

2-2016

The Socio-Political Impact of Large-Scale Damming Along the Mekong River, Particularly in Cambodia

John M. Lynch

Follow this and additional works at: <http://digitalcommons.apus.edu/theses>



Part of the [Environmental Health and Protection Commons](#)

Recommended Citation

Lynch, John M., "The Socio-Political Impact of Large-Scale Damming Along the Mekong River, Particularly in Cambodia" (2016).
Master's Capstone Theses. Paper 89.



APUS Library Capstone Submission Form

This capstone has been approved for submission to and review and publication by the APUS Library.

Student Name [Last, First, MI] *	Lynch	John	M
Course Number [e.g. INTL699] *	EVSP699	Paper Date [See Title pg.]	01/2016
Professor Name [Last, First] *	D'Andrea, Elizabeth		
Program Name *	Environmental Policy and Management		
Keywords [250 character max.]	Mekong River, dams, hydropower, Southeast Asia Environment, d		
Passed with Distinction * Y or N	Y		
Security Sensitive Information * Y or N	N		
IRB Review Required * Y or N	N	if YES, include IRB documents in submission attachments.	
Turnitin Check * Y or N	Y	All capstone papers must be checked via Turnitin.	

* Required

Capstone Approval Document

The thesis/capstone for the master's degree submitted by the student listed (above) under this title *

The Socio-Political Impact of Large-Scale Damming Along the Mekong River, Particularly in Cambodia

has been read by the undersigned. It is hereby recommended for acceptance by the faculty with credit to the amount of 3 semester hours.

Program Representatives	Signatures	Date (mm/dd/yyyy)
Signed, 1 st Reader * [capstone professor]	Dr. Elizabeth DAndrea  Digitally signed by Dr. Elizabeth DAndrea Date: 2016.01.24 21:35:50 -05'00'	01/24/2016
Signed, 2nd Reader (if required by program)		
Recommendation accepted on behalf of the <u>program director</u> *	  Digitally signed by kreiss@apus.edu DN: cn=kreiss@apus.edu Date: 2016.03.06 15:00:30 -05'00'	03/06/2016
Approved by <u>academic dean</u> *	Dan Benjamin  Digitally signed by Dan Benjamin Date: 2016.03.19 15:23:53 -04'00'	

* Required

<p>Send thesis submission to:</p> <p style="text-align: center;">ThesisCapstoneSubmission@apus.edu</p>	<p>Attachments <u>must</u> include:</p> <ul style="list-style-type: none"> • This completed form • FINAL Thesis document as Microsoft Word file • IRB Review docs (if applicable)
---	--

THE SOCIO-POLITICAL IMPACT OF LARGE-SCALE DAMMING ALONG
THE MEKONG RIVER, PARTICULARLY IN CAMBODIA

A Master Thesis

Submitted to the faculty

of

American Public University

by

John Lynch

In Partial Fulfillment of the

Requirements of the Degree

of Master of Science

January, 2016

American Public University

Charles Town, WV

The author hereby grants the American Public University System the right to display these contents for educational purposes.

The author assumes total responsibility for meeting the requirements set by United States Copyright law for the inclusion of any materials that are not the author's creation or in the public domain.

© Copyright 2016 by John Lynch

All rights reserved.

ACKNOWLEDGEMENTS

I wish to thank Seanghai Chang for providing me with essential background information regarding the historical and current social-political climate in Cambodia. His assistance, passion for justice, fairness and concern over the future of his country has enriched my learning experience throughout the course of my research. His friendship has been a source of encouragement, support and motivation, and he helped me to appreciate how scientific research can intersect with the betterment of humanity.

ABSTRACT OF THE THESIS

THE SOCIO-POLITICAL IMPACT OF LARGE-SCALE DAMMING ALONG THE MEKONG
RIVER, PARTICULARLY IN CAMBODIA

by

John Lynch

American Public University System, January 10, 2016

Charles Town, West Virginia

Professor Elizabeth D'Andrea, Thesis Professor

Potential ecological change along in the Mekong River Basin do to the rapid development of hydropower is well-researched. However, little is known about socio-political factors that are contributing to the creation of numerous dams along the Mekong River and major tributaries. A quantitative analysis of precipitation amounts and water levels in the Upper Mekong River Basin attempts to establish a relationship between dams in China and alterations to water levels through the Lower Mekong River. A qualitative analysis is used to explore the political and economic influences that contribute to additional dam construction within the Lower Mekong River Basin that threatens the ecological stasis of the region.

Findings validate predictive modeling used to establish a relationship between upstream dams

and downstream water levels. Findings also reveal how governments in the region are investing in hydropower in order to promote economic growth in the absence of sound environmental planning or management strategies. Consequently, the lack of environmental policies as well as limitations in regional, trans-boundary governance are putting the food, economic and social security of millions of inhabitants in the LMB, particularly in Cambodia, at risk.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION.....	7
BACKGROUND.....	9
II. PURPOSE.....	13
III. LITERATURE REVIEW.....	15
IV. STATEMENT OF THE PROBLEM.....	32
HYPOTHESIS.....	33
V. RESEARCH DESIGN.....	34
DATA COLLECTION.....	36
VI. RESULTS.....	43
VII. DISCUSSION.....	59
VII. CONCLUSION.....	66
LIST OF REFERENCES.....	70

Introduction

The Mekong River is more than 4900 kilometers long, traverses six countries and has a direct or indirect impact on the lives of more than 60 million people. It is considered to be one of the greatest rivers in the world, and supports one of the most diverse ecosystems on Earth (MRC, 2015). Myanmar, Thailand, Laos, Cambodia and Vietnam are situated within the Lower Mekong Basin (LMB).

While all of these countries rely on the Mekong River for food, the transportation of goods and services and economic stability, the Cambodian people are the most susceptible to environmental change within the Mekong River Basin (MRB). Water from the Mekong River sustains agricultural activity and the productivity of inland fisheries in Cambodia. These fisheries provide Cambodia's 14 million inhabitants with the majority of their daily protein intake, and its waters sustain crop production throughout the country.

One of the greatest threats to the ecological health of the MRB comes from large-scale damming projects that have either been, or are planned to be completed by 2030. The first dam to be built across the Mekong river became operational in 1995 in southern China. The Mekong River is called the Lancang River in China, and its catchment is referred to as the Upper Mekong River Basin (UMB). The Chinese government has completed a series of six main-stem dams along the Lancang River, and these dams are collectively referred to as the Lancang cascade. The Lancang cascade was developed primarily for the generation of hydroelectricity that is used to supply the industrial corridor that is situated in the southern part of China. The Lancang cascade is also used to capture and store water for municipal water supplies, irrigation and industrial purposes.

The Laotian government intends to use dams primarily as a way to generate power for domestic consumption as well for export to China, Thailand, Cambodia and Vietnam. The Laotian government perceives this as a stable and long-term opportunity for sustained economic growth. Laos has minimal

natural resources and is considered to be one of the poorest countries in the world. The Laotian government is currently constructing the Xayaburi dam which will be the first main-stem dam to be developed within the LMB.

The Laotian and Cambodian governments have completed, are building or plan to construct numerous dams along tributaries that flow into the Mekong River. Thailand and Vietnam have already developed their respective tributaries to their full hydropower-generating potential and are seeking additional supplies that the Laotian government wants to provide (MRC, 2010). While hydropower is perceived to provide a source of clean and renewable energy that uses proven technology, the extensive development of main-stem and tributary dams can impact the natural flow of the Mekong River to the degree that the ecological stasis of the LMB is threatened.

It is well-known that dams can cause ecological damage. Some examples include how dams obstruct migratory pathways of fish, disturb riparian ecosystems and impede the transport of nutrient-rich sediments downstream. Reservoirs behind dams also flood and alter landscapes upstream as well. Furthermore, water that is discharged from dams can influence downstream water levels and flow rates in addition to contributing to bank erosion and reducing water quality.

Large-scale dam projects within the MRB can have negative consequences for those who are directly and indirectly connected to the Mekong River. Cultural traditions, economic freedom and food security may all be impacted. The potential severity of these alterations also threatens peace and security as dams built by upstream governments can impact the growth and stability of nations downstream.

Background

Figure 1. The Mekong River Basin.

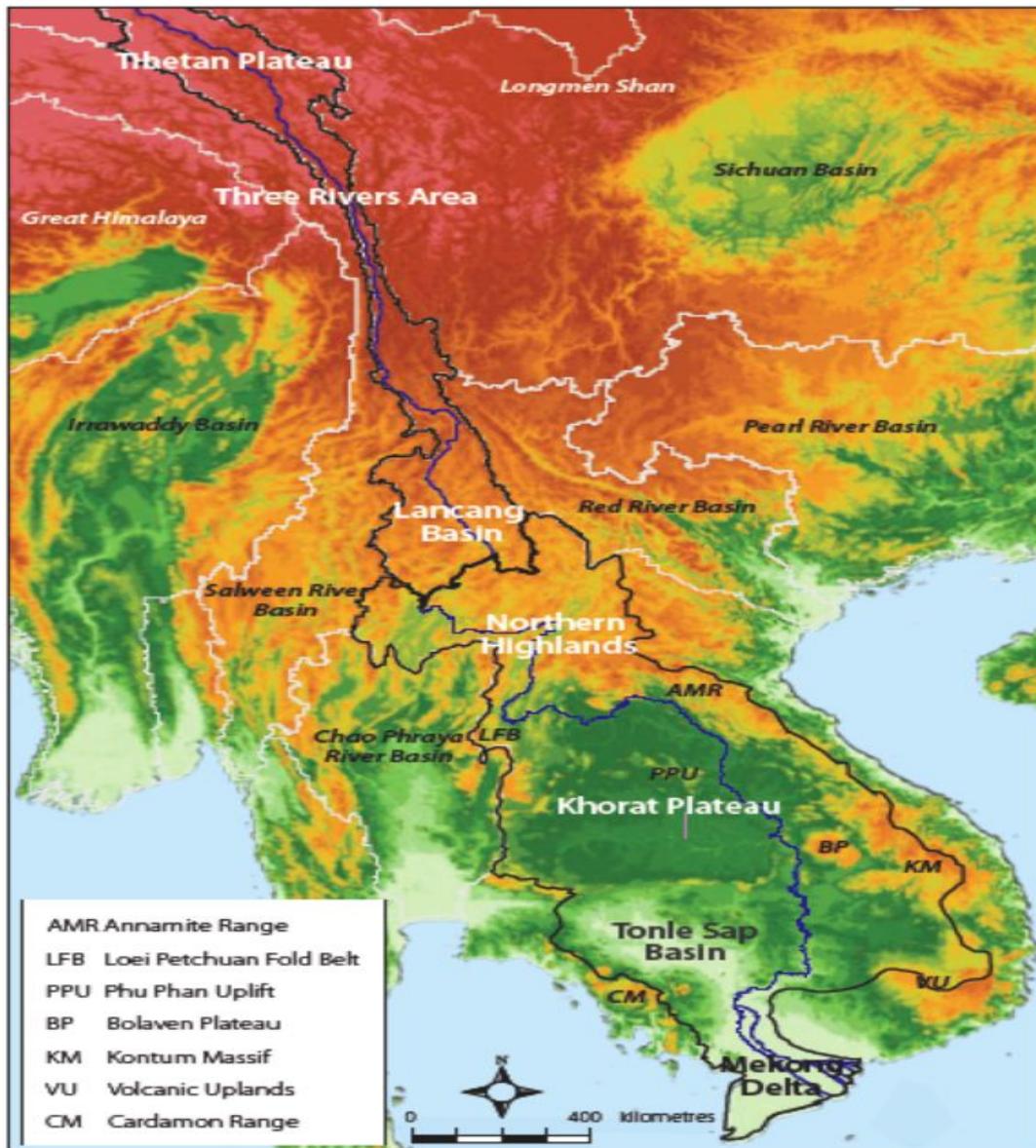


Figure 1. The Mekong River Basin. Reprinted from *Physiographic Regions*, by the MRC, 2010. Retrieved from <http://www.mrcmekong.org/mekong-basin/physiography/physiographic-regions/>. Copyright 2010 by MRC.

The Mekong River originates in the Tibetan Plateau in Southern China. It traverses through Myanmar, Laos, Thailand, Cambodia and Vietnam before discharging into the South China Sea. A

number of important tributaries that are situated within the LMB supply the Mekong River with the largest volume of water and greatest amount of species diversity. The MRC has divided the Mekong River into four sections based on the presence of sub-watersheds. Each section has then been analyzed to determine how much water is fed into the Mekong River. The UMB contributes approximately 16% of total inflow. The two middle sections, which essentially follow the path of the Mekong River across Laos, contribute 40%, whereas the rest comes from catchments in Myanmar, Thailand, Vietnam and Cambodia (MRC, 2009). Consequently, the majority of dams that currently exist, are under construction or are planned will occur in the region where most of the water enters the Mekong River.

Estimates by the MRC indicate that demand for power in the region will increase between six and seven percent annually between 2005 and 2025. Projections indicate that 30% of the electricity that is generated from hydropower will be sold to Thailand and Vietnam. The rest will be used for domestic consumption or export to other nations in the region. Other forms of power will come from fossil fuels, the development of renewable energy technologies and nuclear power plants (MRC, 2009). Laos and Cambodia will only need a fraction of the energy that is supplied by dams that are being built within their national borders. Consequently, any excess power generation could also be sold or exported to other countries or power companies.

