OM 4.5.4 (Rev)

CEPF FINAL PROJECT COMPLETION REPORT

Organization Legal Name:	University of Canterbury
Project Title:	River at Risk: Modeling and Monitoring the Potential Impacts of Large-Scale Disruptions to the Hydrological Cycles of the Mekong River Basin on Biodiversity and Natural Systems
Date of Report:	May 30, 2013
Report Author and Contact Information	Tom Cochrane, e-mail: tom.cochrane@canterbury.ac.nz

CEPF Region: Indo Burma

Strategic Direction: 3. Reconcile conservation and development

Grant Amount: US$298,889

Project Dates: 1 July, 2010-31 March, 2013

Implementation Partners for this Project (please explain the level of involvement for each partner):
* Conservation International – Greater Mekong Program, CI's Freshwater Initiative, CI-Cambodia, and Science and Knowledge team. Contributed to project outcomes, helped ensure strong government and partner links, and active in the dissemination of project information.
* Mekong River Commission (MRC) – Basin Development Programme, Climate Change Adaptation Initiative, and Information and Knowledge Programme: MRC supported the project by providing access to official data/information needed for the project, collaboration on modeling efforts, and by providing a forum for dissemination of results. The collaboration led to joint publication of technical articles and wide dissemination of our work.
* Local government agencies (Cambodia Fisheries Administration, Cambodia Ministry of the Environment, Ministry of Water Resources and Meteorology MOWRAM, Tonle Sap Authority, Lao Department of Energy, and others): information sharing and recipients of reports/information.
* RUPP (Royal University of Phnom Penh) and Pannasastra University of Cambodia: student support for field work in the Tonle Sap and on-going collaboration in the 3S basin.
* Aalto University, WUP-Fin group: collaboration on modeling and analysis.
* NGO's and international institutions acting in the region: Stimson Center, NHI – Natural Heritage Institute, World Fish Centre, Wildlife Conservation Society (WCS), 3S (Sekong, Sesan, Srepok) Rivers Protection Network, International Union for Conservation of Nature (IUCN), ICEM (International Centre for Environmental Management) Indo-Burma/Australia, NGO forum on Cambodia (representing International Rivers Network (IRN), Rivers Coalition of Cambodia, and others), People Resources and Conservation Foundation, Texas A& M University (SWAT modeling team and fisheries team), University of Washington, Foodweb group, UNESCO (IHE) and the World Wildlife Fund (WWF) Greater Mekong initiative: information sharing, recipients of modeling results, analysis and discussion of research needs/outcomes.

Conservation Impacts

Please explain/describe how your project has contributed to the implementation of the CEPF ecosystem profile.

Our project contributed to the implementation of the CEPF Indo-Burma ecosystem profile by quantifying the threat of ongoing and future hydropower development to riverine and wetland ecosystems in the Mekong basin.

Please summarize the overall results/impact of your project.

The goal of our project was to investigate the potential impacts of large-scale disruptions of hydrological cycles on biodiversity and natural systems of the Mekong basin. This was done through systematic analysis of historical water levels in the Mekong River, evaluation of current hydrological/hydraulic models, development of daily hydropower operation models, development of models to predict vegetation and fauna changes in the Tonle Sap, and analysis of various scenarios of development and climate change. The analysis of historical water levels conclusively showed that water resources development from 1991 to 2010 has already affected the raising and falling rates of water, the fluctuation of water levels, and the average seasonal water levels. Results from this analysis support and validate concerns related to impacts of future potential development.

Our modeling results demonstrate that the downstream effects of hydropower development in the basin will be higher than the effects of climate change in terms of habitat disruption and net primary productivity. Full hydropower development will led to reduced seasonal water fluctuation in the Tonle Sap, resulting in a significant decrease in seasonal floodplain area (aka., habitats that flood every year) from 10,187 to 7,994 km^2 (-22%). A large part of the existing gallery forests around the lake, which have the largest biomass and canopy cover of all seasonally flooded vegetation communities, would be permanently inundated. Due to the reduction in seasonal flood extent, agricultural encroachment will likely occur in an area of 1,300 km^2. There will also be a shift in areas suitable for both natural vegetation and fauna. Local authorities and managers are therefore advised to plan for potential shifts in habitat patterns in the Tonle Sap and other wetland in the lower Mekong. With full hydropower development, net primary production of the Tonle Sap is expected to decrease up to 39%, which could result in a comparable loss of fisheries in the region.

