rights and duties associated to membership in the LMB governance system (e.g., implementation of Prior Consultation rule in the Xayaburi affair, monitoring)
Actor group boundary fuzziness (DP1)	Fuzzy	China's dialog partner status maintains a unilateral stance on river basin development that undermines other upstream riparian nations' willingness to cooperate
Proportionality (DP2)	No	Contributions of riparian countries to the governance system's infrastructure have been rather limited. Opportunity costs of stopping current dam building plans are high and the benefits for fisheries conservation are unclear. This hinders bargaining over alternatives
Social-ecological fit (DP2)	Medium	Studies recognize spatial and temporal variability of ecosystem services provided by the basin; programmatic activities of the Mekong River Commission (MRC) are tailored to different areas within the basin; however, MRC regulations apply at the basin scale
Participation in rule making (DP3)	Medium	LMB governance system provides structures for collective choice among riparian countries; however, collective decisions are not binding and participatory processes have deficits, as shown in the Xayaburi dam affair
Self, social monitoring (DP4)	Yes	Procedures for Data Information and Exchange Sharing, Water Use Monitoring and Notification, and Prior Consultation and Agreement contribute to transparency
Environmental monitoring (DP4)	Medium	Water quality, hydrological, and meteorological monitoring stations managed by member nations; difficulties associated with lack of data from the upper basin (China). Nations monitor fisheries but coordination is only nascent. Data and knowledge generated contribute to improved knowledge of the resource dynamics but are still insufficient to estimate accurately the effect of dam-building plans in the basin
Sanctions (DP5)	No	No sanctions associated with rule violation. This has allowed Laos to act unilaterally in the Xayaburi dam affair despite protests of other riparian countries and the MRC resolution
Conflict resolution (DP6)	No	Long-standing informal capacity to solve disagreements among members in the basin, but lacking institutionalized conflict resolution mechanisms. Xayaburi dam conflict remains unsolved and undermines credibility of the LMB governance system
External recognition (DP7)	High	Authority of the MRC is widely recognized internationally and by the riparian states; however, such authority is subsidiary to the members' sovereignty. MRC's decision to postpone the Xayaburi dam project has not been questioned by the international community nor by most of the member states but this has not prevented Laos from implementing the project
Multiple levels (DP8)	Coordination among multiple levels	LMB governance system relies on coordination between MRC and National Mekong Committees for many activities, including the new sustainable hydropower development program; however, coordination between MRC programs and between the LMB governance system and the Asian Development Bank or Association of South-East Asian Nations is still nascent

Note: We follow the distinction between commons and social boundaries (DP1), fit to local conditions and cost and benefit proportionality (DP2), and social and environmental monitoring (DP4), as in Cox et al. (2010). SESMAD questions to assess the variables include the following. Commons boundaries: Are the boundaries that define the spatial extent of this commons clearly defined and highly visible? Actor group boundary clarity: Are there clear rules that are followed about who is and is not a member of this group? Actor group fuzziness: Is membership in this actor group subject to ongoing negotiations? Proportionality: Is there general proportionality between the amount of costs group members incur and the amount of benefits received? Social-ecological fit: To what extent do the institutional arrangements of this governance system fit well with the ecological or physical features of the commons on which they are implemented? Participation in rule making: How high is the level of participation of this actor group in the process that determines how this environmental commons is governed? Self, social monitoring: Does this actor group monitor the activities with respect its own use of this commons? Environmental monitoring: How much environmental monitoring of this commons does this actor group engage in? Sanctions: Are sanctions applied by and to the members of this group for violations of rules regarding extraction or emission? Conflict resolution: Are there mechanisms in place to address conflicts that arise over the use of this commons by this actor group? External recognition: Within this governance system, do larger governmental jurisdictions recognize the autonomy of lower-level jurisdictions and their right to make decisions regarding this commons? Multiple levels: Does this governance system contain multiple levels, with each level having a set of actors who conduct tasks with respect to the management of this commons? If so, is there active coordination across these levels?

[†]Social-ecological Systems Meta-analysis Database.

[‡]Design principle, numbered 1–8.

LMB governance system provides structures for collective choice (DP3) among the riparian countries; however, the extent to which national governments represent the interests of local users is less clear. Similarly, the riparian nations have shown a long-standing capacity to solve disagreements informally, but the LMB governance system does not have any institutionalized conflict resolution mechanisms of its own (DP4). Finally, some principles are not fulfilled. There is no proportionality between the cost and benefits of collaboration, and fit to local conditions is medium (DP2); the contributions of riparian countries to the governance system's infrastructure have been rather limited, the opportunity costs of stopping current dam building plans are high and MRC regulations apply uniformly at the basin scale despite the ecological and social diversity of the system. Also, the sanctioning principle (DP5) is completely absent, as the governance system does not foresee any formal sanctions against rule infractions.

DISCUSSION

We next review the relevance of the design principles and other variables found to be important, such as power and heterogeneous interests. Other coded variables can be found in Appendix 1.