The impact of damming in the LMB presents a particular concern for Cambodia. Cambodia has limited land area. This minimizes options in terms of utilizing available resources to accommodate environmental change caused by alterations to the flow regime of the Mekong River and Tonle Sap Lake. Tonle Sap Lake is the largest freshwater lake in southeast Asia. This large and shallow lake is the primary source of fish for food in Cambodia. It also serves as a breeding ground for numerous species, some of which are endangered, that migrate from the lake into the Mekong River as seasonal flood waters recede. Diminished water flow in the Mekong River has decreased the area of Tonle Sap Lake

and presents one of the biggest threats to food security as demand for fish continues to increase (Arias, Cochrane, Piman, Kummu, Caruso & Killeen, (2012).

The Mekong River Commission

The Mekong River Commission (MRC) was established in 1995 to serve as a cooperative and diplomatic platform for nations who share the LMB to manage the development of the Mekong River. Member countries include Laos, Thailand, Cambodia and Vietnam. Although the headwaters of the Mekong River originate in China, China only maintains an advisory role within the organization. The MRC is the only inter-governmental environmental management organization that oversees development activities in the LMB.

The organization is comprised of governmental representatives from member states, scientists and other stakeholders, who establish guidelines, make recommendations and contribute to a working knowledge-base of the ecological characteristics of the MRB. The mission of the MRC is to promote basin-wide development that fosters economic growth in a socially-responsible manner. However, the MRC does not create and implement policy, develop regulations or enforce environmental laws. It serves in an advisory capacity, and the ultimate decision-making responsibilities with respect to MRB development rests with the individual governments of member states. Unfortunately, this limitation enables countries to develop policies that favor their own growth and development at the expense of their neighbors or the environmental health of the MRB ecosystem.

The recent emergence of scientific research contributes to a growing body of knowledge that explores how the development of numerous, large-scale dams within the LMB has the potential to destroy entire ecosystems and habitats. Numerous species of aquatic organisms, fish, amphibians, reptiles, terrestrial animals, birds and landscapes have adapted to the unique and complex environment within the LMB. Existing research also suggests that the existence of main-stem and tributary dams

within the LMB may contribute to the decline and extinction of scores of fish and other animal species. Reports also indicate that people are adversely impacted by the construction of dams, primarily in the form of losing their livelihoods and becoming socially and economically displaced. However, there is a lack of comprehensive information regarding the socio-political and economic factors that contribute to the desire to harness the power of the Mekong River for electricity.

Purpose

This paper will examine the issue of damming in the MRB with an emphasis on the socio-political influences that are contributing to the rapid development of hydropower in the region. It is important to explore the underlying political and economic reasons that dams are such an attractive option in terms of development despite their known environmental risks. It is also important to evaluate potential human impacts associated with these projects as well as how governments are addressing these concerns. A particular focus will be given to Cambodia since the population has a unique dependence on the Mekong River for food and economic security as well as social stability. The Cambodian people are also particularly vulnerable to the effects of ecological change in the region.

The Chinese government and Chinese business entities have established a substantial role in the financing, construction and management of dams in the region. Investors from around the world are also engaging in hydropower development in the LMB. An examination into these activities will be conducted in an attempt to ascertain why such an interest exists. The economy of financing and investing in dam construction will be examined to gain a better understanding of the relationship between financial opportunities and governmental policies that are associated with the export of energy.

It is also important to examine how governments, particularly in Laos and Cambodia, evaluate the benefits of hydropower versus the potential environmental impacts of dam construction on major tributaries that flow into the Mekong River. This will also include research into how displaced people are compensated and resettled as the result of dam construction. An examination into land use, reductions in the availability or productivity of arable land and fisheries will help to gauge the potential impact that dam construction can have on food security in Cambodia as well. This information will help to evaluate the extent of planning that the Laotian and Cambodian governments have undertaken to mitigate the human impact of current and planned dam projects.

Finally, an evaluation of the impact that these considerations have on the efficacy of the MRC to establish cohesive development strategies will be conducted. This is important as the MRC is the only inter-governmental agency that is tasked with promoting the responsible development of the LMB.

Literature Review

The MRC has produced a detailed development study of the basin-wide impact of hydropower development based on three different scenarios. This baseline was established by creating a “hydrological situation” based on hydrological, economic, environmental and social data from 1985-2000 and the “socio-economic situation” based on data from 2008-2009 (MRC, 2011). Three different scenarios were then evaluated to include various changes to the ecology of the MRB. The first is a definite scenario which considered developments that were “fully expected to occur by 2015”. The second is a “foreseeable future scenario” which examined plans for hydrological development from member countries before the year 2030. A “long-term future scenario” was also established to evaluate the impact of long-term development plans that extend to the year 2060 (MRC, 2011).

This assessment measured each development scenario against 74 parameters which were then weighed against 12 development criteria that have been established by the MRC. The criteria include factors such economic development, environmental protection, social development and equitable development. Findings reveal that the definite scenario will produce “minimal” damage to the ecology of the MRB. However, they also indicate that current and definite dam projects in China will have their greatest ecological impact in the region. This impact is limited to a section of the Mekong River between the point where the UMB transitions into the LMB near Chiang Saen in northeastern Thailand to Vientiane, Laos. This is due to the hydrology of the region where the majority of water that enters the Mekong River is fed by tributaries within the LMB as opposed to being introduced from the UMB.

Furthermore, alterations to the seasonal pulse of the Mekong River, while reducing overall flows, can actually mitigate unwanted flooding in certain areas in addition to providing year-round water that is stored in reservoirs for irrigation during the dry season. Estimates indicate that this scenario will also produce approximately 370,000 new jobs. However, the reduction in size of

wetlands, flow reduction into the Tonle Sap Lake in Cambodia, erosion of the Mekong riverbank and alterations to the “delta shaping processes” in Vietnam are viewed as irreversible. Estimates also indicate that inland fishery productivity will be reduced by seven percent, and 1,000,000 million people will have their livelihood impacted by these changes (MRC, 2011).

Two foreseeable future scenarios are considered that include and exclude main-stem dams, respectively, on the Mekong River. The first scenario projects that water availability for irrigation during the dry season can increase up to 40% as opposed to if the river was allowed to run its natural course. This is expected to contribute eight billion dollars to the regional economy, primarily from agricultural development, and create an additional 650,000 jobs. The construction of 30 planned tributary dams in Laos and Cambodia will also increase the trapping of sediments, create barriers to fish migration, reduce the productivity of wetlands, further reduce delta-shaping processes in Vietnam and further reduce inland fishery productivity from seven to 10%. Furthermore, it is estimated that 1,400,000 people will become exposed to “some degree of livelihood risks.” (MRC, 2011).

The second foreseeable future scenario accounts for the creation of up to 11 main stem dams. An additional \$15 billion United States Dollars (USD) in economic growth will be generated, another 400,000 jobs will be created from constructing and operating the dams, and greenhouse gas emissions will be reduced by 50 million tons per year by 2030 from the use of hydropower instead of fossil fuel consumption. However, environmental destruction will be severe.

It is estimated that inland fishery productivity will be reduced by an additional 15%, an almost complete barrier for fish migration will be created, and sediment and nutrient transport in the LMB will be severely impacted to the degree that the extinction of numerous species will be inevitable. Habitats that are essential for species biodiversity such as rapids, deep pools of water and sandbars will be lost to a series of impoundments. Disruptions to livelihoods can impact 4,300,000 people, water quality

will be altered, and the risk of salinity intrusion into the river increases exponentially. Cambodia will be the most impacted followed by Vietnam which depends on the Mekong River delta for rice production. (MRC, 2011).

The Mekong River originates in the Tibetan Plateau where a series of deep mountain gorges converge in the Yunnan province in China. The UMB is considered to be the stretch of the Lancang River that extends from these headwaters until it converges with numerous tributaries in areas of the Myanmar/Laos border. The Upper Mekong River (UMR) flows for 2200 kilometers while descending 4500 meters before it reaches the LMB. The UMB covers an area of 190,000 km² and receives an annual average of 500 mm of precipitation in the north to more than 1600 mm in the south. Estimates indicate that 76% of the annual flow into the Mekong River in the UMB occurs between June and October. (Rasanan, Koponen, Lauri & Kummu, 2012).

A total of six dams in China were evaluated in this study as the remaining five upstream are considered to present a negligible impact on the MRB. Three dams have already been constructed at the time this study was published. It is estimated that the total amount of water that is captured in the Lancang cascade will represent 28% of the annual flow before it reaches the first MRB gauging station in Chiang Saen, Thailand. This study evaluated the degree of flow reduction based on the three existing dams as well as projections based on the commissioning of all six in the Lancang cascade.

Storage capacity in reservoirs associated with the three dam scenario is estimated to be 10.5 km³ and estimates indicate that 23.2 km³ will be captured when all six dams are completed. Two models were used to simulate flow alterations during the wet and dry seasons as water is released from reservoirs during periods of high precipitation or for regulating hydroelectric dam output based on power demand.

Findings reveal that flow rates at the Chiang Saen, Thailand reporting station and four other

downstream reporting stations decreased during the wet season and increased in the dry season. Additionally, a sustained decrease in seasonal flow variability and flooding magnitude was noted. Furthermore, less discharge was produced from the reservoirs during years of low rainfall as opposed to years with heavy precipitation. The study also paired the storage capacity of the Lancang cascade reservoirs with the different development scenarios established by the MRC. The total basin-wide storage capacity in the foreseeable future scenario is estimated to be 71.9 km³. Storage capacity for the long-term high development scenario is estimated to be 106.1 km³. Estimates indicate that the Lancang cascade will represent 32% of total storage capacity for the foreseeable future scenario, but decreases to 22% when incorporated into the long-term high development scenario. (Rasanan, Koponen, Lauri & Kummu, 2012).

Another study examined water level data from 1990 to 2010 from reporting stations in the LMB to establish a correlation between alterations in water levels and hydrological development. It also hypothesizes that the historic delay in hydropower development in southeast Asia is related to political instability from war in the region while dam building peaked during the 1970s around the world. While the previous study and the general consensus is that UMB dams in China present minimal impact on water levels on the Lower Mekong River (LMR), this study shows that levels are being altered as far south as central Cambodia. However, these majority of these alterations translate into higher dry-season water levels.

Data was collected from six reporting stations throughout the LMB that each represent a large catchment. Recorded water levels were used from 1960-1990 to establish averages before development along the Mekong River began in earnest. They were compared with totals from 1990-2010 to quantify any impact that hydropower development and crop irrigation had on river levels. The study accounted for alterations caused by the dams constructed in China as well as numerous smaller dams built along

various tributaries in Laos, Cambodia and Vietnam.

The study also provides background into the pace of dam building in the region. For example, 17 of the 39 dams that were completed by the date of publication were built between 2006 and 2010. These 17 dams account for 65% of “total active storage and 67% of total reservoir volume in the Mekong Basin up to 2010.” (Cochrane, Arias & Piman, 2014). Findings correlate what was presented in the previous study. Water levels rise during the dry season as water from reservoirs is discharged from dams to regulate hydropower output. A subtle decrease in flow rates after 1991 has been noted as dams reduce water output in order to fill reservoirs during the wet season. However, rise rates are also attributed to regulated water releases as a flood control measure or for irrigation. Most notably, the data also shows that the seasonal swelling and flooding of the Tonle Sap Lake basin in Cambodia was tempered somewhat in post-1991 years (Cochrane, Arias & Piman, 2014).

It is important to note that the data used for this study only extends to 2010. Two large-scale and a number of smaller dam projects have been either completed or are currently under construction between 2010 and 2015. Further analysis of water levels in addition to precipitation amounts at MRB reporting stations is necessary to establish whether additional dams are impacting water levels along the LMR and Tonle Sap Lake in Cambodia.

The Tonle Sap Lake, Cambodia swells from its average minimum surface area of 2600 km² during the monsoon season as water levels in the Mekong River rise to the point where some of the water reverses course and enters the Tonle Sap River. This phenomenon occurs when the maximum discharge rate of 10,000 m/s is reached and the lake is at its minimum average depth of 1.5 meters. This influx of water causes the Tonle Sap River, a minor tributary to the Mekong River, to reverse course. This reversal fills the lake to its annual maximum depth of 10 meters. Additionally, the surface area of Tonle Sap Lake swells to 15,000 km² (Arias, Cochrane, Piman, Kummu, Curuso & Killeen,

2012).

A thorough examination of historical data, primarily derived from GIS information, indicates that land cover changes over time were noted as agricultural productivity and population expansion increased after the end of the Khmer Rouge. However, these changes did not influence the naturally-occurring and seasonal flood patterns. The largest changes with the extent of the flood-pulse are associated with “water infrastructure development” that “is expected to reduce the flood extent by 1200 km².” (Arias, Cocharane, Piman, Kummu, Curuso & Killeen, 2012).

Furthermore, the study suggests that the borders of the lake will be the most likely to be impacted. The greatest changes are expected to occur during years of average rainfall, and the smallest changes are modeled to occur during years of heavy precipitation. Forests and shrublands that ring the lake provide the greatest contribution to habitat integrity because of their contribution to “sediment deposition, nutrient cycling, periphyton growth, primary production, fish food and refuge.” (Arias, Cocharane, Piman, Kummu, Curuso & Killeen, 2012).

The prime threat to the ecological balance of Tonle Sap Lake is not directly connected to a reduction in its seasonal size during the monsoonal flood pulse. Rather, it is expected to occur as the result of longer than average periods of swelling from an increase in dry-season water levels in the Mekong River due to upstream dams (Arias, Cocharane, Piman, Kummu, Curuso & Killeen, 2012). However, there is a well-noted lack of data available with respect to the state of the Tonle Sap Lake fishery as records regarding seasonal catches are not kept or monitored. Additionally, the complexity of this ecosystem and the role that it plays in supporting more than 100 species of aquatic life, many of which are migratory, has yet to be extensively researched.