Although much emphasis has recently been placed in the development of the 11 mainstream dams, little emphasis had been placed in the development of tributary dams. Through our modeling analysis, we determined that the 3S basin is the most critical tributary basin the Mekong. Development of all dams in the 3S basin and operations to maximize energy production will significantly attenuate the difference between wet and dry season flows and sediment flows in the lower Mekong, having a larger impact than all mainstream dams (including the Chinese dams). However, the energy production of 7 proposed dams in the 3S basin will increase only marginally compared to the increase in active storage. The argument can thus be made that the benefit of that marginal increase in electricity production is small compared to the potential impact the dams could have downstream. Our modeling also shows that the magnitude of flow changes varies from location to location and depends on number, size, locations, and operation of the hydropower dams.

Detailed results of our modeling have been available through multiple work meetings and seminars (w/ MRC, Simpson Center, NHI, CI, Lao Dept. of Energy, Tonle Sap Authority, MOWRAM, Cambodia Fisheries Administration, and various NGO's), peer reviewed publications, conferences, and our "www.mekongflows.org" website.

Planned Long-term Impacts - 3+ years (as stated in the approved proposal):

Social, economic, and environmental benefits are maximized by achieving reconciliation between development objectives and biodiversity conservation in the Mekong basin.

Actual Progress Toward Long-term Impacts at Completion:

Our hydrological analysis has conclusively shown that there are quantifiable impacts of historical water resources development on water levels in the Mekong mainstream and the Tonle Sap. The water levels and the productivity of the downstream ecosystem will be further impacted by potential future developments; however, social, economic, and environmental benefits can be maximized by achieving reconciliation between development objectives and conservation. A large knowledge base of data, models, and simulations of alternative scenarios has been transferred to stakeholders to support and improve decision making in the next 3+ years.

Planned Short-term Impacts - 1 to 3 years (as stated in the approved proposal):

a) The potential impacts of large-scale disruptions to hydrological cycles of currently proposed development scenarios on biodiversity and natural systems are demonstrated and quantified.
b) The decision making process that is currently underway on the development of dams in the Mekong and its tributaries is positively influenced through direct engagement with key stakeholders in the formulation of alternative development scenarios to reduce impacts on biodiversity and natural systems.
c) The stage is set for future monitoring of changes and for the design and implementation of a conservation corridor that will allow species to adapt to climate change.

Actual Progress Toward Short-term Impacts at Completion:

a) The potential impacts of large-scale disruptions to hydrological cycles of proposed development on biodiversity and natural systems were demonstrated and quantified through historical analysis and application of modeling tools. These results are supporting further investigation and modeling efforts to address knowledge gaps.
b) Direct engagement with key stakeholders and modelers has enabled analysis of hydropower dam operations, siting, and level of development, which is positively influencing the decision making process that is currently underway on finding viable alternative development scenarios to reduce impacts on biodiversity and natural systems.
c) The project has provided strong arguments for continuous monitoring of flows, sediment, land cover change, and nutrient transport in key tributaries of the Mekong, and monitoring of changes in vegetation and fauna.
d) One of our key team members is now working for MRC and our Mekong Flows team has secured additional funding to work in the 3S basin, which will ensure continuity and dissemination of our work in the short-term.

Please provide the following information where relevant:
Hectares Protected:
Species Conserved:
Corridors Created:

Not directly relevant to our project, although we hope some of our work will contribute to the better management of the Tonle Sap and lower Mekong conservation corridors.

Describe the success or challenges of the project toward achieving its short-term and long-term impact objectives.

The project has been successful in quantifying the impact of hydropower and climate change on downstream natural systems. One key contribution made by this project has been to identify the proposed development in the 3S basin as being of critical importance in terms of potential impacts to downstream ecosystems and productivity of the Tonle Sap, floodplains, and delta.

The main challenge of the project achieving short and long-term impact goals is in terms of the unpredictability of seemingly arbitrary high level policy decisions by individual countries in terms of approving hydropower development. A recent example is the proposal by the Cambodian government to proceed with the development of the Lower Sesan 2 dam, which would cause an unprecedented level of flow and sediment changes downstream, in addition to blocking key fish migration routes.

Our Mekong Flows team has successfully obtained additional funding to focus research in the 3S basin with the aim of improving knowledge on the potential changes to sediment transport, nutrient flows, and landuse change. One of our former team members now works in a senior post at MRC, enhancing collaboration on issues related to the 3S basin.

Project Components

Project Components: *Please report on results by project component. Reporting should reference specific products/deliverables from the approved project design and other relevant information.*

Component 1 Planned:
Current hydrological and hydraulic modeling efforts, Mekong basin development scenarios, and predicted impacts revised and evaluated.

Component 1 Actual at Completion:
Current hydrological and hydraulic modeling efforts, development scenarios, and predicted impacts were revised and evaluated.

