Development of Hydropower as an Energy Source and its Effects on Long-Standing Societal Norms

STS Research Paper
Presented to the Faculty of the
School of Engineering and Applied Science
University of Virginia

By

Jacob Kuchta

May 3, 2020

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: ____

Approved: _____________________________________ Date ________________________
Rider Foley, Department of Engineering and Society

Introduction

The Mekong River region is one of the most biodiverse regions in the world, rivaled only by the Congo and the Amazon. The Mekong is the longest river in Southeast Asia, the seventh longest in the Asian continent, and the 12th longest in the entire world. It flows 4,350 km through both dry plains and luscious rainforest and acts as an irreplaceable resource to the six countries which it winds through: China, Laos PDR, Vietnam, Thailand, Myanmar, and Cambodia (Jacobs, 2019). Millions of citizens have relied on the Mekong River for agriculture, aquaculture, and transportation for hundreds of years. These areas of Southeast Asia have continued to urbanize and develop, and the demand for energy, as well as agricultural and aquacultural production, is on the rise.

In a 2017 study by J. Sabo, there was found to be an estimated 60 million people dependent on the Mekong for food, water, and energy (Sabo, 2017, p.1). Critical to this urbanization and economic growth in the region has been the creation of hydropower infrastructure as well as sand-mining for concrete production. However, these technological developments have posed threats to the sustainability of local communities. Sabo states that, "Hydropower development is crucial to the region's economic prosperity and is simultaneously a threat to fisheries and agriculture that thrived in the natural-flow regime," (ibid). Steps towards sustaining the river's natural qualities must be taken with the increasing threat from climate change on ecosystems worldwide, as well as with the continued negative effects development of hydropower development on wildlife & biodiversity.

So, the technical portion of this thesis will dive into the analysis of the land and water use in the Mekong to quantify the effects of hydropower on the economies, farms, and fisheries in the Mekong river system. Very closely tied, the STS research paper will explore the development of hydropower as an energy source as it relates to the long-standing societal norms of the region, exploring the process of what could occur to a community when a dam is put in place. The goal is to analyze both current infrastructure and proposed infrastructure development in the region and its effects on the lives of the local people, business, and cultural tradition. We will use the computing power available to us to create a quantitative report of economic, agricultural and aquacultural effects of hydropower in the Mekong, using Excel & Minitab software. An analysis of hydropower development in the Mekong and similar valleys will be completed to shed light on how it may be affecting societal norms in these underdeveloped regions.

Land & Water Use in the Mekong Region

From China to Vietnam, the Mekong River is the lifeblood of Southeast Asia and offers a glimpse into the long history and diverse cultures of the region. For thousands of years, the rapids and falls have been the lifeline for populations that depend on it for survival. The Mekong has long been regarded as the foundation of Southeast Asia's economic growth and prosperity (Avalon, 2017, p.1). However, there are now several factors that are leading to an environmental change in the Mekong region and of these drivers, there exist three that have impacts throughout the economies of the region: hydropower development, climate change, and sand-mining. The influence of these three particular drivers on those reliant on the Mekong is increasing at a rapid pace due to the push by governments in the region to urbanize and develop. Moreover, there are three specific industries dependent on the Mekong in which the social and economic effects of these drivers is felt most heavily: farming, fishing, and energy production. The World Wildlife Fund (WWF) indicates that the Mekong region is currently facing a defining point in its history where proposed developments and imminent environmental changes will directly impact economic performance for decades to come (World Wildlife Fund, 2016, p.1).

Research Questions & Methods

In collecting data on macro indicators and case studies, I will attempt to answer the question: How does the development of hydropower as an energy source affect societal norms in developing regions? It is imperative that this analysis is completed now due to the rapid pace of hydroelectric development necessary to keep up with the urbanization of developing regions across the globe. This hydroelectric development has already proven controversial when considering the effects on aquacultural and agricultural industries of the low-income areas that surround dam infrastructure, whose ways of life have not been this significantly changed for hundreds of years.