The biggest direct influence on alterations to Tonle Sap Lake flood-pulse is the development of hydropower along the Sesan, Srepok and Sekong Rivers. These three basins are situated in a

geographical triangle that covers a 78,650 km² area of northeastern Cambodia, southern Laos and southwestern Vietnam. These three rivers generate the largest tributary flow into the Mekong River in the entire MRB and represent 23% of total annual basin-wide discharge (Arias, Piman, Lauri, Cochrane & Kummu, 2014). This study took into consideration the existing and planned dam and reservoirs along these three rivers and concluded that flow alterations exceed those of the entire Lancang cascade in the UMB. Furthermore, the cumulative impact of both dam clusters in the MRB will present a decrease in the availability of water as it enters the Mekong River near Phnom Penh, Cambodia.

However, dry season flow increases are expected to increase the depth of the Tonle Sap floodplain in the months leading up to the annual monsoon season while also extending the annual duration of the flood-pulse. These increases range from 47-61 cm in depth, and these projections are significantly higher than those estimated in future development scenarios produced by the MRC. One explanation is that these smaller hydropower projects and their impacts were not fully evaluated by the MRC at the time of the publication of the report (Arias, Piman, Lauri, Cochrane & Kummu, 2014). What is not understood is the potential impact that this will have on the Tonle Sap Lake ecosystem.

Tonle Sap Lake is an integral part of Cambodian culture, history, food security and economic stability. Nearly half of the population of Cambodia directly or indirectly depends on Tonle Sap Lake for agriculture and food. Approximately 77% of the population in the six provinces that surround the lake are rice farmers or engage in fishing. Most fishing activity in the lake centers on non-commercial enterprises as fishermen use traditional gear and methods to catch food for their families or to be sold in village markets. Fish consumption also represents 70% of the daily protein intake among the entire Cambodian population, and this translates into an average per-person consumption rate of about 60 kg per year (Kingdom of Cambodia Ministry of Environment, 2001).

The flood-pulse of the Mekong River supports the rich biodiversity of Tonle Sap Lake, and

approximately 500 of the 1200 known aquatic species in the Mekong River are from the lake.

Furthermore, it is suggested that the Mekong River could not sustain the current abundance of fish if the Tonle Sap Lake did not exist. Fish in the lake are classified into three categories: White fish, black fish and small fish. Each has adapted to the unique conditions of the lake. For example, the white fish follow the longest migratory path from Tonle Sap Lake through the Tonle Sap River before entering the Mekong River north of Phnom Penh, Cambodia. Black fish thrive in low-oxygen conditions and primarily migrate from the flooded forest areas that surround the periphery of Tonle Sap Lake into the open water. Thirteen out of the 70 most abundant species of fish found in Tonle Sap Lake represent 82% of the total annual catch and consumption (Kingdom of Cambodia Ministry of Environment, 2001).

Deforestation and hydrological infrastructure development represent the two greatest threats to the Tonle Sap Lake ecosystem. These activities lead to secondary problems that include nutrient-loading, sedimentation, habitat fragmentation and a reduction in biodiversity. Most of the deforestation in areas that surround Tonle Sap Lake began in earnest after 1979 when Cambodia was liberated from Vietnamese occupation. Land was cleared for agricultural development and human settlement while wood was primarily used for construction and fuel. A ring of highways, villages and farmland that surround Tonle Sap Lake effectively cuts off the migratory pathways of animals, with the exception of birds, between the surrounding forest and the water.

Overfishing, particularly to satisfy demand from China, is also specifically noted in this report as an imminent threat. The Lake and surrounding forest were declared a UNESCO World Heritage Site and the area was also declared a protected biosphere by a Cambodian royal decree. However, a lack of monitoring, protection and enforcement by government agencies have called the effectiveness of these measures into question (Kingdom of Cambodia Ministry of Environment, 2001).

Weak governance over the preservation of Tonle Sap Lake is indicative of the overall political situation in Cambodia. This is especially true in terms of land-grabbing, lease tenure and the general mismanagement of land resources. A weak justice system, corruption in all levels of government and the desire for economic growth are all interconnected factors that contribute to barriers to development and a reduction in poverty. Land rights are a vital component of the growth and stability of agrarian countries, and Cambodia has limited land resources to begin with. Only 18% of its total land area is arable, primarily due to terrain and forests. Only 10% of available agricultural land is irrigated, and rice production, the primary agricultural crop in Cambodia, is highly-dependent on the seasonal flow of the Mekong River. An estimated 60% of the Cambodian workforce is engaged in the agricultural sector, and the majority of households live in rural areas of the country (Hill & Minon, 2013).

The idea of land ownership is relatively new in Cambodia. The Khmer Rouge abolished private land ownership in the 1970s, and it wasn't until 2001 that a finalized legal framework that governs land rights was enacted. However, due to weak governance and institutions, forced evictions are commonplace, especially in rural areas where most of the population resides. The government has also created a policy that gives land to investors, both foreign and domestic, to be utilized for activities such as forestry, mining and agriculture. Many of these land-use agreements include 99 year leases, but there are widespread incidences of corruption, patronage and illegal seizures that adversely impact local residents despite stipulations in the law that are designed to protect people from these practices. Furthermore, many transactions are far from transparent, and land is often seized and sold only to be used for purposes other than what was officially intended (Hill & Minon, 2013).

Arable land in Cambodia is the highest per capita in SE Asia, but 30% of the land in Cambodia is owned by 1% of the population. Furthermore, the government considers up to 80% of all land in Cambodia to be owned by the state. Economic Land Concessions (ELCs) were created to generate

foreign investment in the country through the lease of public land. There is a legal limit to the size of a plot of land that a foreign entity or investor can lease which is 10,000 hectares. However, investors can obtain special permission from the Prime Minister for larger tracts of land. Furthermore, it is a common practice for investors to purchase adjacent pieces of land so that each plot remains under the 10,000 ha threshold. However, the aggregate size of the land owned by investors can be much larger. Since much of the official, non-state owned land outside of developed areas in Cambodia, such as Phnom Penh, the coastal city of Sihanoukville and Battambang province are not titled, the government can claim the land as being legally held by the state. Consequently, the land can be leased to investors, leaving few options for indigenous residents to consider in order to avoid being evicted or displaced (Neef, Touch & Chiengthong, 2013).

Two case studies in east-central Cambodia illustrate the vulnerability that indigenous residents have with respect to ELCs. First, large land allotments were awarded to foreign entities through the approval of the Prime Minister. Second, encroachment into land held by villagers for decades occurred without prior notification or consultation. Residents only learned of the intrusion when the new owners began to establish lines of demarcation, began forest clearing activities or claimed ownership of productive cropland. In one case, farmers were working on their own cassava fields when a Vietnamese company took over the land. Farmers were faced with the choice of defending their property rights or becoming employees of the company. In both of these cases, villagers had to resort to negotiating with the concessionaires, often in the presence of neutral NGO representatives, government officials and armed police forces. Fortunately, these incidents were resolved peacefully and the villagers got most of their land back. However, this is not always the case (Neef, Touch & Chiengthong, 2013).

An integral component of the ELCs is to provide land for the local population in order to protect

their way of life. Furthermore, the Prime Minister has gone on record stating that land distribution needs to focus on equality, social stability, food security and to promote the effective use of land. Furthermore, the promise of re-settling displaced residents has been mired in bureaucracy, perpetual stall-tactics and the withholding of information regarding their rights under the law. The total amount of promised land to be allocated to landless or displaced individuals has yet to materialize, despite investments from the World Bank to ensure that these lands would be available. Finally, the intent of this program is to promote economic development at the local level as well. Consequently, the assumption is that economic opportunities for local residents, particularly for those who have been directly impacted, would offset the losses created by the concessions. However, these have also failed to produce their intended results, which goes against the principles of investment by international donors to support this program. However, the consensus by those who are impacted is that the situation would be far worse if the donors stopped giving (Neef, Touch & Chiengthong, 2013).

A sampling of households in three villages in three provinces reveals that environmental and agricultural activities at the subsistence level account for the majority of per capita income. However, environmental activities in forests such as logging and cassava harvesting produced the highest earnings. Agriculture accounted for nearly 50% of household income despite being less profitable. Most households that were surveyed received their earnings from multiple sources that are connected to unfettered access to local forests and farmland.

ELCs have consistently limited access to forest resources by villagers which has led to a reduction of household income and increased poverty. Furthermore, forest land in surveyed areas was converted into rubber, sugar and palm plantations and the concessionaires reaped greater profits through the sale of these products. This occurred at the expense of local villagers who were forced to resort to less-profitable income generating opportunities such as making wood coal. Income levels in

households that have been displaced by concessionaires decreased by an average of 25%, while access to grazing lands and productive forest areas were severely restricted. Finally, replacing biodiversity in forests for the sake of developing monoculture crops creates the potential for environmental degradation. This includes soil acidification and a reduction in soil fertility (Jiao, Smith-Hall & Theilade, 2014).

Estimates suggest that nearly 2,300,000 ha, or 63.46% of total arable land in Cambodia, is controlled by concessionaires. Due to the length of lease terms, ranging from 70-99 years, rural residents will not be able to use the land for generations, and this poses a serious risk to the food security of rural Cambodians for the foreseeable future. Furthermore, ELCs include rental fees that are generally much lower than what Cambodian farmers would pay for the same land. Estimates indicate that Cambodians pay between 200-250 USD per ha of farmland. However, in order to make ELCs attractive to investors, concessionaires pay between two and 10 USD per ha. Additionally, it is believed that Cambodian farmers make more productive use of their land, grow crops that benefit Cambodians and promote food security in addition to generating more employment opportunities. Concessionaires tend to plant crops that produce the highest return on investment and export much of their harvests, causing much of the revenue generated from ELCs to leave the country while providing minimal benefit to the Cambodian economy. (Oldenburg & Neef, 2014).

Forced evictions also contribute to an increase in the number of rural poor in addition to transforming the social and cultural landscape from one that was predominately comprised of subsistence land owners to a landless population that is forced into becoming laborers in order to earn a living. They also create civil instability, and violent protests have erupted in the past as people try to hold on to their land. The practice of ELCs in Cambodia officially came to a tragic end when a girl was shot and killed by police as they stormed a village to forcibly evict residents. The government

issued a moratorium on future ELCs in 2012 and began a process of issuing titles for all landholders in the country. However, this process is slow and far from transparent. This policy change also does not reverse ELCs that have been made prior to the moratorium (Oldenburg & Neef, 2014).

ELCs are one of the most visible examples of the extent in which the Cambodian government will go to attract foreign investment into the country. It also illustrates how the government exercises control over citizens when the interests of development and economic expansion clash with individual rights. ELCs also demonstrate how priorities are given to those who can buy influence, power and opportunities for enrichment at the expense of the Cambodian people. This is indicative of the pervasive way of thinking that forms the basis for political influence in the region. “Money politics” have become standard practice in the region and is the primary driving force with regard to policies related to the development of hydropower along the Mekong River. While Cambodia, Vietnam and Laos share three distinct political structures, the common thread between each country is the perception that there are two classes: The elites and the commoners (Gainsborough, 2012).

In the case of Cambodia, a democratic nation, the current Prime Minister has managed to maneuver himself and his ruling party, the Cambodia People's Party, to almost complete control over all levels of government. Elections are viewed as mere formalities, and members of opposition parties are frequently and publicly persecuted, falsely accused of crimes, imprisoned, stripped of their wealth and property or killed. Conversely, government supporters as well as donors find it easy to buy their way into the sphere of influence. This not only shapes the formation of policies, but it also creates a form of insulation that protects commercial interests and the wealthy from the “letter of the law” to the degree where it is relatively easy to buy ways out of trouble and have access to opportunities that would otherwise not be available. The governments in Laos and Vietnam have even gone as far as to grant influential businessmen seats in parliament. (Gainsborough, 2012).

In Cambodia, land has been given outright to prominent businessmen, influential politicians and individuals who donate more than \$100,000 USD to the ruling party. The violence commonly associated with defending the ability of the government to seize and re-appropriate land suggests that government officials have a personal stake in ensuring that evictions take place. One estimate places the number of displaced Cambodians at 261,705. This number represents evictions that occurred in only 13 provinces where NGOs were able to conduct research and obtain a limited amount of data. Furthermore, there is a substantial lack of compensation and accommodation for those who have been dispossessed. Land re-distribution also leads to an unsustainable exploitation of resources, a loss of sustainable, equitable and environmentally-friendly agricultural practices and over-fishing while increasing the number of landless, rural poor (Rudi, Azadi, Witlox & Lebailly, 2013).

Regional politics that are plagued with corruption, paternalism and unabated access to influence are one of the leading causes of the development of hydropower in the MRB. China is by far the largest investor in hydropower in the region and in the world. Currently, China is financing, providing technical assistance, building and overseeing the creation of over 50 dams in Myanmar, Laos, Cambodia and Vietnam. These projects are expected to generate over 50 MW of electricity each, and China also has interests in five dams in Thailand that will produce less than 50 MW each as well. The primary motive of China in making these investments is to establish energy security and fuel their economy. China's overreaching strategy is to entice developing countries that are hungry for foreign investment with offers of aid, manufacturing and trade incentives along with loan concessions in exchange for rights to operate dams and then export the energy back for domestic consumption (Urban, Nordensvard, Khatri & Wang, 2012).

The second strategy is to avoid the environmental and humanitarian consequences of large-scale damming projects domestically. The construction and operation of the Three Gorges Dam forced the

relocation of 1.3 million residents due to the flooding of 13 cities and 140 towns. However, China had the infrastructure in place to relocate residents by providing them with housing, small amounts of compensation or small tracts of land. The Chinese government has concluded that the development of additional dams in the southwestern part of the country is environmentally and economically unsustainable, but there is still a need for more power. Consequently, nations in the LMB provide an attractive alternative as a way to maintain some form of social and ecological balance domestically (Urban, Nordensvard, Khatri & Wang, 2012).