The MRC modeling efforts were revised by our team and a technical paper was published:
Piman, T., Lennaerts, T., and P. Southalack (2013) Assessment of hydrological changes in the lower Mekong Basin from Basin-Wide development scenarios. Hydrological Processes. DOI: 10.1002/hyp.9764

The distributed VMOD model developed by the WUP-FIN group (Lauri et al., 2012) was reviewed and used for scenario modeling impacting the Tonle Sap. Results of the modeling are being presented in the following publication:
Arias, M.E., Cochrane, T.A., Kummu, M., Lauri, H., Koponen, J., Holtgrieve, G.W., and Piman, T. (2013) Impacts of hydropower and climate change on drivers of ecological productivity of Southeast Asia's most important wetland. Ecological Modelling (submitted)

All of the revised models indicated that increased hydropower development levels will result in a downstream increase of flows in the dry season, a decrease in flows in the wet season, and a reduction in the amplitude of flood peaks. Nevertheless, the predicted magnitude of changes varied between studies as a function of the simulation time frame, assumptions made, and the models used.

During the course of our project, stakeholders questioned whether the historical impacts of water resources development in the basin could already be seen in measured water level data. A detailed analysis was therefore conducted to investigate whether there is already evidence of flow alterations caused by historical water resources development. Water level measurements from long term monitoring stations along the mainstream of the Mekong were analyzed for the pre 1991 and post 1991 period. The year 1991 was used because it marks a significant change in the rate of development and magnitude of hydropower dams and irrigation schemes. Observed changes in water level patterns along the Mekong were linked to temporal and spatial of water resources infrastructure development from 1960 to 2010. Our analysis shows that the development of mainstream dams in the upper Mekong basin in the post 1991 period have resulted in a significant change of seasonal water levels (primarily higher dry season levels), water level raise rates, fall rates, and the number of water level fluctuations observed in Chiang Sean, the upper monitoring station of the lower Mekong. This effect diminishes downstream until it becomes negligible at the Mukdahan monitoring station, which represents a drainage area of over 50% of the total Mekong Basin. Further downstream at the Pakse station, changes in hydrological indicators post 1991 were observed to be significant again. The observed changes decrease downstream, but are still quantifiable up to Prek Kdam. Observed changes at Pakse and downstream can be directly attributed to water resource infrastructure development in the Chi and Mun basins of Thailand. A reduction of 23% and 11% in the raising rate and fall rate respectively at Prek Kdam on the Tonle Sap River provides clear evidence of a diminished Tonle Sap flood pulse in the post 1991 period. We extrapolate that future development in the transboundary Srepok, Sesan and Sekong basins will have an even greater effect on the flood pulse of the lower Mekong. This analysis support results obtained from our modeling of development scenarios and potential impacts to natural ecosystems.

Details are included in:
Cochrane, T.A., Piman, T, and Arias, M.E. (2013). An analysis of the impact of water infrastructure on water levels of the Mekong River and the Tonle Sap. Journal of Hydrology (in preparation)

Component 2 Planned:
A hydrologic/hydraulic model developed for daily simulation of individual and coordinated dam operations in the Mekong basin.

Component 2 Actual at Completion:
Although several hydrologic/hydraulic basin wide models were evaluated, limitations in each were found and therefore an advanced daily simulation model for individual and coordinated dam operations in the Mekong basin was developed and applied to the 3S basin.

One key limitation across all Mekong hydrological/hydraulic models was the simplified representation of hydropower development and operations in the tributaries. Out of all Mekong tributaries, the 3S basin (Sesan, Srepok, and Sekong) was identifies as being of critical importance in terms of potential level of hydropower development and subsequent impact on Mekong river flows and sediment. Mean annual discharge from the 3Ss represents approximately 17-20% of total annual flows of the Mekong mainstream, making it the largest tributary contribution to the Mekong River. There are nine existing dams and 11 projects under construction with a total installed capacity of 3,643 Mw and a total live storage of 6,196 mcm. Twenty one other projects are at various levels of planning and priority stages which have a proposed installed capacity of 2,721 Mw and a total live storage of 20,125 mcm. The energy production of those hydropower projects are planned to be destined to support socio-economic development inside the basin, but plans also include the potential to export energy to countries outside the basin. The implications of this development and operation of dams on flows, sediment, and subsequent downstream ecosystems were poorly understood. A detailed model of hydropower development and operations (HEC-ResSim combined with SWAT) was therefore developed and applied.

The model was used to show that development of all dams in the 3S basin and operations to maximize energy production will significantly attenuate the difference between wet and dry season flows. The energy production will increase marginally compared to the increase in active storage in the basin. The magnitude of flow changes varies from location to location and depends on number, size, locations, and operation of hydropower dams.