Clear boundaries, political power, and heterogeneous interests

According to CPR theory, a common-pool resource with clear physical boundaries lends itself more readily to effective monitoring, and a clearly delimited group of potential resource users enables establishment and enforcement of a set of congruent management rules and norms (Ostrom 1990, Cox et al. 2010). Physical boundaries are clear in the LMB. The right to use the resource by the four riparian nations is well understood in the region and internationally, and there is relatively good knowledge of the general limits of the mainstream river, the tributaries, and the LMB (MRC 2013*c*). In addition, there is good knowledge about the location of: hydropower developments in China, Laos, Thailand, and Vietnam on the river mainstream and tributaries; a series of big irrigation projects in Thailand; the Vietnamese paddy cultivations in the Delta; and the Cambodian fisheries in Tonlé Sap Lake (MRC 2010*d*). The clarity of physical boundaries, however, does not prevent controversies. One of the main disputed aspects of the Xayaburi impact assessment commissioned by Laos was the extent of the area covered. The assessment evaluated the potential effects for a downstream area approximately 10 km from the barrage site, which critics consider to be insufficient (Vaidyanathan 2011).

Regarding social boundaries, there is good understanding of the rights and duties of the member states. The hegemonic position of China, however, poses some challenges. China is not only the most upstream country in the basin, but also the one least dependent on it for economic development (Backer 2007). This helps to understand much of its capricious behavior with respect to cooperation in the LMB. The Chinese government has shown a long-standing reluctance to bind itself to a number of international treaties on transboundary water cooperation, notably including the Mekong River Agreement (Boucher 2012, MRC 2009). However, the Chinese government is still motivated to participate in the LMB governance system as a dialog partner to maintain good relations with its neighbors (Backer 2007). Accordingly, the Chinese government has voluntarily participated in annual dialog meetings with the MRC (and Myanmar) and provided the MRC with data on daily water levels and rainfall from two important hydrological stations during the flood season (MRC 2008).

The dialog partner status is optimal for the Chinese government because it satisfies the country's interest in being involved in LMB affairs without binding itself to the agreements; however, the situation is not optimal for the LMB governance system. The hydrological information shared by the Chinese government does not include dry season or historical data and is occasionally retained for strategic reasons, all of which undermine a good understanding of the resource dynamics (Backer 2007, Schmeier 2009). Most importantly, China's special status "keeps open a unilateral stance on river basin development" (Hirsch 2006:193), which undermines the willingness of the other riparian countries to cooperate. Thailand, for example, does not seem to be keen on a detailed flow management scheme as advocated by the downstream riparian countries, partially because it claims that this has no purpose without Chinese participation. Laos in turn is not keen on curtailing its hydropower development potential given recent Chinese investments in the sector (Backer 2007). Moreover, China has argued that dam building on Chinese territory will prove to have beneficial effects downstream (Lebel et al. 2005), thus questioning the very existence of a trade-off and the need for cooperation to solve it.

The role played by China also illustrates a more general point about the heterogeneity of interests. According to CPR theory, heterogeneity of interests can lead to distributional struggles and collective choice disagreements, which are believed to hinder cooperation (Agrawal 2001). As stated by Poteete and Ostrom (2004:435), if "multiple solutions exist but have different distributional consequences, competition over distributional issues can result in failures to co-operate." In the LMB case, there is a general interest in hydropower development in the region (Backer 2007, Schmeier 2009); however, the distributional effects of dam building and its effects on the fisheries are undeniable. Cambodia relies heavily on the Mekong for its fisheries (i.e., the Tonlé Sap region), while its financial capacity to develop hydropower is very limited. Vietnam is strongly dependent on paddy production in the Delta, but is also interested in exploiting its hydropower generation capacity. Thailand has already exploited its hydropower generation capacity and is currently most interested in securing its irrigated agriculture. Laos is mostly interested in exploiting its great hydropower capacity (Schmeier 2009). Given this heterogeneity of interests, it is not difficult to understand the protests of Cambodia and Vietnam against the Xayaburi dam and the eagerness of Laos to implement the project (The Economist 2012).

Congruence between appropriation and provision rules and local conditions

Following Agrawal (2002) and Cox et al. (2010), Ostrom's second design principle can be subdivided into congruence between rules and local conditions and congruence between appropriation and provision rules. The former motivates users to comply with the rules because they are more feasible and perceived as fair (Cox et al. 2010). The latter translates into the "expectation that the benefits to be derived from participation in and compliance with community-based management will exceed the costs of investments in such activities" (Pomeroy et al. 2001:4).