The third motive is to foster regional cooperation and to exert soft power and influence over these developing countries. This is accomplished by providing no-strings-attached bundles of aid that give the impression that China is not interested in meddling with the sovereign affairs of their neighbors. This is in contrast to limited amounts of aid offered by many western countries that include numerous conditions that are perceived to be an exertion of influence and control over their own destiny (Urban, Nordensvard, Khatri & Wang, 2012).

One example is how China has dramatically expanded hydropower investment in Laos. Currently, there are two projects that have been completed in early 2015 with a combined total of 210 MW of energy output. However, dams with a combined total of 1010 MW are under construction with agreements for additional dams with a combined total of 3892 MW to be completed by 2030. China has also invested heavily in hydropower generation in Myanmar that includes 11 dams with the capacity to generate more than 1000 MW each, and one that is expected to produce 7110 MW. However, the argument is being made that the enticement of wealth generated for these countries from the generation of hydropower is being marketed without a complete understanding of the ecological ramifications of such large-scale projects (Matthews & Motta, 2015).

China views Cambodia as its most important ally in the region. The close relationship between

the two governments provides China with an important foothold in the region where it is exerting its influence at the expense of straining some relationships with neighboring nations. Cambodia is heavily- dependent on investment opportunities from China. China has used this to their advantage to not only procure additional power resources, but to establish an ally in the developing ASEAN economic community in which China is not a member state (Matthews & Motta, 2015).

Hydropower investment in the MRB is not limited to China alone. Governmental policy changes have created a favorable atmosphere that in turn has made investing in dams a profitable enterprise. International banks along with private investors from the region and around the world have fueled basin-wide development. The most common type of contract covering dam construction is what is called the build-own-operate-transfer agreement. This essentially allows an investor to build, manage and operate the dam while also keeping most of the profits for a specific period of time. The investor and government then have the option to either renew the contract or allow control over the dam to revert back to the state. Furthermore, agreements commonly include exclusive control over water rights with few exceptions such as following minimum water-release obligations. This usually includes water that flows over the dam as well as what is stored in reservoirs (Merme, Ahlers & Gupta, 2014).

The MRC released a comprehensive report in 2010 that details the characteristics of the MRB which includes a broad range of topics such as geography, hydrology, economic value, threats from climate change and development. This is considered to be the most definitive report as to the state of the MRB, and this report serves as a common frame of reference for numerous scholarly articles that relate to everything from ecological change to socio-economic, political and cultural influences in the region. It also describes in detail, by country, how the basin is used and how each nation benefits and relies on the Mekong River for their very survival.

It also details environmental change in the MRB in the context of climate change variability, pollution, human activity and the development of hydropower. It is estimated that the LMB has the capacity to generate over 30,000 MW of power and that dams constructed as of 2010 generate 3235 MW of power. A brief discussion of the potential to tap into other renewable sources of energy such as wind, solar and biomass is presented as alternatives to hydropower. Estimates suggest that 74 million people in the MRB do not have access to electricity, and that energy demand in the region is expected to grow at an average of 8% per year through 2025. However, the report does not establish a basin-wide value on what current and future energy demands represent in MW (MRC, 2010).

Statement of the Problem

An examination is necessary with respect to how the lack of comprehensive environmental management may lead to the accelerated development of numerous large-scale dams along the Mekong River and the alteration to the ecology of the entire watershed. An exploration of some of the contributing factors that underscore decision-making processes is also necessary in order to contextualize why current attempts to manage the development of hydropower in the LMB are fraught with so many obstacles.

Finally, it is important to separate fact from fiction in terms of public perception, the dire findings of certain research, information from environmental groups and messages to the public by the government. One example is how government officials blamed low water levels in the Mekong River for the cancellation of the 2015 water festival in Phnom Penh. One report speculates that the cancellation was for political rather than environmental reasons (Pheap & Wright, 2015). Climate change is widely-believed by the population at large as the main reason that the characteristics of the Mekong River are changing year over year. While it is possible that climate change does contribute to alterations of seasonal precipitation patterns, data may suggest a correlation between lower water flows and the operation of dams upstream.

The goal of this research is to present information that accurately describes the big-picture in terms of how decisions are made, who will be impacted the most and what is being done to minimize the ecological consequences of large-scale dam projects in the MRB.

Hypothesis

Large-scale, main-stem and tributary dam construction in Laos and Cambodia will lead to the physical or economic displacement of Cambodian people due to a lack of planning and accommodation by the Cambodian government. Furthermore, the absence of adequate planning will lead to a reduction in agricultural and inland fishery productivity that can jeopardize food security for millions of people in Cambodia.

Additionally, attractive investment opportunities, patronage and government corruption, complex relationships between MRC member states, the Chinese government and other entities contribute to the commencement of large-scale dam projects without adequate environmental impact assessments. The lack of transparency with respect to contracts between investors, dam operators and the Cambodian and Laotian government also promotes dam construction without consideration for ecological degradation and the accommodation of displaced persons. These factors limit the effectiveness of the MRC to manage the MRB effectively and inhibit the fulfillment of the vision of the MRC.

Furthermore, an examination of precipitation and water level data in the Mekong River will indicate that dams are primarily responsible for variations in water levels as flows enter the LMB. The expected outcome is that a relationship between existing main-stem dams along the Lancang cascade will produce measurable and consistent variations to corresponding water levels at the Chiang Saen, Thailand Reporting Station.

Research Design

Research will involve the quantitative analysis of existing precipitation and water flow data produced by the MRC. The limitations produced by a lack of information from multiple sources makes the validity and reliability of data questionable. However, the MRC website is the only known source of data related to water levels at various stages along the Mekong River within its jurisdictional boundaries. Water level data will be utilized to establish if there is a correlation between reduced water depth the Chiang Saen, Thailand reporting station and the operation of the dams in the Lancang cascade. Precipitation data from the National Oceanic and Atmospheric Administration (NOAA) will be utilized to establish if there is a correlation between water levels and rainfall over the UMB.

Research will also involve the qualitative analysis of journal articles and media reports that relate to the socio-political influences that may be contributing to the rapid development of hydropower in Cambodia and Laos. This will include an examination of factors that establish a relationship between dam construction and population displacement. A brief analysis of relationships between member states within the MRC along with examining incidences of the exertion of political influence in the region can be a useful measure to understand the complexities of managing the Mekong River in a productive and beneficial manner.

An examination of international influences with respect to damming will also contribute to providing a contextual assessment of the underlying factors that contribute to the current situation. This will include reviewing literature and other relevant information about the role that international investors and other stakeholders who are involved in dam building projects in Laos and Cambodia.

Finally, consideration must be given to the fact that each nation has their own goals, aspirations of generating wealth, distributing that wealth among the population and the exertion of coercion and power among the population at large all play into the current socio-political environment.

A focus on Cambodian governance in particular will explore dynamics between officials and the population in order to establish a relationship between a lack of planning and the potentially-detrimental impact on those who will be directly and indirectly impacted by the construction of dams in the LMB. This will include the specific examination of the exertion of power in terms of land-grabbing and how displaced populations are or are not accommodated.

Data Collection

Water level data was collected at the Chiang Saen reporting station in northeastern Thailand. This site was chosen because it is the closest reporting station to the Lancang cascade in China. It is also just south of the point of delineation where the UMR becomes the LMR and enters the northern jurisdictional boundary of the MRC. Consequently, this station may provide an opportunity to gauge the impacts of Chinese dams with minimal variability associated with geographical features and tributary inflows that influence water levels further downstream.

Monthly total water level and precipitation data was used between 2008-2015 in an attempt to establish a correlation between the alteration of water levels before and after the construction of four out of six dams that was completed after 2007. Precipitation data from the NOAA was also used from five reporting stations in China that are situated within the UMB as rainfall from these areas supplies the UMR. Data for precipitation totals in China is not available through the MRC website. Data was collected for the months of June-October since this period of time represents the annual monsoonal season that produces maximum annual totals throughout the entire MRB.

News reports and scientific articles will be used to examine the relationship between socio-political and economic policies and the impact that dam projects have on ecological change as well as the displacement of individuals. This will be used to establish a cause-and-effect relationship between the construction of dams, the lack of consideration with respect to environmental consequences and a lack of planning on how to accommodate displaced individuals in Cambodia. A historical analysis of similar practices will be performed to contextualize the extent of the practice of land-grabbing and its role in the economic development of Cambodia.

The figure below is a section of Yunnan Province in China that includes five cities/reporting stations within the UMB that were used to collect precipitation data. They are Deqen, Lijang, Lincang,

Pu'er (Simao station) and Lancang, which is not listed on the map, but is situated due west of Pu'er along the western highway that begins to split to the west, south of the City of Lincang.

Figure 2. Map of General Area in China Where Precipitation Data Was Collected.



Figure 2. Map of General Area in China Where Precipitation Data Was Collected. Adapted from *Google Maps*. Retrieved from <https://www.google.com/maps/place/Yunnan,+China/@25.1146565,97.3680482,6z/data=!3m1!4b1!4m2!3m1!1s0x36d083db32a05b29:0xa63cebb7ca8dac29>. ©2016 by Google, Inc.

Table 1. Lijing Monthly Recorded Precipitation Amounts (mm).

	June	July	August	September	October
2008	156.2	187.2	198.1	170.2	55.9
2009	202.7	151.1	258.8	127.3	23.1
2010	143.5	218.7	240.8	123.4	184.7
2011	93.7	255.0	104.9	170.4	39.9
2012	128.5	182.4	172.7	116.3	33.5
2013	112.8	364.7	153.4	140.7	42.9
2014	220.2	354.8	195.3	118.6	10.9
2015	39.9	150.6	337.8	230.1	96.8

Note. Data adapted from *NOAA National Centers for Environmental Information Monthly Summaries Station Details*. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056651/detail>. Copyright 2016 by the United States

Department of Commerce.

Table 2. Lincang Monthly Recorded Precipitation Amounts (mm).

	June	July	August	September	October
2008	195.3	186.9	217.2	97.0	100.1
2009	109.7	199.1	283.0	81.8	66.5
2010	107.2	290.6	237.0	205.7	150.1
2011	133.1	227.8	193.5	211.1	61.5
2012	175.8	240.0	90.7	87.6	44.5
2013	140.7	261.4	261.1	158.2	164.8
2014	160.8	293.1	133.4	159.3	38.6
2015	96.0	281.7	210.1	179.6	132.3

Note. Data adapted from *NOAA National Centers for Environmental Information Monthly Summaries Station Details*. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056951/detail>. Copyright 2016 by the United States

Department of Commerce.

Table 3. Pu'er (Simao) Monthly Recorded Precipitation Amounts (mm).

	Pu'er (Simao) Monthly Precipitation Amounts (mm)				
	June	July	August	September	October
2008	188.7	340.4	263.1	246.4	145.3
2009	231.6	448.3	253.5	150.9	41.4
2010	193.3	281.7	164.3	149.4	144
2011	247.1	146.6	174	299.5	48.5
2012	125.2	255	261.4	178.1	61.5
2013	108.7	356.1	401.6	138.7	306.8
2014	244.6	510.8	239.8	153.4	72.6
2015	66.5	305.6	398.5	186.9	162.6

Note. Data adapted from *NOAA National Centers for Environmental Information Monthly Summaries Station Details*. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056964/detail>. Copyright 2016 by the United States Department of Commerce.

Table 4. Deqen Recorded Monthly Precipitation Amounts (mm).

	June	July	August	September	October
2008	80.0	89.7	146.6	24.9	152.7
2009	49.5	129.0	115.1	45.7	22.6
2010	31.8	152.9	141.0	75.2	87.4
2011	34.3	113.8	92.2	7.9	38.4
2012	93.2	124.7	130.0	104.9	20.6
2013	136.9	144.5	111.0	63.5	36.6
2014	67.8	167.4	59.9	35.8	10.9
2015	33.0	111.3	166.4	36.3	50.3

Note. Data adapted from *NOAA National Centers for Environmental Information Monthly Summaries Station Details*. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056444/detail>. Copyright 2016 by the United States Department of Commerce.

Table 5. Lancang Recorded Monthly Precipitation Amounts (mm).

	June	July	August	September	October
2008	245.1	349	385.1	201.4	231
2009	229.3	310	350	180.6	68.8
2010	159.5	297.7	273.8	165.1	119.9
2011	275.8	350	190.8	234.7	93.2
2012	204.2	486.4	290.6	163.6	152.4
2013	159.5	297.7	273.8	165.1	119.9
2014	229.4	309.9	349.8	180.6	68.8
2015	245.1	349.0	385.1	201.4	230.6

Note. Data adapted from *NOAA National Centers for Environmental Information Monthly Summaries Station Details*. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056954/detail>. Copyright 2016 by the United States

Department of Commerce

The six dams that comprise the Lancang cascade are listed in the table below. Included is their year of commissioning, power generating capacity and physical height. The tables that follow contain wet-season monthly precipitation data from the five reporting stations within the UMB.

Table 6. Existing Dams Along the Lancang Cascade.

Name	Year Commissioned	Power generation	Structural Height
Gongguoqiao	2012	900 MW	130 m
Xiaowan	2010	4200 MW	292 m
Manwan	2007	1550 MW	126 m
Dachaoshan	2003	1350 MW	118 m
Nuozadu	2012	5850 MW	261.5 m
Jinhong	2009	1750 MW	118 m

Note. Adapted from *Environmental and Social Impacts of Lancang Dams*, by International Rivers.

Retrieved from https://www.internationalrivers.org/files/attached-files/ir_lancang_dams_researchbrief_final.pdf.

Copyright 2014 by International Rivers.

Table 7. Precipitation Totals from UMB Reporting Stations (mm).