The 3S basin model is available from our web site: www.mekongflows.org. Other models used for our work are described in the various publication listed below.

Component 3 Planned:
Current and alternative Mekong basin development scenarios compared and evaluated.

Component 3 Actual at Completion:
Various current and alternative development scenarios were simulated. These included using the standard MRC based scenarios (baseline, definite future, and various long term scenarios up to full development). For the 3S basin, scenarios simulated included a baseline, definite future, development in sub-tributaries, development in main tributaries, individual dam simulations, cascade dam systems, large dams, small dams, and various combinations. Three operation scenarios for each dam were also simulated which included maximizing energy production, ecological operation, and flood prevention operation of the reservoirs.

Results from the 3S model simulations, together with basin wide modeling, show that development of proposed dams in the 3S Basin will have a considerable impact on flows and water levels in the Mekong mainstream, but the impact depends on the level of development and how they are operated. The magnitude of flow changes at Kratie from the development and operation of all proposed dams in the 3S basin is comparable to existing and under construction large mainstream hydropower projects in the upper Mekong (China) and significantly larger than the magnitude of flow changes induced by the 11 proposed mainstream dams in the LMB. Changes to flows, together with alteration of fish migration routes and sediment flows, can lead to a subsequent level of decrease of ecological and fish productivity in the Tonle Sap, other lower Mekong flood plains, and enhance salt intrusion in the Mekong Delta.

Changes in flow regimes at the outlet of the 3S basin, however, will mainly be caused by the 7 largest proposed hydroelectric projects in the 3S basin. Their large potential to impact flows and retain sediment, with relatively small gains in overall energy production compared to the substantial increase in active storage, indicate that they should be further scrutinized in term of their combined economic, environmental, and wider social impacts, before premature decisions are made to implement them. The small proposed hydropower projects on sub tributaries of the 3S Rivers have much smaller impact on flow changes and a higher ratio of energy to active storage compared to the proposed large dams on the 3S Rivers mainstream, and thus developing the smaller dams in the sub tributaries may be a compromising alternative for economic development of hydropower in the basin, while reducing social and environment impacts.

Detailed results of multiple scenario simulations are available in the following publications:

Piman, T. and Cochrane, T.A. (2013) Assessment of flow changes from the operation of dams in the Mekong basin. The International Journal on Hydropower & Dams 20(1): 44-48.

Piman, T., Cochrane, T., Arias, M., Green, A. and Dat, N. (2013) Assessment of flow changes from hydropower development and operations in Sekong, Sesan and Srepok Rivers of the Mekong Basin. Journal of Water Resources Planning and Management (early access online) http://dx.doi.org/10.1061/(ASCE)WR.1943-5452.0000286.

Piman, T., Cochrane, T.A., Arias, M.E., Green, A., and Vonnarart, O. (2013) The Effects of Climate Change on Flow Regime and Hydropower Production in the Sekong, Sesan and Srepok Rivers of the Mekong Basin. Journal of Water and Climate Change. (under review)

Piman, T., Cochrane, T.A., Arias, M.E. (2013) Effect of Large Dams on Water Flows and Hydropower Production in the Sekong, Sesan and Srepok Rivers of the Mekong Basin. River Research and Applications (in preparation)

Component 4 Planned:
Expected changes to vegetation and ecosystem productivity from potential changes in river flows demonstrated and quantified.

Component 4 Actual at Completion:
Changes to vegetation, productivity and fauna in the Tonle Sap were quantified for various potential future hydropower development scenarios and climate change. Potential impacts of hydropower were substantially higher than those of climate change. A full hydropower development would result in a decrease of 22% floodplain area, potentially making a large portion of that land viable for agriculture. This change would also result in up to 40% loss of gallery forests and a reduction in net primary productivity of up to 39%. In the long term, a shift in vegetation communities would occur, with a resulting reduction in critical habitat areas for specific fauna. Current conservation areas would shift as the hydrology of the system changes and therefore conservation efforts would need to target new critical habitat areas imposed by future water regimes.

Detailed results can be found in the following publications:

Arias, M.E. (2013) Impacts of Hydrological Changes to the Tonle Sap Ecosystem. PhD Thesis, University of Canterbury (under review).