The second design principle is only moderately present in the LMB case. There are clear differences in topography and water usage between the upper Mekong basin (UMB) and the LMB. Proceeding from the UMB to the LMB, the catchment flattens and widens, losing its potential for hydropower generation and gaining potential for irrigation development and ultimately fisheries. In addition, there are clearly distinguishable wet and dry seasons. An awareness of this variability is well reflected by the Mekong River Agreement and subsequent programs as well as in a good number of scenario studies both at local and basin-wide scales (MRC 1995*b,* 2009). However, many regulations do not seem to follow this detailed level of knowledge and are still designed at the basin scale (http://www.mrcmekong.org/about-mrc/programmes/).

Cost-benefit aspects of the MRC are somewhat elusive because they vary with cooperation goals. Most funds for the MRC have been provided by foreign donors. The establishment of the MRC was initiated with strong sponsorship from the United Nations Development Program (Browder 2000, Menniken 2006, Dinar et al. 2007). Moreover, many of the programmatic activities of the MRC have been either financed or technically supported by international donors. The design and implementation of the Water Utilization Procedures, for instance, has been actively supported by the World Bank (Boucher 2012); the strength of the LMB environmental monitoring system owes much to the technologies sponsored by the Canadian Space Agency and the Canadian Centre of Remote Sensing; and the Basin Development Plan received the advice of international experts on hydropower and irrigation scenario analysis (MRC 2008, Yorth 2014). In 2014, the MRC received a total of USD 13.7 million in contributions, with only approximately USD 2.8 million from member states, and the rest from international partners, with main donors such as Belgium, Denmark, Sweden, and Germany.

Altogether, contributions by the LMB countries to MRC activities have been rather limited, which accounts for low direct costs. However, in as far as abiding by the MRC rules means refraining from development projects, opportunity costs may be incurred (ICEM 2010, Ziv et al. 2012). The system would avoid construction and production costs, but would also face the transaction costs of enforcing the MRC rules. Most importantly, the distributional effect of giving priority to fisheries conservation over hydropower development would be dramatic, with upstream countries bearing most of the opportunity costs and downstream users reaping most of the benefits in the shape of externalities not incurred (ICEM 2010). As far as our knowledge goes, the LMB governance system has not implemented compensation mechanisms, even if requested by local stakeholders (MRC 2011*d*); in that context, the incentive for upstream users to give priority to fisheries conservation are low, and thus so are the chances for a cooperative agreement (Wolf 2007).

Collective-choice arrangements

According to Ostrom (1990), those parties affected by the rules must be given the opportunity to participate in their design. Resource users have first-hand and low-cost access to information about the situation they are acting in, and this provides them a comparative advantage in setting more effective rules for their specific context (Ostrom 1999*a,* Cox et al. 2010).

The possibility of collective choice among the LMB riparian nations is relatively clear. The LMB has a long history of collaboration in the basin, much of which reflects the autonomy of the riparian nations to self-organize and design a governance system that fits their conditions (Sneddon and Fox 2006). This long history of self-organization should not be taken for granted given the likewise long history of colonization in the basin. The LMB governance system includes two collective choice bodies. The Mekong River Council gathers officials from the environment and water ministers of the four members and meets annually to set the strategic agenda for the system. The MRC Joint Committee includes head senior officials from the members and puts the strategic plans into action through programs (MRC 1995*a*).

At the national level, the presence of the collective choice principle is less clear. Stakeholder participation in the elaboration of a number of core MRC programs (MRC 2005) faces some deficits. The Fisheries Program for 2011–2015 was elaborated on the basis of a public consultation process that brought together approximately 400 participants from MRC, fishing communities and their organizations, and national and international nongovernmental organizations and research institutes. Also, the priority of the program is to promote governments' capacities to support user communities in fisheries management via consultation processes (MRC 2010*a*). This priority notwithstanding, the initiative to promote public participation processes is still with national governments and so far has been mostly limited to consultation processes. Moreover, insufficient dissemination of information regarding the resource dynamics seems to hinder effective participation by stakeholders (MRC 2010*a*).

The MRC's hydropower development strategy advocates active stakeholder representation at all levels of planning and decision making, extending beyond the consultation stage (MRC 2005). Indeed, authorities have organized public consultations in districts potentially affected by dam construction projects within the frame of the PNPCA process; however, official participatory procedures have tended to include communities and stakeholder groups that were rather supportive of governmental projects. This has, in turn, resulted in resistance and protests by those left out (Sneddon and Fox 2006, Dore and Lebel 2010). The Xayaburi Dam project is a good example of this problem (Nijhuis 2014; International Rivers, Xayaburi dam: http://www.internationalrivers.org/campaigns/xayaburi-dam).

Monitoring and sanctioning

As reviewed by Cox et al. (2010), social monitoring makes those who do not comply with management rules and their effect on the resource visible to the community, which facilitates the effectiveness of rule enforcement mechanisms and informs strategic and contingent behavior of those who do comply with the rules. For monitoring to be effective, however, monitors should be accountable to the monitored (Ostrom 1990). Environmental monitoring, or the acquisition of information about the conditions of the resource, can reduce uncertainty about resource dynamics, facilitate adaptations, and also detect rule-breaking behavior (Olsson et al. 2004, Cox et al. 2010). In contrast, sanctioning makes violations costly and dissuades users from excessive violations of rules (Cox et al. 2010).

In the LMB case, there exists a strong monitoring system for water quality and streamflow supported by a network of state-managed measuring stations. In 1986, the first permanent stations for monitoring water quality were set up in the Water Quality Monitoring Network (MRC 2015*b*). Later, the Water Utilization

Project and its successor program, the Mekong Integrated Water Resources Management Project, expanded and consolidated the network (MRC 2013*c*). The network has permitted the elaboration of a number of models, estimations, and reports, and thus contributed to improving the knowledge of resource dynamics in the basin. Also, one of the key goals of the Fisheries Program for 2011–2015 is to support riparian organizations in monitoring the status and trends in fisheries, with a particular focus on effects of water infrastructure development (MRC 2010*a*). All LMB countries have their own routine monitoring programs, but they are uncoordinated. This undermines the reliability of estimations about the effects of hydropower development on the fisheries (Vaidyanathan 2011). Recent efforts to start filling that gap include the elaboration of an integrated analysis of data from MRC fisheries monitoring programs in the LMB, which includes data from up to 40 sites along the LMB, and the inception of a fish larvae density monitoring program in Cambodia and Vietnam (MRC 2013*a*).

Social monitoring among the member countries also exists. In 1995, the signing of the Mekong River Agreement resulted in a series of important information sharing protocols among the member countries, including the Procedures for Data Information and Exchange Sharing, Water Use Monitoring and Notification, and Prior Consultation and Agreement (MRC 1995*a*). These protocols contribute to transparency with respect to development plans and actions of national governments in the basin. The current dam-building trend and Lao's plans are under scrutiny due to the application of the Procedures for Notification and Prior Consultation and Agreement. However, the fact that China is not member of the MRC leads to insufficient monitoring of the upper Mekong. In addition, there is only partial accountability of monitors because much of the measuring and data processing are conducted at a national level (e.g., by the National Mekong Committees), and this has raised concerns about the reliability of the data (Boucher 2012). Laos, for example, has repeatedly refused to conduct studies of the effects of logging on water flow, and the Vietnamese government has also been accused of unwillingness to share strategic information (Backer 2007).

Concerning sanctioning, the LMB governance system is rather weak. Despite the abovementioned monitoring efforts, there are no sanctions to punish rule-breaking behavior (Schmeier 2009). This becomes particularly relevant with regard to the Procedures for the Maintenance of Flows on the Mainstream. The procedures specify acceptable minimum and maximum flows to be maintained at specific locations, but do not contemplate mechanisms in case of violation (MRC 1995*a*). Similarly, the prior consultation protocol is an important tool for transparency in the system, but, as illustrated by the Xayaburi affair, neither such a requirement nor the MRC resolutions are binding. Under these conditions, the capacity of the MRC to guarantee the river's sustainable development is substantially weakened (Schmeier 2009).

Conflict resolution

According to the conflict resolution principle, regimes that include low-cost mechanisms for discussing and resolving disagreements are more likely to ensure rule conformance and therefore regime success (Ostrom 1999*a,* Cox et al. 2010). In the LMB, the long history of past collaboration among the riparian countries denotes an ability to solve disagreements (Sneddon and Fox 2006). This history of collaboration and conflict solving is referred to as the "Mekong spirit" (Sneddon and Fox 2006) and is evident in several ways. First, water affairs have tended to foster cooperation in the basin even when international relations in the region were hostile (Schmeier 2009). Second, the history of the number of cooperation and conflict events in the LMB since the 1950s shows clear dominance of the former despite the regular occurrence of the latter (Yorth 2014; Heikkila et al. *unpublished manuscript,* http://web.isanet.org/Web/Conferences/FLACSO-ISA%20BuenosAires%202014/Archive/e5bb2629-b8c0-4711-889c-b8825baaff77.pdf). However, there are no institutionalized mechanisms to solve conflicts between the member states. According to the Mekong River Agreement, disputes are to be solved within the MRC, through the Council of member representatives or through diplomacy, but no procedure is specified (MRC 1995*b*). Also importantly, the conflict-solving capacity of the system is undermined by the lack authority of the MRC to make member states abide by its resolutions, as shown with Laos in the Xayaburi affair (Lange and Jensen 2013).

External recognition

According to the principle of external recognition, the lack of acceptance of a governance system by higher authorities or the external imposition of rules that do not match the existing conditions can lead to the collapse of the system (Hayek 1945, Ostrom 1990, Scott 1998). The external recognition principle is present in the LMB case. The principle can be assessed by examining the decision-making autonomy (Basurto 2013) of the MRC. As illustrated in the Xayaburi affair, the MRC has some authority to make independent decisions from national governments (Boucher 2012). By instructing countries to investigate further some of the environmental, political, and social effects of the dam, the MRC not only proved its autonomy but also set an important precedent for the future (Boucher 2012). However, the agenda of the Committee is still highly dependent on the executive decisions of national governments (Osborne 2004, Backer 2007). International donors have also recognized the role of the LMB governance system and the MRC to avoid trade-offs between development initiatives (MRC 2013*b*). It is unclear, however, to what extent that has had any real effect on the current hydropower development trend.

External recognition can translate also in financial, technical, and organizational support (Anthony and Campbell 2011, Barnes and van Laerhoven 2015). In the LMB, this is evident with regard to international organizations and donors. However, high dependence on donor support comes with a risk (Schmeier 2009). Turning to external aid too frequently can distort perceptions of the costs of self-organization and can erode the willingness of users to cooperate (Ostrom 1999*a,* Gibson et al. 2005). In response to that risk, the MRC has introduced a riparization policy. In future, development partners will focus on funds for the MRC's core budget, and decentralized activities will be financed mainly through member country funding (MRC 2015*a*).

Nested enterprises

The potential advantages of nested governance for large-scale common-pool resource problems are evident from various perspectives. The nesting of governance functions across levels of social organization allows the division of large-scale problems and tasks into smaller ones that can be tackled by small groups and organizations at reduced transaction costs (Ostrom 1990, Marshall 2007). In addition, governance organizations at one level can complement and strengthen functions carried out by organizations at other levels, and this redundancy can contribute to the responsiveness of the system to problems of different nature and scale (Lam 2006, Cox et al. 2010, Cox 2011). In the context of large, transboundary systems, the effectiveness of nested regimes requires appropriate coordination mechanisms or cross-scale linkages. Without such coordination, the division of labor across boundaries or organizations may exacerbate problems rather than contribute to solving them (Young 2002, Heikkila et al. 2011).

The LMB governance system has been conceived as a multilevel governance system. At the international level, the system is structured into three governing bodies: the Council, the Joint Committee, and the MRC Secretariat, each with different governance functions (MRC 2004). At the national level, there are National Mekong Committees (NMCs), each of which is supported by a permanent Secretariat that coordinates with the national Ministries. The Ministries are responsible for collecting and processing hydrological and socioeconomic data, maintaining the monitoring system in coordination with the MRC, and implementing basin-wide programs carried out under the MRC umbrella (MRC 1995*a,* 2004).

Although there is no legally defined relationship between the NMCs and the MRC, communication and coordination between the two have been integral to the implementation of central programs such as the Water Utilization Project, the Basin Development Plans, and the Mekong Fisheries Program, among others. The Water Utilization Project, for example, describes procedures for data tracking on intrabasin water use and interbasin diversion (Boucher 2012). According to the Mekong River Agreement (MRC 1995*b*), during the wet season, members are required to notify the Joint Committee of intrabasin water use. During the dry season, members are subject to prior consultation, which aims at arriving at an agreement by the Joint Committee. This system is important to safeguard against possible flooding, droughts, and problems related to river biodiversity (mainly fish resources). Another relevant example is the Fisheries Program Steering Committee, which includes high-level representatives of the national fisheries agencies and the NMCs. Its main role is to review Fisheries Program progress and effects, and it may recommend actions aiming at maximizing national uptake of the program (MRC 2010*a*).

The nested enterprises design principle has been also associated with polycentricity and the existence of horizontal coordination mechanisms, i.e. across regimes and programs or policies within regimes (Andersson and Ostrom 2008). The MRC works with different international partners under jointly funded projects. Regional partners include the Asian Development Bank (ADB) and ASEAN. The ADB is a donor to the MRC, is granted observer status to the Commission, and supports the MRC Flood Management and Mitigation and Hydropower Sustainability Programs (Backer 2007). The ASEAN-Mekong Basin Development Cooperation was established in 1996 and has convened annually as an economic development forum, mostly to commission feasibility studies on cross-border infrastructure and trade projects (AMBDC 2014). Overall, however, we did not find evidence of any coordinated efforts between the ADB, ASEAN, and MRC to regulate investments in hydropower developments.

At the program level, coordination is rather nascent. The Initiative on Sustainable Hydropower Development has collaborated with the Fisheries Program to elaborate several awareness-raising documents and technical feasibility studies (MRC 2010*b*). The aim, according to the Fisheries Program, is to strengthen collaboration along those lines (MRC 2010*a*). Also, the Fisheries Program maintains close contact and cooperates frequently with a number of fishery-related organizations interested in the area. A prominent example is the Technical Advisory Body on Fisheries Management, which acts as a facilitation hub for communication on Mekong fisheries management cooperation (MRC 2010*a*).

CONCLUSION

If the plan to build 11 dams in the mainstream Mekong River is implemented, the total losses in fish resources will amount to a projected 26–42%, and many species will be lost forever (ICEM 2010). The unilateral stance of Laos in the Xayaburi conflict shows some incapacity of the MRC to promote cooperation among the riparian countries. At the same time, the trade-off between hydropower development and fisheries conservation has become a governance issue because of the transparency and coordination promoted by the LMB governance system among the member states.

Our study demonstrates that CPR theory (i.e., design principles and other cooperation factors) is helpful in explaining the system outcomes. The international support for economic cooperation and hydropower investments, combined with heterogeneous interests among the countries, deficits in the involvement of local users, and the lack of a clear cost-benefit ratio of cooperation, all contribute to the increasing trade-off between hydropower development and fisheries conservation in the region. The environmental monitoring and transparency procedures promoted by the LMB governance system have contributed to raise awareness about the negative externalities of hydropower development; however, data-sharing protocols for the fisheries are still nascent, and this undermines the robustness of estimations about the impacts of dams and the possibility for compensation. Moreover, the MRC does not have enough authority to make binding decisions or impose sanctions on member states, as demonstrated by the Xayaburi affair. The LMB regime has successfully overcome conflict events and policy disagreements in the past; however, there are no institutionalized procedures to cope with power struggles, as also illustrated in the Xayaburi affair. Indeed, the unequal distribution of power among the riparian countries and the fuzzy boundaries of the governance regime (i.e., the changing role of China) can explain why the regime has not been as binding as expected. Finally, horizontal linkages between the LMB governance system and other regimes and across the MRC programs for the promotion of sustainable hydropower development are still nascent, which helps explain the emergence of the hydropower-fisheries trade-off.

Our results partially converge with similar tests of the design principles in large systems and in other sectors (Fleischman et al. 2014*b*). Similar to our results, other works point to the importance of sanctions and the proportionality and distribution of the costs and benefits of cooperation. Contrary to our results, however, previous works did not find external recognition (i.e., in the form of continued financial support) to be a problem (Fleischman et al. 2014*b*). Additionally, our analysis of boundaries revealed the importance of power relationships, which has not been highlighted in similar tests of the design principles.

Other seemingly important variables that we have not commented on in depth include scientific knowledge, markets, spatial heterogeneity, and triggering events. First, according to theory, clear scientific knowledge contributes to effective monitoring and decision making (Stern 2011). Although a number of works have warned about the negative effects of upstream dams on migratory species in the LMB (Dugan et al. 2010, MRC 2011*b,* Grumbine et al. 2012, Ziv et al. 2012), the extent of harm is still subject to controversy. This is arguably why the MRC called for a 10-yr hold on building the Xayaburi dam (Vaidyanathan 2011). Second, some authors have pointed to the importance of triggers of cooperation, which may occur in the form of problems, scientific breakthroughs, or natural disturbances (Mitchell 2003, Villamayor-Tomas et al. 2014). In the LMB, the peace agreement that ended the conflict between Vietnam and Cambodia marked a renaissance of cooperation in the LMB that would lead to the Mekong River Agreement (Schmeier 2009, Boucher 2012). Third, a number of authors have pointed to markets as a driver of environmental commons degradation (Cox et al. 2014). In the LMB, the existence of an internal market for hydropower has contributed to cooperation in the region and locked the riparian nations in a path that makes cooperation for fisheries conservation more difficult. All the riparian nations benefit from hydropower development, either as producers, consumers, or both (Schmeier 2009). These benefits are only expected to grow given the increasing energy demand in the basin and the still high hydropower generation potential of the basin. Reversing the current dam building trend would not only frustrate current energy production and consumption expectations but would also require a reconfiguration of the energy trade relationships in the basin, with uncertain costs to all riparian nations. Finally, there is the role of spatial heterogeneity of the LMB, which explains some of the interest heterogeneity with regard to fisheries conservation. Because the most productive fisheries are situated downstream, China and Laos are less concerned about the condition of that resource than the other countries are (Backer 2007). However, fisheries are also an important food source in Laos, and several hundred people from fishing communities have been displaced in the course of dam construction, with apparently very negative effects on their livelihoods (Tacon 2013). Also, there may be differences in the perceptions of costs and benefits that are not necessarily linked to objective pay-offs. This may undermine awareness about the externalities of hydropower development, but could also facilitate negotiations and the accomplishment of win-win agreements (Ostrom 1999*b*).

We found the SESMAD particularly useful to model the LMB case, assess the governance of hydropower development with regard to its effects on the basin's fisheries, and systematically measure (code secondary data about) the design principles and other variables. This last aspect was of particular relevance. Data contained much more information than needed for some of the variables (i.e., monitoring, nested enterprises) and less information than desired about others (i.e., collective choice, proportionality). Having a clear coding book was useful to use just the necessary information and assess whether the available information was sufficient. This was particularly important to code for the absence of principles (i.e., sanctioning). Also, some authors provided relevant information about the design principles without explicitly referring to them (i.e., the importance of China's special status was frequently pointed out by authors without referring to the issue of fuzzy boundaries), or named the variables differently (e.g., stakeholder participation vs. collective choice, multilevel governance vs. nested enterprises). Again, the SESMAD coding book was helpful to maintain consistency in data collection and analysis.

Our study contributes to SESMAD development in different ways. First, the study constitutes a new entry in the database. One of the original goals of the database is to build a large compilation of cases of large-scale CPRs for comparative purposes (Cox 2014). Comparisons of multiple cases will enable performing more general tests of the design principles across different large-scale cases and sectors, as well as exploring other relevant factors. Second, the study illustrates the usability of the SESMAD to assess the governance of an environmental commons when there are conflicts between different uses of it. Previous applications have used the database to model the conditions of a single environmental commons such as forestry (Fleischman et al. 2014*b*), two similar commons such as the eastern and western Atlantic bluefin tuna (Epstein et al. 2014*b*), two complementary commons such as fish and coral in the Great Barrier Reef (Evans et al. 2014), and the externalities of a pollutant on a natural resource (Epstein et al. 2014*a,* Villamayor-Tomas et al. 2014). To that list, we add the assessment of negative externalities that one resource use creates on another.

Our study has limitations, some of which can also be understood as limitations of SESMAD. First, data availability limited our ability to develop a more sophisticated model of the case, e.g., by looking at different types of actor groups (governmental vs. nongovernmental, national vs. local). Second, our analysis is not equally conclusive about the relevance of all the design principles. It is, for example, unclear to what extent the collective choice and conflict resolution principles are critical for the success of the governance system. The principles are present but are not strong or institutionalized enough, and we did not find conclusive accounts of how that has affected the system or the Xayaburi affair. Third, our arguments about the relevance of factors other than the design principles should be taken with caution because those findings are the result of an exploratory exercise rather than theory testing. Fourth, our model of the case is one of many possibilities. We did not assess, for example, the governance of hydropower generation alone (e.g., coordination for water flow and dam management) or the governance of fishing activities (e.g., against overexploitation). Both activities, however, are important to understanding the performance of the LMB system. Finally, SESMAD does not contain all potentially relevant variables; the database does not explicitly include, for example, cooperative political culture (Berardo and Gerlak 2012) or the existence of clear management rules (Huisman et al. 2000). This limited the internal validity of our analysis, although not necessarily our ability to test the design principles. Future efforts should integrate some of these additional variables into the SESMAD.

As per our assessment of the LMB case, the role of China is of particular relevance. Some authors argue that cooperation by the Chinese government can only increase in the long term (Elhance

1999). In the short term, however, findings are a bit less optimistic. By doing business with its LMB neighbors (e.g., for hydropower generation) and limiting its role to that of a dialog partner, China not only avoids direct monitoring by the MRC but also discourages other members from making the LMB system more binding. Further research is necessary to understand better how the current and longer term behavior of China will affect the performance of the LMB governance system.

In closing, our study illustrates the relative importance that governance systems such as the LMB's count on firm boundaries, clear assessments of the costs and benefits of cooperation, and sanctioning mechanisms. Our results are less clear about whether these principles are more important than other principles. Little is known about the conditions under which each of the design principles and other CPR variables can make a difference (Agrawal 2001). Without such diagnostic explanations, studies that rely on CPR theory run the risk of overdetermination. We tried to minimize the risk of overdetermination by assessing the process through which each of the design principles has influenced cooperation under the LMB governance system. SESMAD was designed to facilitate case comparisons that allow one to tease apart when some variables and groups of variables are important. As more cases are filled in the database, our understanding of the LMB case and the relevance of the design principles will hopefully become clearer.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/8105

Acknowledgments:

We thank the Bologna Lab and the Division of Resource Economics (Humboldt University) for supporting the development of the Fall 2014 course on "Systematic case study analysis of natural resource management using a social-ecological perspective." Any errors or omissions are those of the authors.

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Appendix 1. Full characterization of the lower Mekong basin case study based on social-ecological system meta-analysis database variables.

Variable	Characterization
	Actor group: the MRC and the LMB riparian nations
Actor Scientific Knowlege	The MRC possesses a significant amount of information and technical knowledge on the MRB, particularly on hydrology and water quality. However, the MRC still lacks statistics on fisheries, and has problems predicting the water flow, floods and droughts.
Monitoring Technology	Latest technologies and technical support from developed countries such as Canada and the USA.
Self/external monitoring	Procedures for Data Information and Exchange Sharing, Water Use Monitoring and Notification, and Prior Consultation and Agreement.
Environmental monitoring	Present in the LMB since 1986, including water quality, hydrological and meteorological monitoring stations. Some difficulties in monitoring water flow due to lack of access to the Chinese part of the river. Also, reduced accountability of monitors (national governments).
Economic Heterogeneity	High, Thailand being the most developed state in the group, Vietnam rapidly developing, and Cambodia and Laos lacking basic human development.
Economic Dependence	The LMB riparians are highly dependent on the river for hydropower as well as irrigation and navigation and fisheries.
Economic Status	Medium, all members of the MRC are developing countries. Thailand, the most developed one of the group, has been suffering from an economic downturn in the last decade.
Commons Political Power	The MRC's power is limited due to its full dependency on donor funding and lack of mandate to act on its own without prior approval from its member countries.
Actor group Boundary Clarity	The MRC's scope includes only the lower Mekong river, excluding the tributaries and the half of the river flowing through China.
Actor group Boundary Fuzziness	China's Dialoge Partner status keeps open a unilateral stance on river basin development
Costs Benefits	With no benefit-sharing provisions in place, the MRC is mostly financed through international donors, incurring few costs for its member states. Benefits include projects in water monitoring and creation of work places.
Interest Heterogeneity	Conflicting interests of the riparians: hydropower development, a common interest of all member states, poses a threat to Cambodia, Laos, and Vietnam, who are also dependent on the river's fisheries and irrigation capacities.
Past Collaboration	Institutionalized cooperation in the LMB since the 1950s did not stop even in times of hostility. Long-standing economic cooperation within the framework of the ASEAN and the ADB
	Environmental common: Water flow (as used for hydropower and fisheries)

Beginning Condition	LMB hosts some of the most productive fresh water fisheries in the world (with reports of declining catches in the past several years, possibly due to falling per capita rather than total catches); annual river discharge 460 billion m^3.
Bio Diversity Trend	Dams are predicted to have detrimental effects on fish biodiversity, 16% of species threatened with extinction.
Commons boundaries	Good knowledge of the limits of the Upper and Lower basins, mainstream river and tributaries; and of the location of dams and fish hotspots.
Commons Condition Trend	Declining, with upstream dams negatively affecting water flow for irrigation, sediment content, and fish populations.
Dams	31 damns on the tributaries and the Upper and Lower mainstream Mekong. 12 new dams planned in the mainstream.
Dams Role	Production of hydropower, water storage, reservoir fisheries. Expected negative effects on water flow predictability, sediment flows, and capture fisheries.
ES Markets	Both for fish (estimated at US$3.9–7.0 billion per year) and for hydropower, with Thailand and Vietnam investing in Laos.
Human Population	High rate of population growth.
Run off Input	Salt water intrusion in the delta during dry season.
Technical Storage	Water storage in dams; fish storage in ponds and dams.
Technical Substitute	None, neither for fish nor hydropower generation. Little room to mitigate impact of dams on fisheries.
Physical Boundaries	Good knowledge of the limits of the Upper and Lower basins, mainstream river and tributaries; and of the location of dams and fish hotspots.
Intra and Inter Annual Predictability	Water flow: moderate due to climatic factors, decreasing because of Chinese mainstream dams. Fish: moderate due to water flow variations and mobility.
Commons Mobility	87% of species in the LMB are migratory, many with mobility range over 100 km.
Productivity	High water flow productivity due to heavy precipitation and large catchment area (highest potential for hydropower generation in Laos); the most productive freshwater fishery in the world.
Renewability	Fish is renewable; not applicable to water flow.
Spatial Heterogeneity	Moderate, water flow naturally heterogeneous with highest hydropower potential in Laos, and the highest fisheries potential in Cambodia, particularly in the lake Tonlé Sap.

Governance System: the (Lower) Mekong agreements and programs

Conflict Resolution	Lack of institutionalized conflict resolution mechanisms, the MRC process has still contributed to informal conflict-solving.
Self/External Sanctions	The MRC lacks binding rules and sanctions for rule violators.
Proportionality	The contributions of riparian countries to the governance system's infrastructure have been rather limited.The opportunity costs of stopping current dam building plans are high; the benefits in terms of fisheries conservation are unclear.
Socio-ecological fit	Studies recognize spatial and temporal variability of the ecosystem services provided by the basin; programmatic

	activities of the MRC are also tailored target different areas within the basin; however, the MRC regulations apply at the basin scale.
Participation in Rule making	The LMB governance system provides structures for collective choice among the riparian countries.
Trust	Unique “Mekong spirit”, formed through decades of cooperation on water-related issues.
Metric Diversity	Goal of the treaty: to maintain a healthy and sustainable ecosystem while promoting economic growth and development has not changed since its inception.
Trigger	Peace treaty with Cambodia (turned the cooperation in the region towards searching for a balance between economic and social development).
External Recognition	The MRC is funded mostly by third parties, including the World Bank; UNDP played a key role in promoting negotiations which led to the MRC establishment.
Multiple Levels	Three branches of the MRC (the Council, Joint Committee (JC), and the MRC Secretariat), complemented by the National Mekong Committees in member nations.
Horizontal coordination	Coordination between MRC programs, and between the LMB governance system and the ADB or the ASEAN is still nascent.
Science Based Policy	The MRC tries to make decisions based on scientific assessments, but faces problems with its implementation on behalf of the member states (Xayaburi dam case); mostly absent in member states (economic considerations prevail).