	June	July	August	September	October
2008	865.3	1153.2	1210.1	739.9	685
2009	822.5	1237.5	1260.4	586.3	222.4
2010	635.3	1241.6	1056.9	718.8	686.1
2011	784	1093.2	755.4	923.6	281.5
2012	726.9	1288.5	945.4	650.5	312.5
2013	658.6	1424.4	1200.9	666.2	671
2014	922.8	1636	978.2	669.8	201.8
2015	480.5	1198.2	1497.9	834.3	672.6

Note. Data adapted from *Graph of Water Levels and Reports*, by the Mekong River Commission, 2015. Retrieved from http://ffw.mrcmekong.org/historical_rec.htm. Copyright 2015 by the Mekong River Commission.

Table 8. Average Monthly Mekong River Water Height at Chiang Saen Station (m).

	June	July	August	September	October
2008	4.0	5.8	7.7	6.6	4.9
2009	3.3	4.7	5.8	5.4	3.6
2010	3.0	4.3	5.3	5.2	4.7
2011	3.7	4.8	5.4	5.4	3.8
2012	2.2	3.7	5.9	4.8	4.0
2013	2.7	3.5	4.9	4.4	3.8
2014	3.0	3.6	4.4	4.6	4.0
2015	3.6	3.8	5.1	4.2	3.2

Note. Data adapted from *Graph of Water Levels and Reports*, by the Mekong River Commission, 2015. Retrieved from http://ffw.mrcmekong.org/historical_rec.htm. Copyright 2015 by the Mekong River Commission.

Years of particular interest are 2009, 2010 and 2012 when four dams were commissioned. In order to quantify any potential impact that these dams have on water levels at Chiang Saen, year over year differences in precipitation and water level changes based on the 2008 baseline will be calculated. This will make it possible to compare any changes in precipitation totals with corresponding water levels. This can help to identify a possible correlation between changes in water levels and the operation of dams along the Lancang cascade.

Any decrease in precipitation should be reflected in a similar decrease in water levels along with any corresponding increases. For example, a 3% decrease in precipitation between 2008 and 2009 should correspond to a similar decrease in water levels. A larger margin could be indicative that the presence of dams may be a factor in measured water levels at Chiang Saen. The formula for calculating percent decrease is as follows: Value of decrease/original amount x 100. The formula for calculating percent increase is as follows: Value of increase/original amount x 100.

Table 9. Percent Change (%+/-) in Total Precipitation Amounts from 2008 Baseline in UMB.

	June	July	August	September	October
2009	-4.9	7.3	4.2	-20.8	-67.5
2010	-22.8	0.3	-16.1	22.6	208.5
2011	23.4	-11.9	-28.5	28.5	59
2012	-7.3	17.9	25.15	-29.6	11
2013	-9.4	10.5	27	2.4	114.7
2014	40.1	7.31	4.15	-20.8	-67.5
2015	-47.9	-26.8	53.1	24.6	233.3

Note. Data adapted from *Graph of Water Levels and Reports*, by the Mekong River Commission, 2015. Retrieved from http://ffw.mrcmekong.org/historical_rec.htm. Copyright 2015 by the Mekong River Commission.

Table 10. Percent Change (%+/-) in water levels at Chiang Saen Reporting Station from 2008 Baseline.

	June	July	August	September	October
2009	-17.5	-19	-24.7	-18.2	-26.5
2010	-25	-12.1	-25	-18.1	-26.6
2011	-7.5	-17.2	-30	-18.2	-22.4
2012	-45	-19	-23.3	-27.2	-18.3
2013	-32.5	-39.7	-36.3	-33.3	-22.4
2014	-25	-43.1	-43	-30.3	-18.4
2015	-10	-43.5	-34	-36.4	-34.7

Note. Data adapted from *Graph of Water Levels and Reports*, by the Mekong River Commission, 2015. Retrieved from http://ffw.mrcmekong.org/historical_rec.htm. Copyright 2015 by the Mekong River Commission.

Results

The highest recorded precipitation for the month of June was recorded in 2014 that represents a 40.1% increase above 2008 baseline totals. However, this corresponds to a 25% decrease in water levels at the Chiang Saen station. This measurement was taken two years after the last dams were constructed in along the Lancang cascade. The highest recorded precipitation for the month of July was in 2014 that represents a 7.31% increase above 2008 baseline totals. However, this corresponds to a 43.1% decrease in Chiang Saen water levels. The highest recorded precipitation for the month of August was in 2015 that represents a 53.1% increase above 2008 baseline totals, but this corresponds to a 34% decrease in water levels at Chiang Saen. The highest recorded precipitation for the month of September was in 2011 that represents a 28.5% increase above 2008 baseline totals, and this increase corresponds to an 18.2% decrease in water levels at Chiang Saen. There were only four dams completed along the Lancang Cascade in 2011.

The lowest recorded precipitation for the month of June was recorded in 2015 which represents a -47.9% decrease from 2008 baseline totals. However, this only corresponded to a 10% decrease in water levels. The lowest recorded precipitation for the month of July was in 2011 which represents a -11.9% decrease from 2008 baseline totals. The lowest recorded precipitation for the month of August was in 2011 which represents -28.5% decrease from 2008 totals but produced a reduction water levels at Chiang Saen that was measured at 17.2%. The lowest recorded precipitation for the month of September was in 2009 which represents a -20.8% decrease from 2008 totals. This corresponds to an 18.2% decrease in water levels at Chiang Saen. The lowest recorded precipitation for the month of October was in 2014 which represents a -67.5% decrease from 2008 totals, but this amount corresponds to an 18.4% decrease in water levels at Chiang Saen. The greatest decrease in water levels at Chiang Saen occurred in June of 2012. That month produced a 45% decrease in water levels whereas

precipitation amounts were only 7.3% lower than during the same month in 2008. The smallest reduction in water levels at Chiang Saen occurred in June of 2011. However, the 7.5% decrease corresponds to a 45% decrease in water levels during the same time frame.

The highest water levels at the Chiang Saen station were all recorded in 2008. Recorded water levels were lower than the 2008 baseline for the months of June, July, August, September and October of every year from 2009-2015. The lowest water level at the Chiang Saen station was recorded at 2.2 m in June of 2012. The highest water level was recorded at 7.7 m in 2008.

The greatest percentage decrease of precipitation occurred in October of 2009 and 2014 respectively at 67.5%. However, the percentage of decrease in recorded water levels at the Chiang Saen in October of 2009 was 26.5%, whereas the percentage of decrease in October of 2014 was 18.4%.

Dry Season Flow Irregularities

Average water levels in the LMB begin to decrease in November and reach their lowest levels in March before increasing in April. This trend follows the seasonal monsoonal pattern which includes the transitional months of April and May before significant rainfall begins in June and decreases in September-October. Slight variations to this pattern exist. For example, the monsoon was declared over in September of 2013, whereas in 2014, the monsoon was declared over in October (MRC, 2014). However, it is unclear as to what criteria is used to make this determination.

However, a period of an unusual increase in water flow through portions of the northern LMB in February of 2014, particularly in Thailand and Laos, was recorded and attributed to “human activities” since there was no precipitation associated with this anomaly (MRC, 2014). This anomaly, along with a sudden rise in water levels that were recorded from northeastern Thailand to Cambodia in September of 2013, was significant enough to be highlighted in the annual flood report produced by the

MRC (MRC, 2014).

The September incident was severe enough to cause considerable flooding over the banks of the Mekong River in portions of Thailand and Laos. One news article related the story of a villager in Thailand who witnessed a surge of debris-laden water sweep through the community. The sudden flood carried away fishing boats and destroyed crops that were planted near the banks of the normally tranquil Mekong river. Villagers who were interviewed posited two possibilities for this anomaly. First was a concern that excess water was being discharged from dams in China, which has been increasingly common since the Lancang cascade became operational. Second, unusually heavy rains fell across the region during that time (Clark, 2014).

The September flood promoted renewed public concerns that Chinese dam operators manipulate the flow of water through the Mekong River. The MRC attributed this particular incident to significant precipitation that fell across the region and specifically mentioned that Chinese dam regulation was not responsible for the anomaly. However, the MRC report also mentioned that Chinese officials promised to keep water discharges from dams below a threshold of 4,500 m³ in order to avoid causing “overflows” downstream (MRC, 2014). This was in response to the February, 2014 incident in which the MRC stopped short of directly blaming Chinese dam management for the influx of water while Chinese officials stopped short of admitting responsibility.

The Role of China in LMB Dam Building

Laos has been relatively transparent about their intentions to construct a series of main-stem dams along the Mekong River as well as along numerous tributaries. The term “relatively” is used because there was a period when government officials engaged in obfuscation and stall tactics with respect to transparency over the construction of the Xayaburi and Don Sahong dams. The Laotian government intends to use dams as a way to generate power for domestic use as well as to generate

revenue from the sale of electricity to neighboring countries.

However, the term “neighboring countries” is vague. Thailand has invested in the creation of at least one main-stem dam in Laos for the purpose of the importation of electricity. A consortium of six Thai investment banks is financing the construction of the Xayaburi dam that will be the first main stem dam in the LMB. The dam is expected to become fully operational in 2019 (Laos Department of Energy and Mines, 2013). Power generated will be used domestically and exported to Thailand under a lease-purchase agreement that will last for 27 years (Vientiane Times, 2014). Thai banks are also investing in three other hydropower projects in addition to a number of coal-fired power plants in Laos (Middleton, 2009).

However, China is by far the leading stakeholder in the development of hydropower in Laos with nearly 30 projects planned, currently under construction or already completed. Chinese participation in Laos involves providing financing, technical expertise, construction, management and operation of dams. Officially, only one proposed dam, out of the entire Laotian hydropower plan, is listed to be built for purposes of energy export to China (Laos Ministry of Energy and Mines, 2015).

Chinese companies are also linked to the development and management of seven out of eight dams that are currently operational in Cambodia. Another Chinese company is also currently constructing the Lower Sesan 2 and Srepok River hydropower dams in northeastern Cambodia (Grimsditch, 2012). Chinese companies have also entered into memorandum of understanding agreements to construct at least four new dams as well (Open Development Cambodia, 2016). The Cambodian Prime Minister, Hun Sen, is also seeking additional loans from China to finance the expansion of power grids, which includes the creation of at least two additional dams that will become operational by 2020 (Reuters, 2015).

The Chinese, Laotian and Cambodian governments have all seized land from local residents, villagers or indigenous peoples for the construction and operation of dams. However, a lack of information and statistics makes it a challenge to count the total number of individuals who may be displaced as the result of the construction of multiple dams in the LMB. Furthermore, the indirect impacts of post-dam construction and operation, such as ecological change within the MRB at local levels, is not fully-understood. For example, a reduction in arable land, land for grazing, forest products, fish stocks and species diversity up or downstream from dam sites can adversely impact the livelihood of families who depend on farming and fishing in order to earn a living.

Estimates indicate that the Laotian Government resettled 6,200 indigenous residents to accommodate the reservoir behind the Nam Theun 2 dam that became operational in 2010. However, the downstream impact of the dam is estimated to have impacted more than 110,000 people who depend on the Xe Bang Fi River for fishing and agriculture (International Rivers, 2015).

The MRB does not require that member states present a detailed EIA or resettlement plan for each dam that is constructed within its jurisdiction. However, member states may voluntarily submit such information. Furthermore, national laws or stipulations that are set forth by investors may require that resettlement plans be developed and implemented prior to the approval and commencement of dam-building projects.

For example, the Nam Theun 2 dam was financed in part by the World Bank. Part of the conditions for receiving financing involved the study, production and implementation of detailed resettlement plans to accommodate individuals who were directly and indirectly displaced during construction or after the dam became operational. These plans included factors such as the provision of adequate housing and land, economic compensation, material resources to help displaced individuals develop new sources of income and how to minimize the impact of cultural or social change due to

relocation (World Bank, 2004). A resettlement plan was also presented to the MRC that outlines similar steps that will be taken to accommodate individuals who are displaced as the result of the Don Sahong dam project in Laos as well. The report also specifically mentions that Laotian law stipulates that a resettlement plan as well as an EIA must be incorporated into any dam project (MRC, 2014).

There is currently no law in Cambodia that requires resettlement plans and compensation for individuals who are displaced by the construction of dams. Consequently, each situation is considered on a case-by-case basis (Kimkong, Samchan, Thea, Vichet & Rasmey, 2013). This is the case with the Lower Sesan 2 dam project that is underway along the Sesan River in Cambodia. There are no official and documented resettlement plans that have been produced by the Cambodian government despite claims by officials that indigenous peoples are being offered just compensation. One news report presents an estimate that the construction and commissioning of the Lower Sesan 2 dam in Cambodia will destroy the livelihoods of more than 45,000 people (Denyer, 2015).

Another report that covered a protest by approximately 200 villagers who are being displaced due to the construction of the Lower Sesan 2 dam relates a different approach to resettlement and compensation offered by the Cambodian government. The protest was centered on the unwillingness of the government to offer appropriate compensation or resettlement options. A quote from a government official stated that the government would not be able to provide compensation at fair market prices “but didn't offer an explanation as to why.” Furthermore, the official suggested that villagers avail themselves of the courts and legal process to resolve the dispute if they were not happy with the compensation package. The company building the dam has stated that the project will continue as planned despite the protests because they have received “the green light” from the Cambodian government (Chev, Yun & Lipes, 2015).

Another report mentions that the reservoir behind the Lower Sesan 2 dam will displace 5,000

people and flood an area of 336 km². It also mentions a survey in which 93% of respondents wanted construction halted because it will destroy their cultural identity in addition to ancient burial and spiritual lands. Village officials claim that they asked for time to negotiate with the government and developer for a suitable compensation package. The government official in charge of working with villagers responded by claiming that 60% of villagers have accepted the compensation offer and that the survey should not have been published because it was “not independent enough.” (Titthara, 2015).