Arias, M.E., Cochrane, T.A., Piman, T., Kummu, M., Caruso, B., and Killeen, T.J. (2012) Quantifying changes in flooding and habitats in the Tonle Sap Lake (Cambodia) caused by water infrastructure development and climate change in the Mekong Basin. Journal of Environmental Management, http://dx.doi.org/10.1016/j.jenvman.2012.07.003

Arias, M.E., Cochrane, T.A., Elliott, V. (2013) Modelling future changes of habitat and fauna in the Tonle Sap wetland of the Mekong. Environmental Conservation (under review)

Arias, M.E., Cochrane, T.A., Norton, D., Killeen, T.J., and Khon, P. (2013). The flood pulse as the underlying driver of vegetation in the largest fishery of the Mekong Basin. AMBIO (under review)

Arias, M.E., Cochrane, T.A., Kummu, M., Lauri, H., Koponen, J., Holtgrieve, G.W., and Piman, T. (2013) Impacts of hydropower and climate change on drivers of ecological productivity of Southeast Asia's most important wetland. Ecological Modeling (submitted)

Component 5 Planned:
A current high resolution land cover map of wetland, flooded forests, and agricultural lands of the Mekong River and main tributary floodplains compiled as a base-line for future monitoring and modeling of changes.

Component 5 Actual at Completion:
A high resolution land cover map of the area between Stung Treng and Kratie was developed from SPOT imagery. This map will provide a benchmark land cover map for future studies. The area between Stung Treng and Tonle Sap was classified with Landsat imagery and flood extents were derived from Modis imagery. A preliminary examination of the feasibility of a large scale corridor along the mainstream of the Mekong floodplain was done. Unfortunately much of the current landuse along the Mekong is dedicated to cultivation, but there are some remaining areas which could form part of a conservation corridor. Site visits and detailed analysis would be necessary to advance this further. The maps and information were given to organizations working in the region who could pursue this in the future. The maps will be used by our team to investigate the geomorphological and vegetation changes which could occur in this stretch of the Mekong as a result of hydropower operations in the 3S basin.

Component 6 Planned:
A framework for monitoring and mitigating impacts on biodiversity and ecosystems from future potential changes in hydrological and climate regimes proposed.

Component 6 Actual at Completion:
The modeling framework developed to predict changes in fauna and vegetation in the Tonle Sap, and other wetland areas, was used to identify key areas for monitoring of changes based on predicted future development scenarios.

Continuous monitoring of sediment, flows, and nutrients from Mekong tributaries was identified as being of critical importance to evaluate ongoing hydropower development. The MRC is now investing in monitoring sediment from the 3S basin and these results will be in follow-up work.

A framework for payments for ecosystem services was developed which can be applied to forested catchments above hydropower facilities in the Mekong basin. Details of this framework can be found here:
Arias, M.E., Cochrane, T.A., Lawrence, K., Killeen, T.J. and Farrell, T.A. (2011) Paying the forest for electricity: A modelling framework to market forest conservation as payment for ecosystem services benefiting hydropower generation. Environmental Conservation, 38(4), 473-484. http://dx.doi.org/10.1017/S0376892911000464.

Component 7 Planned:
Results from modeling efforts and alternative development options disseminated and welcomed by stakeholders and decision makers.

Component 7 Actual at Completion:
Results from the modeling efforts and alternative development options have been disseminated to stakeholders and decision makers through the following means:
1. An extensive number of work meetings and seminars (w/ MRC, Simpson Center, NHI, CI, Lao Dept. of Energy, Tonle Sap Authority, MOWRAM, Cambodia Fisheries Administration, and various NGO's).
2. Peer reviewed publications / reports / thesis (see list below)
3. Conferences (see list below)
4. Website: www.mekongflows.org
5. Collaboration with CI is ongoing for wider dissemination of our work through short film and news reports.

Were any components unrealized? If so, how has this affected the overall impact of the project?

The core of all components was realized, but we ensured enough flexibility to pursue critical avenues of study as our project progressed. For example, we placed a large emphasis on historical analysis of water level data, the 3S basin modeling, and analysis of impacts to vegetation, fauna, and productivity of key wetland areas such as the Tonle Sap. We believe the decision to focus more effort on those components enhanced our project results. However, we also had to limit some components of the project. A detailed landcover map for the whole Mekong, for example, was not possible due to time and budget constraints. The area between Stung Treng and Kratie is, however, critical and the land cover map developed for this area will be a valuable benchmark for future studies.

Please describe and submit (electronically if possible) any tools, products, or methodologies that resulted from this project or contributed to the results.

Published papers:

Piman, T. and Cochrane, T.A. (2013) Assessment of flow changes from the operation of dams in the Mekong basin. The International Journal on Hydropower & Dams 20(1): 44-48.

Piman, T., Cochrane, T., Arias, M., Green, A. and Dat, N. (2013) Assessment of flow changes from hydropower development and operations in Sekong, Sesan and Srepok Rivers of the Mekong Basin. Journal of Water Resources Planning and Management (early access online) http://dx.doi.org/10.1061/(ASCE)WR.1943-5452.0000286.