Understanding the issues at hand is made possible through the use of data sets released by various organizations such as the World Wildlife Fund, The Mekong River Commission, and the World Resource Institute. Data collected on the economic effects of hydropower development are some of the most quantifiable metrics in this study, and will be helpful in the analysis of the research question. Several sets of agricultural data were used, and regressions and hypothesis tests were completed to understand the relationship between the implementation of hydropower and the status of the agricultural industry. The goal in analyzing economic and agricultural data is to identify trends in macro indicators of societal wellbeing. The region being analyzed is the Lower Mekong River Basin, the area of the world which has experienced the most growth in installed hydropower capacity globally in the last 20 years. In looking at these trends in the data, 2-population sample T-tests and linear regressions were run in order to see the relationship between these macro indicators and installed hydropower capacity, on a yearly basis. Data analyzed is divided into categories based off country, with the highly affected downstream countries being those analyzed (Thailand, Vietnam, Lao PDR, and Cambodia). Ideally, I would be able to analyze data on a more household/community level, as opposed to a macro level, in order to better quantify how societal norms may be changing. However, this type of data is often very hard to find or is not gathered in regions where hydropower implementation has the greatest effects on daily life, namely developing regions. So, statistical correlations will be found between hydropower implementation levels and macro indicators in economic and agricultural sectors. These correlations will be put into our context in order to fully interpret the effects that hydropower implementation may be having on societal norms in affected regions. Furthermore, prior literature and case studies will be used to analyze the environmental effects of climate change on the properties of the river system. It is essential to realize the dynamic natural qualities of the settings in which these dams are being put in place to best encapsulate how future consequences of hydropower development may be compounded for generations. An additional resource in representing some of the altercations to societal norms that occur is a source that details the displacement of local inhabitants during dam construction and implementation.

Analyzing Using a Framework

The interconnection between the development of hydropower and the local inhabitants of the Mekong can best be understood using the framework of Interactive Sociotechnical Analysis (ITSA). This framework is notably outlined in the paper *Unintended Consequences of Information Technologies in Health Care—An Interactive Sociotechnical Analysis* (Harrison et al., 2007). Harrison demonstrates that there is a necessity for the study of the relationships among new elements, workflows, and organizations. Specifically, he emphasizes using

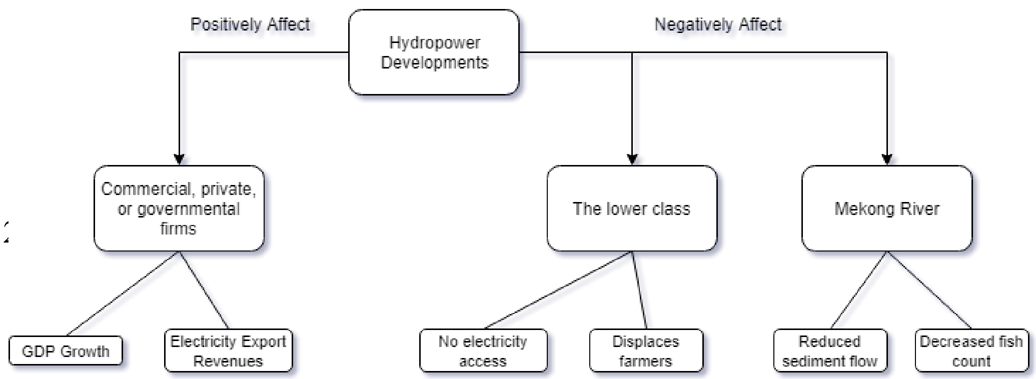
Interactive Sociotechnical Analysis (ISTA) to highlight the recursive and iterative nature of these relationships and their potential for producing unintended consequences. This framework highlights the user interpretation of a technology's features & the interdependence of social and technical systems, as well as the recursive relation of a system's subcomponents with the user. Harrison uses Health Information Technology (HIT) infrastructure as an example of how ISTA can be a pivotal tool in examining the actual uses of HIT against the uses intended or envisioned by designers or managers. One case stated of how the social system is producing unintended consequences of the technology is how, "extensive reporting requirements lead physicians to cut & paste whole reports, rather than extracting pertinent facts," (Harrison et al, 2007, p. 545). In essence, the ITSA framework highlights that although technical flaws often cause problems, many harmful or otherwise undesirable outcomes of technological implementation flow from sociotechnical interactions—the interplay between new technology and organization's existing social and technical systems—including their workflows, culture, social interactions, and technologies (Harrison et al, 2007, p. 542).

I will analyze the evidence found through the scope of the aforementioned Interactive Social Technical Analysis (ISTA) framework. Through this lens, we must first analyze how developers of these dams envision they would be ideally implemented. The first and most obvious reason for implementing a dam is to create a hydroelectric power source that is relatively reliable and stable compared to other forms of alternative energy such as wind power. Furthermore, developers will create dams to control waterways that produce disastrous floods for many communities. In theory, dams would also provide a great source of irrigation, creating a reservoir that can be used as a source of water for farm and/or industrial activities. We must now remember the system in which these hydroelectric energy sources are being built into. Along the

Mekong, there are nearly 60 million inhabitants reliant on the Mekong as a water source for their livelihoods. Sustainable development and human well-being are intricately linked to, and dependent on, the Greater Mekong's remarkable natural support system. If this natural support system is disrupted, the impact on people's livelihoods could be dramatic. This dependence amplifies any unintended consequence of hydropower as repercussions are felt by millions. In addition, the physical nature of the South-bound flowing river means that a dam implemented in Lao PDR could have trickle-down effects on inhabitants hundreds of miles downstream in Thailand. It is in the coupling of these prior case studies, environmental reports, and the macro-level data that I attempt to accurately depict the product of interactions between hydroelectric systems and the inhabitants of the Mekong.

Hydroelectric infrastructure is implemented as a sustainable energy source, and therefore should yield the benefit of providing electricity to surrounding areas. However, as I have found in case studies, this is often not true in the long-standing rural communities most affected by dams' negative consequences. Along the banks of the Zambezi river in Africa, another developing region of the world using hydroelectric power as an energy resource, local inhabitants are not the actors in the system that are receiving the benefits. The Kariba dam, one of Africa's largest dams, produces 6,400 GWh of electricity annually, which is an ample amount to supply the surrounding areas (Thieme, 2012, p.1). However, years after implementation, tens of thousands of inhabitants displaced by the dam still have no electricity or adequate water supply. Further down the Zambezi in Mozambique, the Cahora Bassa dam is yielding similar negative effects, "Cahora Bassa's capacity of 2,075MW is in principle sufficient to supply the electricity needs of all of Mozambique, but 95% of Mozambicans have no access to electricity. Instead, most of the power is exported at below market price to South Africa. At the same time, reduced river flow has decimated the once lucrative shrimp fisheries in the Zambezi delta, depriving local fishermen of a valuable income," (Thieme, 2012, p.2). Before hydropower was implemented in these developing areas such as the Mekong & the Zambezi, social systems had been established that thrived off of the natural order of the river system for agricultural and aquacultural production. With the help of the ISTA framework, it is apparent that new hydroelectric technology is affecting long-standing relationships in these social systems, see Figure 2.

Figure 2



Results of Analysis

Upon looking at several case studies performed by environmental scientists and running multiple regressions and population tests on agricultural and economic data from the Mekong region, I was able to shed light on the relationship between hydropower implementation and societal prosperity. In reading reports released by the World Wildlife Foundation, I found a general sentiment of environmental scientists expressing their concern on negative implications of hydropower development in the Mekong region. These concerns range from consequences of irregularities in wet season behavior to lack of proper nutrient transfer leading to augmentation of agricultural cycles. In regards to the economic data analysis, the region experienced growth in

GDP and GNI in the last 15-20 years (as expected), but this growth is statistically unrelated to installed hydropower capacity. The agricultural data analyzed led to a more ambiguous conclusion about the relationship between prosperity in the sector and hydropower implementation, with changes in farming techniques occurring globally coinciding with the implementation of hydropower in the region. We also find some harsh realities when looking at the process of dam displacement, one of the most direct negative effects of dam implementation. In looking at all of our sources, we see that hydroelectric systems really do pose a serious threat to the way of life in Southeast Asia.

In attempting to look at economic prosperity throughout society, one metric analyzed over the last 20 years in the region was Gross National Income (GNI) per-capita. This annual GNI per capita metric is compared to a country's corresponding installed hydropower capacity level in determining a relationship between the two. Here, T-tests were run with the null hypothesis that mean GNI per capita was the same in years where either more or less than 50MW of hydroelectric capacity was installed. Across the Lower Mekong region, the null hypothesis was proved to be correct to a confidence level of 95% in all countries besides Thailand. Furthermore, a boxplot analysis was then completed to identify the particular mean GNI per capita levels per country in years with less than 50MW of capacity installed and in years with greater than 50MW of capacity installed. Results showed that in all countries besides Thailand, mean GNI per capita is higher in years with less than 50MW of installed hydropower capacity. Therefore, we conclude that hydropower implementation is not a driver of GNI per capita growth, ensuing that the positive effects of hydropower may not be felt economically by those in surrounding areas. This observation proves pivotal in marking a difference between ideal implementation in the mind of the developer and actual implementation. Developers are not seeing a positive correlation between their hydropower implementation and income per-capita, which is alarming considering the several benefits supposedly provided by dam creation. This goes to prove that implementation into a community/into society may not go as planned, and that unintended consequences are apparent.

Continuing with the analysis of economic data, another metric that was analyzed was development spending in the region. I ran a linear regression on regional development spending data in comparison with installed hydropower capacity levels in the region, using the same 50MW threshold for differentiation as the previous analysis. Development spending growth rates have gradually inclined over the last 20-year period, with a spike in rural development spending coming in 2015, see Figure 1. To provide context, this stems from current problems around the Mekong Delta. Currently, hydropower dams are blocking downflow sediment which both hinders agricultural and fishery output but also does not counteract the erosion and sand mining taking place. Without this sediment compounded with increasing sea levels, the Delta is shrinking at over one centimeter per year. The logical shift in development spending would be to direct towards fishery and agricultural development to look for alternative ways to cope with this issue. However, the 2015 spike in rural development shows that foreign investments are mainly going towards infrastructure projects such as buildings and roads.

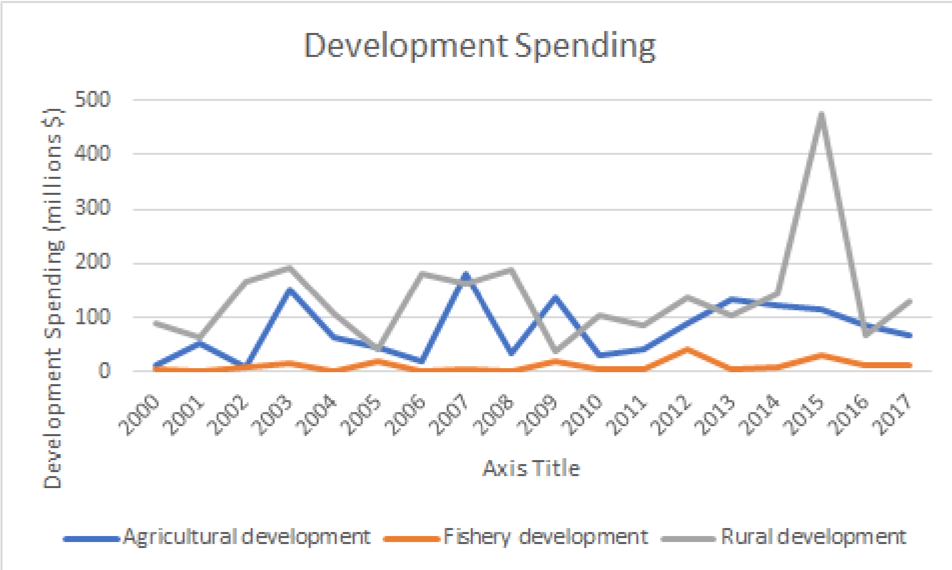


Figure 1: Time-series of Development Spending in the Mekong region, per sector (source: FAO)

The final metric included in data analysis of the region is the Agricultural Net Production Index (ANPI) of each country in the Lower Mekong region. Net production quantities of each commodity are weighted by average international commodity prices and summed for each year. To obtain the index, the aggregate for a given year is divided by the average aggregate for the base period. In layman's terms, ANPI is "Production – Feed – Seed." Results of regression analysis of ANPI compared to installed hydropower capacity show that ANPI has grown expectedly over time, and that ANPI values are actually higher in years with more installed hydropower capacity. While this was unexpected, background research about the farming industry in the region lends the explanation that this growth can be attributed to the switch to precision farming in recent times. By contrast, precision farming combines sensors, robots, GPS, mapping tools and data-analytics software to customize the care that plants receive without increasing labor. This change in farming technique is a factor contributing the growth in return margins (ANPI) in recent years, those same recent years in which hydropower installation has increased in magnitude.

Transitioning to look at some of the environmental data to come out of the Mekong Region, we see that investigations regarding hydropower development, specifically, have been topics of research and analysis by several environmental scientists in the last 10 years. It is very important to look at the environmental trends of the region, as negative effects onset by hydropower will only be amplified by climate change behavior (e.g. river levels/ flood stages). It is because of this that when answering the research question, a picture of the environmental scene must be painted to fully understand how everyday activity of inhabitants might be infringed upon. One of these research endeavors was carried out by Jory Hecht, a hydrologist with the United States Geographical Survey. In Hecht's report, he uses the standard seasonal characterization of the wet season as June to November where there is a significant increase in rain, and the dry season from December to May where average rainfall significantly decreases (Hecht, 2018, p.2). Following with the idea of a changing ecological nature of the system, he goes on to state that, "reduced wet season flows and increased dry season flows will potentially damage the river's ecological productivity and the livelihoods of the people dependent upon it," (Hecht, 2018, p.3). In addition, he reports a reduction in vital nutrient transport and an increased risk of saltwater intrusion, the beginnings of a process called oligotrophication.

Now, it is important to take a closer look at what may be causing a reduction in wet season flows and an increase in dry season flows, as well as a reduction in nutrient levels. Hydropower infrastructure has been identified as the source of these irregular patterns. Long P. Hoang, a Postdoc researcher for Water Systems and Global Change at Wageningen University, reported on this very issue. Hoang has quantified potential flow changes in response to hydropower infrastructure as, "+160% in the dry season and -40% in the wet season," (Hoang, 2017, p.601). As more and more research is done on the region, it is clear that hydropower development in upstream locations of the river is altering the natural flow of the river, augmenting agricultural cycles with production levels of local industry feeling the unintended consequences.

Looking at some more environmental effects, large scale climate change is negatively affecting the industries native to the Mekong river region. Wassmann, a climate change expert at the International Rice Research Group, reported that roughly 78% of land in the Vietnamese Mekong Delta in the year 2000 was used for rice production, and most of the land in the Delta is less than two meters above sea-level (Wassman, 2004, p.90). Wassmann goes on to estimate that a one-meter increase in sea level caused by climate change would result in a loss of $17 Billion in GDP from the agricultural sector in Vietnam (Wassman, 2004, p.92).

In addition to rising sea levels, the Mekong region is severely at risk of facing further industrial challenges due to average temperature rise. Tuan Ahn Lu of the Research Institute of Climate Change explains how, "temperature rise in the upstream region of the Mekong River may affect the flood regime of the Mekong Delta, which may lead to an extension of the current boundaries of flooding patterns" (Wang et al, 2017, p.207). Projected increases in temperatures, changes in precipitation & flooding patterns, and reductions in water availability may all result in reduced agricultural productivity. As we remember, goals of an ideal implementation of a dam is that it would provide a great source of irrigation and it will would act as a flood control mechanism for communities. However, we see from these studies that hydropower implementation has become more of an influencer of unintended consequences than the regulator that developers would have hoped for it to be. Given the fact that the river's natural flow is already being affected so greatly by environmental change, parties involved with creating hydroelectric systems must understand the necessity to be more careful than ever with their geological planning and proper implementation.

To gain a better understanding of the altercations to the way of life of inhabitants due to hydropower implementation, we must detail the process of dam displacement. Those displaced by reservoirs are only the most visible victims of large dams. Millions more have lost land and homes to the canals, irrigation schemes, roads, power lines and industrial developments that accompany dams. Many more have lost access to clean water, food sources and other natural resources in the dammed area. A review of available literature shows that Dam Induced Displacement & Resettlement (DIDR) programs typically focus on resettling displaced people to 'similar' settings, i.e., from rural-to-rural region and attempt to reconstruct similar livelihoods as those lost due to dislocation. This proximity principle in itself is logical as it strives to minimize changes in livelihood sources and setting and, as such, limits dislocation. Yet, at the same time, one may wonder how realistic such reconstruction of natural resource-intensive (land, water, forest) livelihoods is in a context of increasing scarcity of natural resources (land, water, forest). In many cases resettled people are left with less land and worse access to common pool resources than before resettlement or these resources are of a lesser quality. Social scientist Brooke Wilson of La Trobe University studied this process in detail and reports an even more startling occurrence, "recently, several countries have resettled displaced people from rural-to-urban areas as in the case of China and Indonesia," (Wilmsen, 2011). This model attempts to replace rural livelihoods by urban employment, but, here again, livelihood outcomes of displaced households are often poorer than before resettlement, possibly because people lack skills, networks and other assets necessary to do well in a very different environment. Dam displacement is a severe issue when dealing with effects of hydropower implementation, with it being a glaring example of how this technology is causing consequences to the system is it being implemented into.

Discussion

In the Mekong region, hydropower development is producing several unintended consequences relating to the flow of the river and the inhabitant's dependent on it. Hydropower infrastructure sections off portions of the river, causing several migratory species of fish native to the area & integral to the fishery industry to face extinction. Furthermore, damming the Mekong impacts the region's natural monsoonal flood/drought cycles, and blocks sediment and nutrient transfer which seriously impacts the farming industry of both the river and wetlands. It will also require tens of thousands of people to relocate because their homes and lands will be flooded (Gilbertson, 2019). In relation to the ISTA framework, the users of these new systems, local inhabitants, have already felt the unintended consequences in the prior iterations of hydropower development. In the Lower Mekong Region, the region most at risk of feeling downstream effects of dam infrastructure, 65-85% of employment is in the agricultural industry with (William & Pearse-Smith, 2012, p.78). A survey taken in this region found that one in six households reported having a family member who changed occupation due to the decline of aquacultural productivity while 21% of those households claim to have no option for a second occupation. In one report from Vietnam, inhabitants still able to produce crops and aquaculture downstream from the Yali Falls dam have felt an average household income drop from $109/month to $46/month in the three years following the dam's implementation (ibis). These people still today look for answers to the question: why was this dam constructed in the first place? As ISTA is used to analyze innovations not as things, but as elements within an unfolding process of sociotechnical interaction, we see the dynamic nature of the Mekong River and the inhabitants it supports.

In looking back on this sociotechnical paper, I understand that there were some limitations in my analysis. The biggest of these limitations coming in the form of the specifics of regional data acquired. The data on this region in which I was able to analyze, the data that is publicly accessible, was all at a macro level (GNI, GDP, production outputs, etc.). When attempting to try and answer this research question to its fullest, data from withing countries at a regional level is necessary. This would eradicate the prevalent issue of country-level specific data causing any misrepresentations in terms of regions most effected. When trying to quantify effects of a specific dam, this type of data would allow analysis at a far more geographical level, with trickle-down effects from dams in bordering countries able to be represented. Furthermore, I was only able to find one case study encompassing exactly what was happening economically at a household/community level. Along these lines, I searched and was not able to find any data on travel/social/work patterns or behaviors for this region of the globe. Many of the areas looking to be analyzed along the Mekong are developing regions, which could be contributing to the lack of data gathered.

So, in the future, I would repeat a similar analysis if I was able to personally travel to the region to survey inhabitants themselves. This would allow me to better encapsulate changes in societal norms instead of relying on macro- level metrics to deduce the magnitude of effects from hydropower implementation. I do not think there is a solution to the lack of data gathered in developing regions, as the consequences of hydropower implementation affect developing regions more significantly.

I will use what I learned in this research in my career when I am dealing with shortcomings in data accessibility. The ideal metric an analyst might be looking for is not always readily available, and overcoming of this obstacle is necessary to draw any sort of conclusions. In this study, I combatted this hurdle by instead focusing on macro-level data, coupling it with specific case studies relevant to the problem to form a basis of understanding to then draw conclusions.

Conclusion

The goal of this study was to model and understand the effects of hydropower implementation on societal norms. The motivation for this project was to validate or gauge how effective hydropower proves to be as a reliable, renewable energy source. With climate change intensifying each and every day, the importance to find the most optimal renewable source of energy is ever present. It is the job of engineers such as myself to analyze both positive and negative effects of a renewable resource before construction and implementation. From this study, we have seen that hydropower implementation has significant ecological effects on the riverway, and it does not contribute to economic prosperity in a way one would think it would. As governments, commercial entities, and private firms continue to implement hydroelectric technology in the region, the Mekong river is at risk of its natural properties changing forever. Ideally, these aforementioned stakeholders would read this holistic report on the effects of the accelerated hydropower construction in developing regions of the globe as it relates to disruptions of normal farming/fishing activity, place of residence, and economic stability. It is important to keep in mind that with the increasing desire to find profitable, sustainable energy sources, inhabitants most directly affected by hydroelectric infrastructure cannot be overlooked by those who drive change in society.

References

Beiser, V. (2018, March). See how sand mining threatens a way of life in southeast Asia. *National Geographic.* Retrieved from https://www.nationalgeographic.com/news/2018/03/vietnam-mekong-illegal-sand-mining

Gilbertson, S., (2019). *Infrastructure development in the greater Mekong.* Retrieved from http://greatermekong.panda.org/challenges_in_the_greater_mekong/infrastructure_development_in_the_greater_mekong/

Food and Agriculture Organization of the United Nations. (1997). FAOSTAT statistical database. [Rome] :FAO,

Harrison, M., Koppel, R., & Bar-Lev, S.,(2007). *Unintended Consequences of Information Technologies in Health Care—An Interactive Sociotechnical Analysis*, *Journal of the American Medical Informatics Association*, 14(5), 542-549.

Hecht, Jory & Lacombe, Guillaume & Arias, Mauricio & Dang, Thanh & Piman, Thanapon. (2018). Hydropower dams of the mekong river basin: a review of their hydrological impacts. *Journal of Hydrology. 568. 285-300.* 10.1016/j.jhydrol.2018.10.045.

Hoang, Long & van Vliet, Michelle & Kummu, Matti & Lauri, Hannu & Koponen, Jorma & Supit, I. & Leemans, Rik & Kabat, Pavel & Ludwig, Fulco. (2018). The mekong's future flows under multiple drivers: how climate change, hydropower developments and irrigation expansions drive hydrological changes. *Science of The Total Environment.* 10.1016/j.scitotenv.2018.08.160.

Jacobs, J.W., Owen, L., White G.F., (2019). Mekong river. *Encyclopedia Britannica.* Retrieved October 22, 2019, from https://www.britannica.com/place/Mekong-River

Sabo, J., Ruhi, A., Holtgrieve, G. W., Elliott, V., Arias, M. E., Ngor, P. B., ... Nam, S. (2017). Designing river flows to improve food security futures in the lower mekong basin. *Science*, *358*(6368). https://doi.org/10.1126/science.aao1053

Thieme, M., (2012). *WWF's dams initiative: Hydropower in a changing world.* Retrieved from http://d2ouvy58p0dg6k.cloudfront.net/downloads/hydropowerfacts.pdf

Wang, W., Lu, H., Leung, L. R., Li, H.-Y., Zhao, J., Tian, F., Yang, K., & Sothea, K. (2017). Dam construction in lancang-mekong river basin could mitigate future flood risk from warming-induced intensified rainfall. *Geophysical Research Letters*, *44*, 10378– 10386. https://doi.org/10.1002/2017GL075037

Wassmann, R., Hien, N.X., Hoanh, C.T. et al. (2004). Sea level rise affecting the Vietnamese Mekong delta: Water elevation in the flood season and implications for rice production*.* *Climatic Change*, 6(1), 89-107. https://doi.org/10.1023/B:CLIM.0000053144.69736.b7

William, S., & Pearse-Smith, D. (2012). The Impact of Continued Mekong Basin Hydropower Development on Local Livelihoods. *Consilience: The Journal of Sustainable Development*, 7(1). 73-86. doi: 10.7916/D85X28NG

Wilmsen. B (2011) Progress, problems, and prospects of dam-induced displacement and resettlement in china. *China Information 25(2),* 139-164 doi:10.1177/0920203X11407544

World Wildlife Fund. (2016, November 10). Development on the Mekong River risks entire region's economy: WWF report [Press release]. Retrieved from http://greatermekong.panda.org/our_solutions/mekongintheeconomy/