The Cambodian government has an established record for forcibly-evicting indigenous people for the sake of utilizing land for development. Unfortunately, many of these cases occur in very rural areas and either go unreported or are relegated to being little more than rumors. Two notable exceptions occurred in Phnom Penh, and they illustrate the extent of the problem of land-grabbing for the sake of development. These incidents were considered to be precedent-setting cases with respect to the issue of land-rights due to the publicity they generated.

Boeung Kak Lake was a large, swampy, natural reservoir situated in northern Phnom Penh. Over 4,000 families, or an estimated 20,000 individuals lived on or near the lake. It was originally an undesirable piece of land that attracted poor families and settlers who returned to Phnom Penh after the fall of the Khmer Rouge in the late 1970s. In the absence of land-use laws, it was common practice for people throughout the country to find some land and stake their claim without possessing a deed or title. Even after a more definitive land law was enacted in 2001, the issuance of titles was a painfully-slow process riddled with corruption and patronage.

Many residents simply could not navigate the complicated legal process or afford to pay officials to process the paperwork, so the land remained non-titled even though families may have lived on these lands for a generation or more. Since non-titled land is considered state land, the government was able to lease Boeung Kak Lake to a developer for 99 years in 2007. This set the stage for the

forced eviction of residents who refused to accept the settlement offer. The settlement offer included compensation that totaled \$72 million on land that was valued at \$2 billion. It also included relocation to an undeveloped site 12 km south of Phnom Penh that lacked basic infrastructure such as water, electricity or sewage systems (Gluckman, 2008). Many people refused to leave, violent clashes erupted between residents and police until the land was ultimately cleared and the lake was filled in with earth. Development of the land did not begin in earnest until 2014 (Worrell & Kunthea, 2014).

The other incident involved Koh Pich, a small island situated near the confluence of the Mekong, Tonle Sap and Bassac Rivers along the eastern edge of Phnom Penh. Koh Pich contained remarkably-fertile soil and was settled by migrants following the end of the Khmer Rouge as well. At least 300 families lived on the island since 1979 and primarily used the land for subsistence vegetable and rice farming. The Cambodian government sold the land to a developer in 2004 after approving a proposal to convert the island into an entertainment and recreation complex. Residents were offered an initial settlement offer of \$2.50 per m² despite appraisals that valued the land at nearly 10 times that amount. Cash compensation amounts increased slightly, depending on the location of a particular plot on the island, and many families still refused to leave. Land that was being made available for relocation was equally remote and undesirable as the area offered to residents who were evicted from Boeung Kak Lake (Rith & Cochrane, 2005). Protests ensued along with numerous clashes with police, and people also died.

The courts ruled that the residents had no legal standing to be on the island despite a provision in the law that stipulates that residents who have been occupying non-titled land for more than five years are considered the rightful owners of the property. This ruling came on the heels of a huge legal battle that was financed by private donations and assisted by expert land-law attorneys from the United States. The development of Koh Pich is still ongoing as of 2015.

The Effectiveness of MRC Governance

The creation of the MRC was intended to promote international cooperation in order to manage the Mekong River in “an economically prosperous, socially just and environmentally sound” manner. (MRC, 2010). However, due to the fact that the MRC has no legal authority and all action by member nations is voluntary, the interests of individual states can take precedence over the potential ecological risks to the region. Furthermore, China and Myanmar are only part of the MRC in an advisory capacity, yet China is playing a pivotal role in altering the flow regime of the Mekong River while also investing heavily in the construction of dams in the LMB. This complex arrangement presents a unique challenge for the MRC to effectively manage the river and protect the ecological health of the MRB. This is particularly true as Laos has unilaterally decided to proceed with the construction of the Xayaburi dam along the main-stem of the Mekong River despite a 10 year moratorium established by the MRC over the construction of main-stem dams.

Additionally, the rate in which tributary dams are being constructed in Laos and Cambodia pose an ecological threat to the MRB that has yet to be addressed by the MRC since the moratorium only extends to main-stem dam construction. Findings reveal that Laos as well as Cambodia are utilizing dams to generate hydropower within their borders as well as for the storage of water for irrigation and other anthropogenic uses. These include providing water for municipal use and industrial applications. Consequently, the effectiveness and overall purpose of the only governing body over the management of the MRB is becoming increasingly unclear.

The Laotian government, in response to the controversy generated over the construction of the Xayaburi dam, has issued an explanation of their position on the issue. Key points include how Laos has the sovereign right to utilize its water resources as a way to improve the national economy and lift citizens out of poverty. Furthermore, the position of the Laotian government is that it has cooperated

with the MRC by making a good faith effort to accommodate objections with respect to potential environmental impacts of creating main-stem dams on the Mekong River.

These include working with the MRC to address concerns over impediments to fish migration and the transport of sediment downstream along with a plan for resettling displaced residents. Additionally, the Laotian government has “retained world-renowned consultants, with vast experience developing successful and environmentally friendly hydropower projects on Europe's international rivers.” Furthermore, these consultants have provided “exhaustive technical and environmental studies” to ensure that the project meets international standards without causing a “significant impact” on the environment in Laos or in downstream countries (Laos Department of Energy and Mines, 2013).

Officials from Poyry, a Finland-based engineering and consulting company retained by the Laotian government, participated in a workshop to discuss issues related to the Xayaburi dam project in July of 2015. Highlights from this meeting discuss how significant and expensive design changes were implemented to make the dam as environmentally-friendly as possible. These changes center on developing complex and advanced fish passage systems and special “low-level outlets for flushing sediment”. They also claim that the knowledge gained from these changes can be implemented in future dam projects along the Mekong River and throughout the world. Furthermore, a series of studies related to fish migration, biomass, sediment transport, water quality and ecology will be given to the MRC for review (Laos Department of Energy and Mines, 2015).

Finally, the Laotian government has demonstrated a reluctance to provide the MRC with detailed information about the Don Sahong dam project because it is situated on a tributary as opposed to the main-stem of the Mekong River. The Cambodian government has not been transparent or forthcoming with the MRC with regard to the Lower Sesan 2 dam project for similar reasons. However, more information is available with respect to the decision-making process surrounding this

project.

An EIA (Environmental Impact Assessment) was published and accepted by the government in 2008, but the findings have not been released to the public or the MRC. However, The NGO Forum in Cambodia obtained a copy of the EIA and published a critical review of the study. Some highlights include a lack of transparency or an opportunity for public scrutiny, the absence of stakeholder participation and a lack of evidence that the Lower Sesan 2 dam would produce power at a lower cost when compared to other available sources. The review also mentioned that the EIA lacked a review of potential alternatives, a plan to accommodate individuals who would be displaced as well as how to mitigate potential environmental change (NGO forum on Cambodia, 2009).

A study produced by environmental researchers at The Royal University of Phnom Penh also highlights deficiencies in the decision-making process with regard to the construction of hydroelectric dams. They include corruption and the need to pay commissions to individuals in order to process applications and paperwork or to arrange meetings between developers and high-level government officials (Kimkong, Samchan, Thea, Vichet & Rasmey, 2013).

The study also finds that the EIA process is flawed for three reasons. First, the government lacks the appropriate resources to evaluate an EIA for large-scale hydropower projects. Second, there is weak interaction between inter-governmental agencies and departments. Finally, an EIA is considered to be a low priority by government officials. Furthermore, an EIA is considered to be a tool that is used to attract investors and get projects approved instead of examining factors that could lead to their rejection. Additionally, high-ranking government officials can influence the EIA process in order to gain support for projects by exerting pressure on subordinates (Kimkong, Samchan, Thea, Vichet & Rasmey, 2013).

The quality and reliability of the EIA process for the Lower Sesan 2 dam project is called into

question due to the lack of public participation and scrutiny. Findings show that there were only three meetings where public comment on the project was possible. 85% of participants present at the first meeting rejected the project. 94% of participants at the second meeting approved the project, but it was discovered that they could not speak the language in which the meeting was conducted. The third meeting involved villagers who would be directly impacted by the project, but very few asked questions out of fears of reprisal from government officials (Kimkong, Samchan, Thea, Vichet & Ramsay, 2013).

Finally, the issue of resettlement is called into question as the government does not have clear guidelines in place. In cases where small projects are involved, local or provincial officials are responsible for making resettlement arrangements. The national government assumes the responsibility for large-scale projects. Furthermore, the resettlement process is often contentious as it involves negotiations with the developer, government as well as individuals who will be impacted by the project. In the case of the Lower Sesan 2 dam project, resettlement offers went through various stages of negotiation before a tentative agreement was reached. However, the guarantees that were offered by the government have yet to be honored (Kimkong, Samchan, Thea, Vichet & Ramsay, 2013).

The Yali Falls dam, situated along the Upper Sesan River in Vietnam, became operational in 2001 after six years of construction. However, periods of intense flooding or reduced water levels as well as a reduction in fish catches downstream along the Cambodian portion of the Sesan river were being observed by villagers as early as 1996. The Yali Falls dam was considered to be the largest tributary dam constructed in the LMB at the time. Erratic water flows and a reduction in fish productivity contributed to the slow abandonment of numerous villages.

Reports of the unexpected occurrence of flash flooding, in both the dry and rainy seasons led to the deaths of numerous individuals who were caught off-guard. Findings from surveys also indicate

that 40,962 chickens, 612 buffaloes, 322 cows, 2389 pigs and 3559 ducks have been “drowned or lost” due to unexpected flooding from water released by the dam during both rainy as well as dry seasons. The majority of rapid increases in water levels occur at night with little or no warning. Furthermore, a reduction in water quality as a rise in illnesses associated with coming into contact with high water levels after releases have been reported. However, no study has been undertaken to determine what causes these illnesses (Ratankari Province Fisheries Office, 2000). Estimates reveal that more than 3500 individuals have been forced to relocate in order to avoid the unpredictability and alterations to the Sesan River after the Yali Falls dam was commissioned. There is no evidence that individuals received compensation or offers of resettlement by Cambodian officials (3S Rivers Protection Network, 2007).

Both of these examples involve dam projects that are situated on major tributaries to the Mekong River within the LMB. The potential environmental risks, particularly with habitat fragmentation, a reduction in sediment transport, alterations to water quality and deforestation have been well-documented. Both tributaries serve important routes for a number of migratory fish species as well. Impediments caused by dam creation can have a significant impact on the ecological health of the Mekong River, but they have yet to be addressed by the MRC.

All governments within the MRC have a shared interest in protecting the MRB while also exploiting it for power generation and economic development. This has created a conflict of interest that has been a challenge to address and difficult to resolve. For example, Thailand has heavily invested in dam construction in Laos in order to secure a reliable source of electricity. Cambodia imports hydropower from Laos and wishes to construct dams in order to gain more energy independence and reduce energy costs. However, the Cambodian and Vietnamese governments have publicly criticized the Laotian government for building the Don Sahong tributary dam due to the

potential downstream environmental risks (Naren & Chen, 2013). These criticisms occur while Cambodia and Vietnam have completed and continue to construct additional major tributary dams that can also degrade the ecological health of the LMB.

Financing the Mekong River

The development of hydropower along the Mekong River represents an attractive opportunity for investors. It is common practice to enter into agreements that stipulate how financiers are the first to recover their investments and profits after dams become operational. The revenues generated through the production and sale of hydropower are considered to be sufficient enough to repay investors within the first 10 years of operation. This minimizes the exposure of risk to investors from losses associated with the long-term costs of operating dams such as major repairs, equipment overhauls and ongoing maintenance. This arrangement creates a low-risk investment with the potential for creating high-returns. The dam operator also profits from the sale of hydropower while governments benefit from the generation of tax revenue. It is not uncommon for the investor to also be the dam operator. This creates a perceived stable and predictable long-term revenue stream since many contracts can be in effect for 20 years or more.

Another common stipulation in contracts is that the investor/developer/operator/manager will also have rights to the water that flows through the dam as well as what is stored in the reservoir. This can present significant ramifications for host countries who lease the dams as fees associated by operators. Fees associated with water acquisition for irrigation, drinking, municipal or industrial use can be assessed and passed on to the end user. This can create a situation where the end user is susceptible to the effects of supply and demand. Periods of drought as well as increased consumption due to population or economic growth can all influence how much the end user will have to pay for water.

These arrangements create an inherent incentive to regulate the flow of water through dams in order to maximize profit margins. For example, flows need to be continually monitored and adjusted to produce optimal power generation according to the needs of the customer or the demands of the market. Furthermore, the release of water from reservoirs during the dry season or periods of drought can lead to ecological impacts downstream. Retention of water during periods of high rain in order to offset reservoir depletion can also impact flow rates and water levels along the Mekong River. The release of water from reservoirs during periods of heavy rain can also have similar downstream impacts.

Consequently, the continual management of flow rates and reservoir levels associated with dams will contribute to variability throughout the MRB. The cumulative impact that nearly 100 operational and planned dams along the Mekong River and tributaries is unknown at this time. This includes a lack of understanding with respect to cause-and-effect relationships between dams, downstream flows and water levels as each one is adjusted to meet specific production or retention targets.

Cambodian Food Security

The 2013 agricultural census produced by the Cambodian government indicates that 79% of the population lives within the central plain region of the country. This region also includes the Mekong River flood plain. Four out of five households in Cambodia raise livestock on their property or nearby land. Four out of five households also engage in the growing of crops and fishing. Total land area for agricultural purposes is 3.1 million hectares. Consequently, 2.48 million hectares of land is located within the central plain. There are 4.5 million hectares of total arable land available in Cambodia, and 3.9 million hectares are available for farming. However, only 68% of arable land is being used. The census suggests that 70% of agricultural production in Cambodia is for subsistence consumption.