Piman, T., Lennaerts, T., and P. Southalack (2013) Assessment of hydrological changes in the lower Mekong Basin from Basin-Wide development scenarios. Hydrological Processes. DOI: 10.1002/hyp.9764

Arias, M.E., Cochrane, T.A., Piman, T., Kummu, M., Caruso, B., and Killeen, T.J. (2012) Quantifying changes in flooding and habitats in the Tonle Sap Lake (Cambodia) caused by water infrastructure development and climate change in the Mekong Basin. Journal of Environmental Management, http://dx.doi.org/10.1016/j.jenvman.2012.07.003

Arias, M.E., Cochrane, T.A., Lawrence, K., Killeen, T.J. and Farrell, T.A. (2011) Paying the forest for electricity: A modelling framework to market forest conservation as payment for ecosystem services benefiting hydropower generation. Environmental Conservation, 38(4), 473-484. http://dx.doi.org/10.1017/S0376892911000464.

Publications under review or in preparation:

Arias, M.E. (2013) Impacts of Hydrological Changes to the Tonle Sap Ecosystem. PhD Thesis, University of Canterbury (under review).

Arias, M.E., Cochrane, T.A., Elliott, V. (2013) Modelling future changes of habitat and fauna in the Tonle Sap wetland of the Mekong. Environmental Conservation (under review)

Piman, T., Cochrane, T.A., Arias, M.E., Green, A., and Vonnarart, O. (2013) The Effects of Climate Change on Flow Regime and Hydropower Production in the Sekong, Sesan and Srepok Rivers of the Mekong Basin. Journal of Water and Climate Change. (under review)

Cochrane, T.A., Piman, T, and Arias, M.E. (2013). An analysis of the impact of water infrastructure on water levels of the Mekong River and the Tonle Sap. Journal of Hydrology (in preparation)

Arias, M.E., Cochrane, T.A., Norton, D., Killeen, T.J., and Khon, P. (2013). The flood pulse as the underlying driver of vegetation in the largest fishery of the Mekong Basin. AMBIO (under review)

Arias, M.E., Cochrane, T.A., Kummu, M., Lauri, H., Koponen, J., Holtgrieve, G.W., and Piman, T. (2013) Impacts of hydropower and climate change on drivers of ecological productivity of Southeast Asia's most important wetland. Ecological Modelling (submitted)

Piman, T., Cochrane, T.A., Arias, M.E. (2013) Effect of Large Dams on Water Flows and Hydropower Production in the Sekong, Sesan and Srepok Rivers of the Mekong Basin. River Research and Applications (in preparation)

Conference presentations/papers:

Arias, M.E., Cochrane, T.A., Norton, D., Killeen, T., Khon, P. (2013) The flood pulse as the underlying driver of vegetation in the Tonle Sap. Mekong Environmental Symposium, 5-7 March, 2013, Ho Chi Minh City, Vietnam.

Arias, M.E., Cochrane, T.A., Lawrence, K., Killeen, T., Farrell, T. (2013) Paying the forest for electricity: a modeling framework to market forest conservation as payment for ecosystem services benefiting hydropower generation. Mekong Environmental Symposium, 5-7 March, 2013, Ho Chi Minh City, Vietnam.

Piman, T., Cochrane, T.A., Arias, M., Green, A., Omanong, V. (2013). Flow changes in the Mekong from Hydropower Development and Climate Change in the Sre Kong, Se San, and Sre Pok Rivers. Mekong Environmental Symposium, 5-7 March, 2013, Ho Chi Minh City, Vietnam.

Piman, T. and Cochrane, T.A. (2012) *Assessment of Flow Changes from Operations of 41 Dams in the Sekong, Sesan and Srepok Rivers of the Mekong Basin.* Chiang Mai, Thailand: Asia 2012: Fourth International Conference on Water Resources and Renewable Energy Development in Asia, 26-27 Mar 2012.

Piman, T., Cochrane, T.A. and Arias, M. E. (2012) *Combined Impact of Climate Change and Hydropower Development on Flows of the Sre Kong, Se San and Sre Pok Rivers in the Mekong Basin.* IWA (International Water Association) World Congress on Water, Climate and Energy. Dublin, Ireland, 13-18 May 2012.

Arias, M.E., Cochrane, T.A., Piman, T. and Kummu M. (2012) *Impacts of hydrology and habitat changes on the primary production of Southeast Asia's largest lake.* IWA (International Water Association) World Congress on Water, Climate and Energy. Dublin, Ireland, 13-18 May 2012.

Arias, M.E., Cochrane, T.A., Caruso, B., Killeen, T. and Kummu, M. (2011) *A landscape approach to assess impacts of hydrological changes to vegetation communities of the Tonle Sap Floodplain.* Brisbane, Australia: 34th World Congress of the International Association for Hydro-Environment Engineering and Research (IAHR), Jun 26-Jul 1 2011. (Published in Conference Proceedings)

Arias, M.E., Cochrane, T.A., Norton, D. (2011) Fish, Mud, Thorns, and Rice: Field Survey of Floodplain Habitats in the Tonle Sap, Cambodia. 25th International Congress for Conservation Biology, Auckland, New Zealand, December 5-9, 2011 (Oral Presentation).

Cochrane, T.A. and Piman, T. (2011) *Assessment of Flow Changes from Hydropower Development and Operations in Sre Kong, Se San and Sre Pok Rivers of the Mekong Basin.* Conservation International, Arlington, United States: Expert Group Meeting, 30 Aug 2011. (Oral Presentation)

Cochrane, T.A. and Piman, T. (2011) *Assessment of Flow Changes from Hydropower Development and Operations in Sre Kong, Se San and Sre Pok Rivers of the Mekong Basin.* US Army Crops of Engineers, Davis, CA, USA: A Climate Resilient Mekong: Maintaining the Flows that Nourish Life Workshop on Data and Models, 19 Aug 2011. (Oral Presentation)

Teasley, R., Cochrane, T.A. and Arias, M. (2011) *Characterizing Potential Alterations in Streamflow in the Mekong River from Dam Construction and Operation in the Nam Ngum Tributary.* Palm Springs, CA, USA: 2011 World Environmental & Water Resources Congress, 22-26 May 2011. (Conference Contribution - Oral presentation)

Piman, T. and Cochrane, T.A. (2011) *Hydropower Dams on the Mekong and "3S" Rivers: A Regional Environmental and Socioeconomic Perspective.* Stimpson Center, Washington, DC, USA: 31 Aug 2011. (Oral Presentation - http://www.stimson.org/video/interview-with-dr-tom-cochrane/)

Cochrane, T.A., Arias, M.E., Teasley, R.L. and Killeen, T.J. (2010) *Simulated changes in water flows of the Mekong River from potential dam development and operations on the Se San and Sre Pok tributaries.* Montreal, Canada: IWA World Water Congress and Exhibition (IWA 2010), 19-24 Sep 2010. (Conference Contribution - Paper in published proceedings)

Lessons Learned

Describe any lessons learned during the design and implementation of the project, as well as any related to organizational development and capacity building. Consider lessons that would inform projects designed or implemented by your organization or others, as well as lessons that might be considered by the global conservation community.

Project Design Process: (aspects of the project design that contributed to its success/shortcomings)

Given the rapidly changing political and development situation in the basin, flexibility in designing and implementing this project was necessary to ensure good outcomes. Having support from key organizations such as MRC, CI, and various NGO's from the onset of the project contributed to the success of the project and facilitated the dissemination of results.

Project Implementation: (aspects of the project execution that contributed to its success/shortcomings)

A large portion of the project was about modeling, and thus establishing a good relationship and collaborative atmosphere with key modelers in the region (both local and international) allowed our team to focus on developing better tools where obvious gaps were found. Developing and running new models would not have been possible without extensive collaboration and sharing of available data with other modelers. Having local modelers in our team ensured uptake of our models by local institutions. Publishing our work gave a higher level of credibility to our results.

Other lessons learned relevant to conservation community:

One contribution made by this project has been to identify the proposed water resources development in the 3S basin as being of critical importance in terms of potential impacts to downstream ecosystems and productivity of the Tonle Sap, floodplains, and delta. A risk which has recently developed is the directive by the Cambodian government to develop the Lower Sesan 2 dam, effectively blocking both the Sesan and Sre Pok Rivers. Broader dissemination of the potential downstream impacts of full hydropower development in the 3S basin is necessary to counteract or avoid poor political decisions. Furthermore, knowledge is needed on understanding the potential related effects of landuse change in the region and how this will affect ecosystem productivity. Modeling and scenario work has to be ongoing as new dam proposals emerge and other threats emerge.

Additional Funding

Provide details of any additional funding that supported this project and any funding secured for the project, organization, or the region, as a result of the CEPF investment in this project.

Donor	Type of Funding*	Amount	Notes
University of Canterbury	In-Kind	$116,000	PhD scholarship, conference funding, salary/benefits, computer software, hardware, monitoring equipment
CI	In-kind	$80,000	In country support for field work, coordination, meetings, local and international travel
MacArthur Foundation	B/C	$260,000 for 2013-2015	New project to improve modeling of the 3S basin and study the feasibility of implementing PES in relevant catchments above hydropower dams.