There are an estimated 2.7 million head of cattle in Cambodia, and 70.3% are situated in the central plain. Forty percent of the 472,000 buffalo are also situated in the same geographical area (Cambodia Ministry of Planning, 2013).

The census indicates that 84% of active farmland in Cambodia is irrigated by seasonal rainfall and the flood pulse of the Mekong River/Tonle Sap Lake system. Eleven percent of active farmland receives water from developed irrigation systems. Consequently, Cambodian agricultural production and food security is currently susceptible to alterations to the flow of the Mekong River (MRC, 2010). Furthermore, land-use changes associated with the construction of dams and associated reservoirs will reduce the availability of arable cropland. A reduction in the area available for grazing lands and pastures for livestock production, and the variability associated with diminished fish stocks due to the impact of dams also contribute to the risk of a decrease in agricultural production in Cambodia. This risk is enhanced by the sustained practice of land-grabbing for the sake of development as it reduces available land and displaces rural residents who make up the majority of the population in Cambodia. The Cambodian government has yet to produce a comprehensive and specific plan to address these concerns.

Discussion

Findings indicate that a consistent reduction in water levels has occurred after 2008 as new dams were commissioned along the Lancang cascade. The last of the six dams along the Lancang cascade was commissioned in 2012. While the recorded water levels in 2015 are not the lowest, they are still lower than what was recorded in 2008. However, a reduction in water levels in 2010 over 2009 can be observed with the exception of the month of October. However, the greatest amount of October precipitation occurred in 2009 as well. A similar reduction occurred in 2013 where water levels for every month but June were lower than in 2012. However, precipitation in June of 2013 was also lower than in 2012.

While a relationship between the construction and commissioning of dams may be attributed to reduced water levels at the Chiang Saen station, there is no conclusive link or pattern that exists. This could be explained for a number of reasons. First, there is a lack of data available prior to 2008 that establishes a baseline trend in water levels at Chiang Saen before the first dams along the Lancang cascade were commissioned. Two dams were operational before water level data became publicly available at the MRC website.

Second, the small number of reporting stations in the UMB may not provide enough data to establish trends or deviations from norms in terms of regional precipitation levels during the monsoon season that includes the months of June-October. The lack of dry-season data also limits the scope of this experiment to the evaluation of water level changes at the Chaeng Saen station during the monsoonal months of June-October. A lack of data with respect to influences that other factors, such as snow or glacial melt in the upper reaches of the UMB may have with respect to introducing water into the Lancang river may also be a contributing factor.

Furthermore, variability associated with geography in the UMB, evaporation, pooling of water,

underground aquifer infiltration and other hydrological or geological characteristics all may contribute to the rate and amount of precipitation that runs off into the Lancang River. Therefore, the hypothesis that a direct relationship exists between dam operation and water levels as flows enter the LMB cannot be accurately validated through a comparative analysis of precipitation and water levels alone.

However, the reduction in water levels at the Chiang Saen station based on the six operational dams along the Lancang cascade are similar to values that were produced by predictive modeling that incorporated more complex variables prior to the completion of all of the dams. This is particularly evident for the months of July, August and September. However, modeling indicated increased water flow in June and decreases in October that were less than 10% (Rasanan, Koponen, Lauri & Kummu, 2012). The findings in that study contrast the decreases in June and more substantial decreases in October that were recorded in this simplified experiment. However, this test suggests that it is possible to extrapolate trends and infer that alterations to the flow of the Mekong River can be attributed to the Lancang cascade.

Previous research established a relationship between elevated water levels at the Chiang Saen station when there was a decrease in precipitation. Findings suggest that water stored in reservoirs is released during periods of low-precipitation in order to maintain flow rates that will produce desired levels of hydropower generation. Conversely, during periods of high-precipitation, water in reservoirs is replenished and dam-releases may be reduced. However, periods of high precipitation can also lead to a release of excess water through dams in order to prevent flooding once reservoirs are full (Rasanen, Koponen, Lauri & Kummu, 2012). However, this research was published before three of the six dams in the Lancang cascade became operational. Furthermore, the MRC has not published dry-season flow data on its website for the same time frame as wet season data was available.

The MRC also published estimates that the Lancang dam cascade in China led to a reduction of

water flow into the LMB by 15% during the wet season and 40% during the dry season (MRC, 2010). However, this data was also compiled before 2010 when only two of the six dams in the Lancang cascade were completed. The same report did not include hydropower development along tributaries in Laos. Consequently, a comprehensive and current assessment of water level changes in the LMR is unavailable.

The size, location, operation and management of the six dams on the Lancang cascade present variables in terms of the amount of water that is released as well as water that is stored in reservoirs behind the dams. Furthermore, water depth in sections of the Lancang River between dams and reservoirs is unknown. The storage capacity of reservoirs is also not fully understood. Variables associated with the release of water from reservoirs or the reduction of the amount of water that passes through dams as a means to regulate flow and thus power generation are also not known. It is also unclear how much water from reservoirs is diverted for irrigation, municipal use or other purposes. Finally, it is unclear as to when each dam became commissioned or operational. While information as to the years the dams went online is available, the exact dates are not known. Consequently, these variables inhibit the extrapolation of a cause and effect relationship between dam operation, reservoir water retention and water levels as flows pass through the Chiang Saen reporting station.

Chinese Role in Dam Construction

It is difficult to state with any degree of certainty exactly what interests China may have in the region with respect to designing, building and operating dams. However, there are three valid explanations to consider. First, the Chinese government may be using the development of hydropower and associated control over water rights in the region to expand their sphere of influence. This is evident with how the Chinese government packages foreign aid assistance that includes money for infrastructure development. For example, the Lower Sesan 2 dam project was financed out of larger

aid package that was accepted by the Cambodian government (Denyer, 2015). One of the benefits of operating and managing dams in other countries is that Chinese companies also have the ability to acquire water rights, regulate prices as well as supplies.

Second, Cambodia and Laos are interested in developing hydropower potential for energy and economic security, and China has the resources to accommodate these policy goals. Furthermore, this assistance does not come with the constraints that may be associated with help from western countries (Urban, Nordensvard, Khatri & Wang, 2012). Some constraints may include environmental considerations, building standards and labor issues. This essentially allows China to present more cost-effective options and produce results at a faster pace. Finally, developing, managing dams and exporting power back to China gives the Chinese government, utility companies and business interests access to a reliable source of electricity at prices they can control. This could place China in an advantageous position as many lease agreements for operating dams can exceed a period of 20 years, and this can enhance their access to affordable and long-term energy security.

Resettlement and Land-use Changes

The majority of the population in Cambodia is particularly vulnerable to land-seizures by the government when the interests of development take precedence over the rights of residents who will become displaced. The scale of human displacement associated with dam operations is evident through the examination of the Don Sahong and Lower Sesan 2 projects. More than 175,000 indigenous people are expected to either be forced to relocate or find alternative income sources once these dams become operational. The Cambodian government has plans to build at least 10 dams, limited available land resources and a record for not providing comparable or adequate accommodation for displaced persons.

Furthermore, the cumulative impact of dams in the MRB can alter the seasonal flow regime, reduce water coverage in the central Cambodian flood plain and impact the livelihoods of millions of

individuals who depend on subsistence fishing and farming to generate income and maintain food security. This has the potential for a secondary displacement that the Cambodian government has yet to develop comprehensive plans to address.

Cambodian Food Security

The majority of Cambodian agricultural production and the raising of livestock is connected to the natural flood pulse of the Mekong River that extends throughout the central Cambodian plain. Flooding that is less-extensive due to upstream dams can have a negative impact on nutrient transport and deposition that contributes to soil fertility, crop productivity and the health of pasture and grazing lands. Extensive development of irrigation systems would be needed to offset any sustained reductions in the geographic reach of the seasonal floodplain within the central Cambodian plain. Furthermore, the introduction of fertilizers to offset the reduction of naturally-occurring nutrient deposition can lead to the degradation of water quality downstream. The cumulative impact on inland fisheries from the creation of numerous main-stem and tributary dams is also unknown. What is known is that fish is the leading dietary source of protein intake for the Cambodian people, and reductions in fishery productivity can have an impact on access to this dietary staple.

The MRC has concluded that these losses could be offset through the development of aquaculture and the cultivation of more productive rice crops in the Mekong River delta region of southern Vietnam (MRC, 2010). Cambodia does not currently have the land resources that would be needed to fully-develop fish farms. However, this solution does not provide an alternative for the majority of the Cambodian people who depend on agriculture and fishing to generate income. Furthermore, this solution could also lead to an increase in staple food prices while decreasing food choices through the reduction in fish diversity that is now currently available. Products will also need to be transported, imported and distributed throughout Cambodia, and these additional costs would

arguably be passed on to the consumer. Additionally, causes of disruption in production from events such as extreme weather, pest infestation or the spread of disease in fish stocks could place supplementary food supplies at risk.

Financing Hydropower Development

It is clear that investors, developers and governments in the MRB can profit from the extensive generation of hydropower. The cost of harnessing and utilizing the full hydropower-generating potential in the MRB is estimated to be in excess of \$50 billion USD (MRC, 2010). However, a lack of transparency with regard to contracts and other transactions related to dam projects, systemic and institutionalized corruption and the absence of data regarding the price of electricity that is generated makes it impossible to estimate revenues and profits. Furthermore, the value of profits associated with securing water-rights and then selling water back to users in host countries is also unknown.

The Effectiveness of MRC Governance

“An economically prosperous, socially just and environmentally sound Mekong River Basin” is the mission statement of the MRC (MRC, 1995). Achieving this goal requires the cooperation of the member states of Thailand, Laos, Cambodia and Vietnam, along with the advisory partnership of the Chinese and Myanmar governments. However, the emerging challenge of rapid hydropower development by all states who share the Mekong River limits the ability of the MRC to establish a cooperative approach for the prioritization of protecting the ecology of the LMB.

This is particularly true as Laos has moved forward with the construction of the Xayaburi dam project despite calls from member states to abide by the moratorium. The development of dams along major tributaries also poses a significant threat to the ecology of the LMB. However, the MRC has failed to reach a consensus with respect to how to address this issue. Furthermore, the MRC appears to be shifting from a proactive management organization to one that is tasked with developing an

understanding of the impacts of large-scale damming in order to create solutions in an attempt to mitigate ecological change within the MRB.

Compounding this dilemma is that member states are either working together to promote hydropower development or opposing one another based on decisions made at the national level that may be detrimental to the interests of other nations within the MRB. Inconsistencies with respect to how individual states establish, prioritize and implement environmental policy and water management within their jurisdictional boundaries also influence how the MRC is able to promote its mission effectively.

The existence of the MRC has provided for the creation of a repository of research and data that has led to an unprecedented understanding of the complexities and fragility of the MRB ecosystem. However, the knowledge that is obtained appears to lag behind the alterations that are being made from the development of hydropower. This trend is inhibiting the ability of the MRC to propose effective management strategies at a time when potentially-irreparable harm is being caused to the ecosystem that may impact the lives of millions of people basin-wide, particularly in Cambodia.

Conclusion

The Mekong River is one of the last, great rivers in the world to be developed for hydropower. However, rapid development, since construction of the first main-stem dam in China began in 1991, has created a significant environmental and humanitarian risk within the MRB. The MRC was formed to promote international cooperation among nations who share the LMB. This organization established a framework of governance that provides a forum for collaboration and compromise with respect to how to manage development on the Mekong River. The Mekong River supports 70 million people and over 1600 aquatic, amphibious, terrestrial and avian species within the jurisdictional boundaries of the MRC.

The ecological impacts of large-scale dams on river ecosystems is well-understood. The richness, diversity and sensitivity that numerous species and habitats have to environmental change within the MRB continues to be researched. However, an understanding of the potential impact of large-scale damming to the ecology of the MRB is still in its infancy with respect to scientific research. Furthermore, there is also a lack of research associated with the impact that environmental change can have on the human population in the region.

This paper further validates the relationship between the construction of main-stem dams along the Lancang cascade in China and a reduction of water levels in portions of the LMR. This paper also establishes how politics, government policies, business interests and the desire for economic expansion are influencing the rapid development of hydropower within the MRB. These factors provide a contextual basis that can lead to a better understanding of why the current management of water resources in the MRB does not align with the vision of the MRC to create a sustainable and socially-just framework for development in the region.

Cambodia is particularly susceptible to alterations of the historic and natural flow regime of the

Mekong River. The Cambodian population is dependent on the cyclical flood-pulse of the Mekong River to sustain agricultural and livestock production, fisheries, the majority of the workforce and the health of the national economy. The majority of families depend on subsistence agriculture and fishing for food and income. Main-stem as well as tributary dam projects in Laos and Cambodia also threaten to block migratory fish routes and the transport of nutrients that are essential to sustaining the supply of inland fishery stocks and crop productivity. The lack of infrastructure development in terms of land management and irrigation jeopardize the stability of these activities if upstream dams alter the extent of inland flooding or water levels in the Mekong River. These alterations may occur before solutions to mitigate these changes can be implemented.

The threat is compounded by a lack of detailed environmental policies, the inconsistent application of laws, corruption and the desire of Government officials to favor economic development over the ecological health of the region and the welfare of its citizens. This socio-political undercurrent is particularly well-established in Cambodia. The potential displacement of millions of people without fair and just compensation and accommodation due to dam building projects in the country is a concern that has yet to be addressed by the Cambodian government or the MRC.

Power generation and infrastructure development are key components to the economic policies of the Cambodian government. Cambodia imports electricity from Laos, and the creation of dams represents an opportunity for the country to become energy independent. Economic policies also favor foreign investment and the influx of foreign aid. Chinese interests have exploited this policy through the creation of attractive aid packages and trade opportunities that provide Cambodia with significant financial benefits in exchange for the rights to build and operate dams and manage associated water supplies.

This business model has been associated with dam-building projects throughout the LMB. The

low-risk and potential to receive high returns have lured investors from the region and around the world. The monetizing of the Mekong River is also one of the underlying factors that are contributing to the rapid development of hydropower within the MRB. The sale of water rights and the regulation of reservoir storage and water flow through dams has the potential to create a flow regime along the Mekong River that is optimized to maximize profits and the efficiency of hydropower generation. This approach represents a potentially-significant risk to the stasis of the hydrological regime and ecological balance in the MRB that has developed over the course of time.

This paper also examines and discusses some of the challenges and limitations associated with attempting to quantify the cumulative impact that dams have on altering the flow of the Mekong River. This calls attention to the importance of recognizing and accepting the validity of qualitative assessments to examine how human activity contributes to ecological change in the large, dynamic and complex Mekong River Basin. A reliance on quantitative data alone can lead to a narrow and limited understanding of the cumulative risks associated with large-scale dam building that may be easier to explain and demonstrate through qualitative means. It can also contribute to the delay of forming and implementing appropriate policies and effective management decisions to protect the ecology of the MRB.

The full-scale development of hydropower in the MRB should be considered a foregone conclusion. Dam construction continues despite efforts by the MRC to slow the pace of development until potential environmental impacts can be better understood. However, current projects, and those that are planned to commence in the near future, may be completed before these assessments are evaluated. Consequently, serious ecological degradation may occur that poses a direct threat to the food security and economic well-being of millions of people. This possibility calls attention to the importance of developing, testing and implementing solutions before engaging in large-scale and

ecologically-disruptive dam projects that threaten to create a humanitarian crisis in the region.

References

- 3S Rivers Protection Network. (2007). Abandoned villages along the sesan river. Retrieved from <http://www.3spn.org/wp-content/uploads/2011/10/3SPN-2007-Abandoned-Villages-Along-the-Sesan-River-Ratanakiri-Province-NE-Cambodia.pdf>
- Arias, M. E., Piman, T., Lauri, H., Cochrane, T. A., & Kummu, M. (2014). Dams on mekong tributaries as significant contributors of hydrological alterations to the tonle sap floodplain in Cambodia. *Hydrology and Earth System Sciences*, 18(12), 5303. doi:<http://dx.doi.org/10.5194/hess-18-5303-2014>
- Arias, M. E., Cochrane, T. A., Piman, T., Kummu, M., Caruso, B. S., & 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*, 112, 53-66. doi:10.1016/j.jenvman.2012.07.003
- Cambodia Ministry of Planning. (2013). Census of agriculture in Cambodia 2013. Retrieved from http://www.fao.org/fileadmin/templates/ess/ess_test_folder/World_Census_Agriculture/Country_info_2010/Reports/Reports_5/KHM_EN_REP_PRI_2013.pdf
- Chev, P., Yun, S. & Lipes, J. (2015). Cambodian villagers threaten renewed protests against dam developer. Retrieved from <http://www.rfa.org/english/news/cambodia/dam-03022015173133.html>
- Clark, P. (2014). Troubled waters: the Mekong river crisis. Retrieved from <http://www.ft.com/cms/s/2/1add7210-0d3d-11e4-bcb2-00144feabdc0.html>
- Cochrane, T. A., Arias, M. E., & Piman, T. (2014). Historical impact of water infrastructure on water levels of the mekong river and the tonle sap system. *Hydrology and Earth System Sciences*, 18(11), 4529. doi:<http://dx.doi.org/10.5194/hess-18-4529-2014>

- Denyer, S. (2015). China-built dam in Cambodia set to destroy livelihoods of 45,000. Retrieved from <http://www.scmp.com/magazines/post-magazine/article/1858974/china-built-dam-cambodia-set-destroy-livelihoods-45000>
- Denyer, S. (2015). In building dam for Cambodia, China widens role-but at a cost. Retrieved from <https://www.bostonglobe.com/news/world/2015/09/12/cambodia-china-feels-extent-and-limits-its-growing-power/ZobyZ2vvFegcu7SVBh6DaI/story.html>
- Gainsborough, M. (2012). Elites vs. reform in Laos, Cambodia, and Vietnam. *Journal of Democracy*, 23(2), 34-46. Retrieved from <http://search.proquest.com/docview/1014267562?accountid=8289>
- Gluckman, R. (2008). *The battle for boeung kak lake*. Hong Kong: Review Publishing Company Ltd. (Hong Kong).
- Google. (2015). Map of lancang cascade. Retrieved from <https://www.google.com/maps/place/Yunnan,+China/@25.1146565,97.3680482,6z/data=!3m1!4m2!3m1!1s0x36d083db32a05b29:0xa63cebb7ca8dac29>. ©2016 by Google, Inc.
- Grimsditch, M. (2012). Understanding the new threats and challenges from hydropower development to biodiversity and community rights in the 3S river basin. Retrieved from http://www.internationalrivers.org/files/attached-files/3s_rivers_english.pdf
- Hill, H., & Menon, J. (2013). Cambodia: Rapid Growth with Weak Institutions. *Asian Economic Policy Review*, 8(1), 46-65. doi:10.1111/aepr.12003
- International Rivers. (2015). Nam Theun 2 dam. Retrieved from <https://www.internationalrivers.org/campaigns/nam-theun-2-dam>
- Jiao, X., Smith-Hall, C., & Theilade, I. (2015). Rural household incomes and land grabbing in Cambodia. *Land use Policy*, 48, 317-328. doi:10.1016/j.landusepol.2015.06.008
- Kimkong, K., Samchan, H., Thea, S., Vichet, S. & Rasmey, L. (2013). Improving hydropower project

decision making processes in Mekong basin: Case studies of Lower Sesan 2 and Kamchay hydropower projects, Cambodia. Retrieved from <https://wle-mekong.cgiar.org/download/mk8-improving-hydropower-decision-making-processes-in-the-mekong/Final%20report%20of%20MK8%20research%20project%20report%20RUPP.doc>

Kingdom of Cambodia Ministry of Environment. (2001). Tonle Sap ecosystem and value. Retrieved from <http://www.mekonginfo.org/assets/midocs/0001325-environment-tonle-sap-ecosystem-and-value.pdf>

Kummu, M., Tes, S., Yin, S., Adamson, P., Józsa, J., Koponen, J., & Sarkkula, J. (2014). Water balance analysis for the tonle sap Lake–floodplain system. *Hydrological Processes*, 28(4), 1722-1733. doi:10.1002/hyp.9718

Kummu, M., & Sarkkula, J. (2008). Impact of the mekong river flow alteration on the tonle sap flood pulse. *Ambio*, 37(3), 185-192. doi:10.1579/0044-7447(2008)37[185:IOTMRF]2.0.CO;2

Laos Department of Energy and Mines. (2013). Description and main features of the project. Retrieved from http://www.laoenergy.la/pageMenu.php?id_menu=4

Laos Department of Energy and Mines. (2013). Frequently asked questions about xayaburi hydropower project. Retrieved from http://www.laoenergy.la/pageSubMenu.php?id_submenu=34

Laos Department of Energy and Mines. (2015). Consultation, technology reduce potential environmental harm from xayaburi project, say engineers. Retrieved from http://www.laoenergy.la/pagelaoEnergyNews.php?id_hotNews=26

Laos Department of Energy and Mines. (2015). Power Projects. Retrieved from <http://www.poweringprogress.org/new/power-projects>

Matthews, N., & Motta, S. (2015). Chinese state-owned enterprise investment in mekong hydropower:

Political and economic drivers and their implications across the water, energy, food nexus.

Water, 7(11), 6269-6284. doi:10.3390/w7116269

Merme, V., Ahlers, R., & Gupta, J. (2014). Private equity, public affair: Hydropower financing in the mekong basin. *Global Environmental Change*, 24, 20-29. doi:10.1016/j.gloenvcha.2013.11.007

Middleton, C. (2009). Thailand's commercial banks role in financing dams in Laos and the case for sustainable banking. Retrieved from https://www.internationalrivers.org/files/attached-files/sustainablethaibanks_ir_dec09.pdf

MRC. (1995). Vision and mission. Retrieved from <http://www.mrcmekong.org/about-mrc/vision-and-mission/>

MRC. (2009). The flow of the Mekong. Retrieved from <http://www.mrcmekong.org/assets/Publications/report-management-develop/MRC-IM-No2-the-flow-of-the-mekong.pdf>

MRC. (2010). The Mekong river basin. Retrieved from <http://www.mrcmekong.org/mekong-basin/physiography/physiographic-regions/>.

MRC. (2010). State of the basin report 2010. Retrieved from <http://www.mrcmekong.org/assets/Publications/basin-reports/MRC-SOB-Summary-reportEnglish.pdf>

MRC. (2011). From local watershed management to integrated river basin at national and trans-boundary levels. Retrieved from <http://www.mrcmekong.org/assets/Publications/Reports/Watershed-Management-report2011.pdf>

MRC. (2014). Don Sahong hydropower plant, Lao PDR. Resettlement action plan, RAP. Retrieved from: <http://www.mrcmekong.org/assets/Other-Documents/Don-Sahong/DSHPP-RAP-FINAL-2013.pdf>

MRC. (2015). Graph of water levels and reports. Retrieved from http://ffw.mrcmekong.org/historical_rec.htm.

- MRC. (2015). Mekong basin. Retrieved from <http://www.mrcmekong.org/mekong-basin/>
- Naren, K. & Chen, D. (2013). Officials criticize Laos over don sahong dam. Retrieved from <https://www.cambodiadaily.com/archives/officials-criticize-laos-over-don-sahong-dam-44888/>
- Neef, A., Touch, S., & Chiengthong, J. (2013). The politics and ethics of land concessions in rural Cambodia. *Journal of Agricultural and Environmental Ethics*, 26(6), 1085-1103.
doi:<http://dx.doi.org/10.1007/s10806-013-9446-y>
- NGO Forum on Cambodia. (2009). Lower sesan 2 hydro project eia review. Retrieved from http://library.opendevdevelopmentcambodia.net:8080/newgenlibtxt/CatalogueRecords/SeSan2_EIACComments_August%202009%20NGOF.pdf
- Oldenburg, C., & Neef, A. (2014). Reversing land grabs or aggravating tenure insecurity competing perspectives on economic land concessions and land titling in Cambodia. *Law and Development Review*, 7(1), 49-77. doi:<http://dx.doi.org/10.1515/ldr-2014-0014>
- Open Development Cambodia. (2016). Hydropower: dams. Retrieved from <http://www.opendevdevelopmentcambodia.net/hydropower/hydropower-dams/>
- Pheap, A., Wright, G. (2015). Water festival cancelled; doubts over water fears. *Cambodia Daily*. Retrieved from: <https://www.cambodiadaily.com/news/water-festival-canceled-doubts-over-motives-98935/>
- Räsänen, T. A., Koponen, J., Lauri, H., & Kummu, M. (2012). Downstream hydrological impacts of hydropower development in the upper mekong basin. *Water Resources Management*, 26(12), 3495-3513. doi:10.1007/s11269-012-0087-0
- Ratanakiri Province Fisheries Office. (2000). A study of the downstream impacts of the yali falls dam in the se san river basin in ratanakiri province, northeast Cambodia. Retrieved from <http://www.gapeinternational.org/wp-content/uploads/2011/08/A-Study-of-the-Downstream->

Impacts-of-the-Yali-Falls-Dam-in-the-Se-San-River-Basin-in-Ratanakiri-Province-Northeast-Cambodia.pdf

Reuters. (2015). Cambodia pm stands by hydropower, dismisses critics as 'extremists'. Retrieved from <http://www.reuters.com/article/us-cambodia-energy-idUSKBN0U60V220151223>

Rith, S. & Cochraine, L. (2005). Koh Pich: an island in a stream of greed. Retrieved from <http://www.phnompenhpost.com/national/koh-pich-island-stream-greed>

Rudi, L., Azadi, H., Witlox, F., & Lebailly, P. (2014). Land rights as an engine of growth? an analysis of cambodian land grabs in the context of development theory. *Land use Policy*, 38, 564-572. doi:10.1016/j.landusepol.2013.12.016

Titthara, M. (2015). Stop sesan dam, locals tell gov't. Retrieved from <http://www.khmertimeskh.com/news/18534/stop-sesan-dam--locals-tell-gov---t/>

United States Department of Commerce. NOAA. (2016). National centers for environmental information monthly summaries station details. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056651/detail>.

United States Department of Commerce. NOAA. (2016). National centers for environmental information monthly summaries station details. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056951/detail>.

United States Department of Commerce. NOAA. (2016). National centers for environmental information monthly summaries station details. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056964/detail>.

United States Department of Commerce. NOAA. (2016). National centers for environmental information monthly summaries station details. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056444/detail>.

- United States Department of Commerce. NOAA. (2016). National centers for environmental information monthly summaries station details. Retrieved from <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:CHM00056954/detail>.
- Urban, F., Nordensvard, J., Khatri, D., & Wang, Y. (2013). An analysis of china's investment in the hydropower sector in the greater mekong sub-region. *Environment, Development and Sustainability*, 15(2), 301. doi:10.1007/s10668-012-9415-z
- Vientiane Times. (2014). Thai banks finance Lao hydropower project. Retrieved from https://wle-mekong.cgiar.org/thai-banks-finance-lao-hydropower-project/?doing_wp_cron=1452056067.0345420837402343750000
- World Bank. (2004). Nam Theun 2 hydroelectric project. Social development plan and resettlement action plan. Retrieved from wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/12/14/000112742_20041214185906/Rendered/PDF/RPL2770v4.pdf
- Worrell, S. & Kunthear, M. (2014). Shukaku pushes forward at Boueng Kak. Retrieved from <http://www.phnompenhpost.com/national/shukaku-pushes-forward-boeung-kak>