Additional funding should be reported using the following categories:

A *Project co-financing (Other donors or your organization contribute to the direct costs of this project)*

B *Grantee and Partner leveraging (Other donors contribute to your organization or a partner organization as a direct result of successes with this CEPF funded project.)*

C *Regional/Portfolio leveraging (Other donors make large investments in a region because of CEPF investment or successes related to this project.)*

Sustainability/Replicability

Summarize the success or challenge in achieving planned sustainability or replicability of project components or results.

All the modeling we did can be replicated and new scenarios of potential development can be simulated. The models have been transferred to stakeholders and the results of a series of scenarios have been published (or are being published). Our Mekong Flows team is now focusing research in the 3S basin to improve knowledge on the potential changes to sediment transport, nutrient flows, and landuse change. One of our former team members now works in a senior post at MRC, enhancing collaboration on issues related to the 3S basin.

Summarize any unplanned sustainability or replicability achieved.

Safeguard Policy Assessment

Provide a summary of the implementation of any required action toward the environmental and social safeguard policies within the project.

N/A

Additional Comments/Recommendations

We express our immense gratitude to CEPF for giving us the opportunity to investigate the potential impacts of large-scale disruptions of hydrological cycles on biodiversity and natural systems of the Mekong basin. We strongly believe that a better future for the people in the basin is possible by through reconciliation between development objectives and biodiversity conservation.

Information Sharing and CEPF Policy

CEPF is committed to transparent operations and to helping civil society groups share experiences, lessons learned, and results. Final project completion reports are made available on our Web site, www.cepf.net, and publicized in our newsletter and other communications.

Please include your full contact details below:

Name: Tom Cochrane
Organization name: University of Canterbury
Mailing address: Private Bag 4800, Dept. of Civil and Natural Resources Engineering, Christchurch, New Zealand 8140
Tel: +64 3 3642378
Fax:
E-mail: tom.cochrane@canterbury.ac.nz

*****If your grant has an end date other than JUNE 30, please complete the tables on the following pages*****

Performance Tracking Report Addendum

CEPF Global Targets				
(Enter Grant Term) **Provide a numerical amount and brief description of the results achieved by your grant.** **Please respond to only those questions that are relevant to your project.**				
Project Results	**Is this question relevant?**	**If yes, provide your numerical response for results achieved during the annual period.**	**Provide your numerical response for project from inception of CEPF support to date.**	**Describe the principal results achieved from** 1 July, 2012 to 31 March, 2013 **(Attach annexes if necessary)**
1. Did your project strengthen management of a protected area guided by a sustainable management plan? Please indicate number of hectares improved.	No			Please also include name of the protected area(s). If more than one, please include the number of hectares strengthened for each one.
2. How many hectares of new and/or expanded protected areas did your project help establish through a legal declaration or community agreement?	No			Please also include name of the protected area. If more than one, please include the number of hectares strengthened for each one.
3. Did your project strengthen biodiversity conservation and/or natural resources management inside a key biodiversity area identified in the CEPF ecosystem profile? If so, please indicate how many hectares.	No			
4. Did your project effectively introduce or strengthen biodiversity conservation in management practices outside protected areas? If so, please indicate how many hectares.	No			
5. If your project promotes the sustainable use of natural resources, how many local communities accrued tangible socioeconomic benefits? Please complete Table 1below.	No			

If you answered yes to question 5, please complete the following table

Table 1. Socioeconomic Benefits to Target Communities

Please complete this table if your project provided concrete socioeconomic benefits to local communities. List the name of each community in column one. In the subsequent columns under Community Characteristics and Nature of Socioeconomic Benefit, place an X in all relevant boxes. In the bottom row, provide the totals of the Xs for each column.

Name of Community	Community Characteristics								Nature of Socioeconomic Benefit												
									Increased Income due to:												
	Small landowners	Subsistence economy	Indigenous/ ethnic peoples	Pastoralists/nomadic peoples	Recent migrants	Urban communities	Communities falling below the poverty rate	Other	Adoption of sustainable natural resources management practices	Ecotourism revenues	Park management activities	Payment for environmental services	Increased food security due to the adoption of sustainable fishing, hunting, or agricultural practices	More secure access to water resources	Improved tenure in land or other natural resource due to titling, reduction of colonization, etc.	Reduced risk of natural disasters (fires, landslides, flooding, etc)	More secure sources of energy	Increased access to public services, such as education, health, or credit	Improved use of traditional knowledge for environmental management	More participatory decision-making due to strengthened civil society and governance.	Other
Total																					

If you marked "Other", please provide detail on the nature of the Community Characteristic and Socioeconomic Benefit: