Using Water-Energy-Food Nexus Analysis Index to Develop Sustainable Development Policy in Transboundary River Basin, a Case Study of Mekong River Basin

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Abstract:

Mekong River region is one of the most significant region of Asia, for the high value of its culture, history and development. However, the competing demand of water, energy and food, also the threats posed by climate change, place constraints on the region's future development. In this paper, multi interdisciplinary approach- Resilience Index was used to examine the current state of individual countries' water, energy and food risks. This tool helps to gauge the level of a country's combined food water and energy securities so as to assisting policy makers to make better sustainable development policies in that region.

Keywords:
Mekong River, Resilience Index, Climate Change, Water Security, Water- Energy- Food Nexus, Sustainable Development, Policy, Water Management, Water Risks

1.Introduction

Water and food are inseparable along the Mekong. The river, its floodplains, and wetlands sustain about 61 million people living in the four countries. Paddy rice is the staple food and is widely grown, supplemented by fish, vegetables, and livestock. Most people earn their livelihoods through small scale, subsistence farming and fishing. There are threats on the horizon. These include climate change and competing demands for water by different sectors: population growth, hydropower, irrigation, industry, navigation, water diversion and commercial fisheries. Such development will likely have unwanted impacts on aquatic ecosystems and on household livelihoods. Many predict that future dam construction upstream will bring serious unintended consequences to people living downstream, who use resources from the river for food and income (Bouapao & Eckman, 2012). Hydropower is the major energy source of Mekong River region, and Mekong will experience a hydropower boom in the next couple of decades. ("Energy Investment At Risk," 2010)

Previous Vulnerability Assessments

Based on the MRC's Basin Development Plan criteria, Bouapao & Eckman developed an equation to model food security and vulnerability with the goal of capturing the interconnectivity of water and food (2012). The core variables in their equation were exposure, sensitivity, and resilience. These depended on the demographics of the residents of the study location, such as their livelihood and access to support and aid. The data for the study was collected through questionnaire-based survey responses collected from individual members of communities along the river in the Lower Mekong Basin.

2. Study Area

The Mekong River is one of the most important trans-boundary rivers in Southeast Asia. Starting from the Tibetan Plateau, the 4800 km-long river flows across six different countries, namely China, Myanmar, Laos PDR, Thailand, Cambodia, and Vietnam, before finally draining into the South China Sea. The economies and societies along the Mekong are strongly linked to their use of the Mekong River as a primary water resource (MRC, 2010).

Fig. 1 A general view of Mekong River

The food, energy, and water securities of a region are critical to its survival. The Nexus encompasses these three elements and the way they affect one another. This paper has utilized this approach as the basis for its development. There will be an introduction of the current water, food, and energy standings of four different countries in the Mekong River Basin--Cambodia, Vietnam, Lao PDR, and Thailand. Then, an overview of the entire project is presented, followed by a literature review with related research that inspired the analysis method featured in this paper. A detailed description of the analysis method is given, and the results are discussed and accompanied by recommendations for improvements in policy.

This paper is aiming at exploring a scientific framework to analyze the long-term resilience of the Mekong river basin using the Water, Food, and Energy risks index. By assessing both the short and long term water policies and tradeoffs using the developed vulnerability assessment framework, so as to draw policy recommendations for each country's future development based on its individual assessment.

The hypothesis of this paper is: by changing the choice of water management practices, crops, and energy sources, can help to mitigate the regional water, food and energy risks, and create a sustainable development plan under the threat of water shortages due to upstream damming and climate change. The boundary of this paper is the four countries in the Mekong River Basin. The baseline data is the current data available for Cambodia, Vietnam, Laos, and Thailand, and future scenarios will be short term goals based on next 5-10 year range.

Through conducting the quantitative data analysis into a qualitative holistic approach to examine the linkages/nexus of water, energy, and food sectors, this research could help the public or private sectors in navigating nexus issues and making their future investment and development policies.

1.1 Lao People's Democratic Republic (PDR)

Water

Lao PDR occupies the majority of the watershed area of the Mekong River Basin, and has an abundance of rivers, including a 1,900 kilometer section of the Mekong River (Nam Khong). As the economy of Lao PDR flourishes, the plans for developing hydropower infrastructure grow in ambition (Pillai, 2014).

Food

Agriculture and industry combined comprise approximately 75% of Laos' GDP. (citation here) Unfortunately, its citizens are facing significant food insecurity; over a third of the population has experiences rice shortfalls for at least 2-6 months out of the year. According to the National Risk and Vulnerability assessment conducted by the World Food Program, almost 188,000 households are facing significant food insecurity from their losses in access to natural resources, floods, droughts and natural disasters (Portal, 2016).

Energy

The mountainous terrain along the river endows the country with natural hydro potential. In addition, Laos PDR is rich in natural resources including coal, hardwood timber, hydropower, gypsum, tin, gold, and gemstones. Mining and hydropower investments have increased significantly in recent years, which is a primary contribution to the current economic growth and development. (Pillai, 2014)

Climate change

Lao PDR is vulnerable to extreme events, such as droughts and floods. These disturbances are increasing in frequency and severity and affecting food security, drinking water supply and irrigation, public health systems, environmental management, and lifestyle.(Portal, 2016)

1.2 Thailand

Water

Thailand accounts for 18% of the catchment area of the River Mekong. The river constitutes an additional external resource for Thailand, which has been estimated as half the discharge of the river, Thailand's contribution to this river has to be deducted over a long distance (FAO,2016).

Food

Rice has long been Thailand's traditional food crop and the country's main export product. According to the report of Thailand's Rice Farmers Adapt to Climate Change by United Nation University "Over 80% of the Thai population eats rice as their main meal, with annual per capita consumption totaling 100.8 kg". Also, climate change has already been defined as major challenge of rice growing Thailand due to changes in seasonal temperature and precipitation levels (Kawasaki, 2015).

Energy

In 2015, the energy production of in Thailand has been decreased, and Thailand had have to import more energy to meet the domestic demand. The final energy consumption increased by 4.0% because the Thai economy started to recover (GDP grew by 2.8%) (Ministry of Energy, 2016)

Climate change: The unpredictability of conditions that affect rice growing — such as rainfall distribution, temperature levels and increasing types and occurrences of pests and diseases will intensify due to climate change. This means Thailand will see drier spells in the middle of the wet season which can damage young plants, and floods at the end of wet season that affect harvesting. (Kawasaki, 2015)

1.3Cambodia

Water

The Mekong River crosses Cambodia and is the most prominent geographic feature. The river flows directly from north of Cambodia down to the south of Mekong delta. One of the largest and most important lakes, the Tonle Sap Lake, relies mainly on the water discharged from Mekong during the rainy season (WorldBank, 2016a). It is located in the southwest region of the country.

Food

The whole country's economy is heavily reliant upon Agriculture (33% of GDP). (FAO,2015). A substantial proportion of the population is dependent on the farming and fishery sectors.(WorldBank, 2016a)

Energy

Cambodia has substantial hydropower resources as well as oil, gas and coal. However, with increasing energy demands, there is an urgent need to explore other energy alternatives and sources. Currently, other available energy sources in Cambodia include biomass, solar, and mini hydro. The key issue is focusing on how to diversify the sources of energy as well as intensify the exploration of the natural gas and renewable energy sources.(UnitedNations)

Climate Change

The contribution of industry to GDP has doubled since 1993, but a substantial proportion of the population is still dependent on the farming and fisheries sectors. (WorldBank, 2016a)

1.4 Vietnam

Water

Vietnam has rich water resources, however, the water resource distribution of Vietnam is highly variable during the whole year due to the monsoon season. Therefore, the extreme variability of rainfall, combined with limited storage and flood control infrastructure, results in devastating floods in the wet season and extreme low flows in the dry season (FAO, 2016).

Food

Rice production has been historically important to food security, and continues to be a significant source of rural employment in Vietnam. Vietnam is the world's second-largest rice exporter. The two most important rice-growing areas are the deltas of the Mekong and Red River (WorldBank, 2016b).

Energy

Vietnam is experiencing a high rate of energy demand growth. Vietnam changed its energy structure significantly by exploring and developing the country's gas resources (increased from 6 GWh in 1990 to 36141 GWh in 2009) and hydropower generation potential (increased from 5369 GWh in 1990 to 29981 GWh) Vietnam relies heavily on hydropower as a main energy source. However, with the development of renewable energy technologies, Vietnam is expecting to develop more non-hydro resources in the future (Globserver, 2015).

Climate Change

Located in the Mekong delta, Vietnam has been one of the countries most vulnerable to climate change due to the increasing severity of monsoons. Storms and flooding, in particular, are responsible for significant economic and human loss. Given that a high proportion of the country's population and economic assets (including irrigated agriculture) are located in coastal lowlands and deltas, Vietnam has been ranked among the five countries likely to be most affected by climate change (WorldBank, 2016b).

3 Methodology

3.1. Decision platform

An outline of the procedure followed in the development of the project methodology is shown in figure 2. First, the main risk areas were defined and broken down further into five indicators: Renewable Energy in Energy Profile, Water Risk Index, Water Withdrawal for Agriculture/Cultivated Land Area, Prevalence of Undernourishment, and Percentage of Agricultural Land. Then, an analysis tool, referred to as the Resilience Index, was formulated using the previously defined indicators. For each country, a data set was gathered to provide the current value for each of the indicators. The resulting score was analyzed and policy recommendations were formed to improve the Resilience Index by focusing on the main risk-contributing indicators. The projected effect of the implementation of these suggestions is then used to calculate a new Resilience Index.

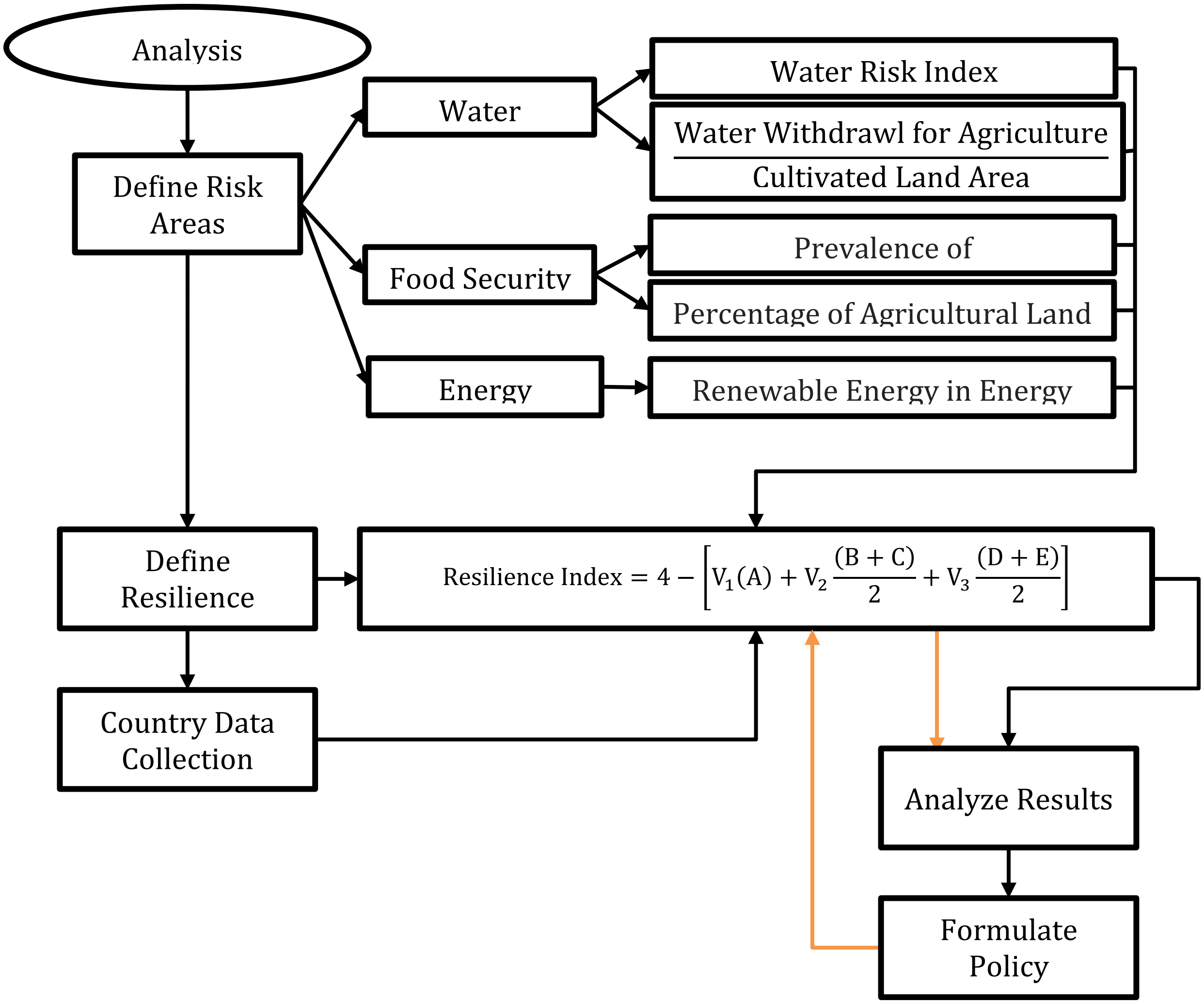


Figure 2. Development flow of the Resilience Index analysis method.

3.2. Resilience Index

Resilience Index: is a data based framework of five risk indicators used to analyze a region's vulnerability through the calculation of its water, energy and food risks. The resilience index will be treated as a score for comparison purposes and will have a value from 0 (lowest resilience) to 4 (highest resilience).

The Resilience Index was calculated for the baseline scenario using the most recent data. After identifying which indicators were in most need of improvement for each country, courses of action were proposed along with costs, potential trade-offs, and complications for each scenario. These include suggestions for improving the energy plan, suggestions for changing the crop production portfolio, and suggestions for alternative water sources. Once the effect that these changes would have on the initial five indicators was estimated, the Resilience Index was recalculated to show the projected change.

The framework for evaluating each country consisted of a scorecard with five data-based elements. The main goal in performing this evaluation was to identify the vulnerabilities to sustainability in each location. With this information, a plan dedicated to increasing the overall resilience of each country could be developed. Each indicator of resilience was scaled to a fraction of four for use in the following equation:

$$Resilience\ Index = 4 - \left[V_1(A) + V_2\frac{(B+C)}{2} + V_3\frac{(D+E)}{2}\right]$$

Note: The coefficients V_1, V_2, and V_3 must sum to a total of 1 and will be weighted according to the focus of the calculating party. V_1 is representative of energy security importance, while V_2 and V_3 represent the importance of water security and food security, respectively. If all three elements are valued equally, then they may each be given the value of 0.33. The values for A-E are based on regional data and represent the indicators listed in table 1.

3.3. Data Sources and Processing

Indicators		Sector	Original Scale	Conversion for Raw Data Value (x)
A	Renewable Energy in Energy Profile (0,4)	Energy	100	4-x/100*4
B	Water Risk Index (0, 4)	Water	4	x
C	Water Withdrawal for Agriculture/Cultivated Land Area (0-~)	Water	N/A	x/8.25
D	Prevalence of Undernourishment (% of population) (0, 4.59)	Food	100	x/ 21.8
E	Percentage of Agricultural Land (0, 4)	Food	100	4-x/100*4

Table 1. Food, Water, and Energy Security Indicators.

Energy Security

Indicator A is a percentage representative of the renewable energy share in a country's total final energy consumption. This data was obtained from the World Bank's database, Sustainable Energy for All (2015). The statistics used for this indicator were from the year 2012. The raw data was converted to decimal form, subtracted from 1 to convert the value into an indicator of risk, and multiplied by 4, the basis of the scale.

Water Security

Indicator B comes directly from The World Resources Institute's analysis of global water risk. The number reported in the table is an area weighted average for each country based on a 0 to 4 rating represented by the country's color in the Aqueduct Water Risk Atlas (Aqueduct Water Risk Atlas, 2016).

The purpose of Indicator C is to represent the intensity of land irrigation. This was calculated using two data categories from the Food and Agricultural Organization for the United Nations' AQUASTAT database (2016). The Agricultural Water Withdrawal in Mm^3/year was divided by the Cultivated Area. The cultivated area statistic consists of both arable land and land under permanent crops measured in 1000-ha. Since the resulting number was at an unsuitable scale for comparison, these values were normalized between the four countries using the highest data point, 8.25, as the level 4 risk equivalent.

Food Security

The data for indicators D and E was found in the database entitled World Development Indicators provided by World Bank (2016). Indicator D is the percentage of the population that is unable to continuously meet daily dietary nutrition needs. The data for indicator D was normalized on a basis of the highest percentage of the four countries for ease of contrast. Indicator E is the percentage of the total land which is occupied by crops or pastures which was subtracted from 1 to convert the value into an indicator of risk, and multiplied by 4, the basis of the scale.

Analysis Standards:

- The score scale is from 0-4.
- For the Indicators: 0-1 is normal(Green), 1-2 is medium(Yellow), 2-3 is high(Orange), and 3-4 is severe(Red).
- For the Resilience Index: 3-4 is normal, 2-3 is medium, 1-2 is high, and 0-1 is severe.
- This comparison tool is for use among the four highlighted countries of the Mekong River Basin since some of the data was normalized based on the geographic region.

4 Result and discussion

4.1. Base scenario

4.1.1 Cambodia

Indicator		Original Data	Score	Risk Level
A	Renewable Energy in Energy Profile	72.5	1.1	Medium
B	Water Risk Index	2.8	2.8	High
C	Water Withdrawal for Agriculture/Cultivated Land	0.5138924	0.249074	Normal
D	Prevalence of Undernourishment	16.1	2.954128	High
E	Percentage of Agricultural Land	32.9	2.684	High
		Current Resilience Index Score	2.19	Medium

Table 2. Cambodia's Baseline Score Results.

Cambodia has the highest Resilience Index score of the four evaluated countries. The water risk was moderate despite the comparatively low risk for Indicator C. The future water gap will have to be bridged by means other than increasing the efficiency of irrigation. Other tactics, such as water reuse, could have a greater effect for Cambodia. With urbanization occurring at such a fast rate (The World Bank, n.d.), providing for large cities' water needs on existing resources will become increasingly difficult, making urban wastewater reuse a viable option. Another solution, currently being utilized in Hong Kong, is salt water use for toilet flushing and other non-potable uses (Jimenez, Asano, 2008).

The median data for Cambodia, based on a set of 16 climate change projection models for the 2020 to 2039 period, generally show increased rainfall in the summer and a decrease in rainfall in the spring (The World Bank Group, 2016). According to the same models, days and nights will also get hotter year round. This may lead to a necessary change in planting seasons.

4.2.2 Vietnam

Indicator		Original Data	Score	Risk Level
A	Renewable Energy in Energy Profile	29.1	2.836	High
B	Water Risk Index	2.3	2.3	High

C	Water Withdrawal for Agriculture/Cultivated Land	8.252839401	4	Severe
D	Prevalence of Undernourishment	12.9	2.36697	High
E	Percentage of Agricultural Land	35	2.6	High
	Current Resilience Index Score		1.17	High

Table 4. Vietnam's Baseline Score Results

As seen in table 3, Vietnam's greatest risk factor is a result of high agricultural water withdrawals with respect to their cultivated land area. To decrease the amount of water necessary, more efficient irrigation practices should be encouraged, and the feasibility of switching drier areas to a different crop type should also be considered. Currently, Vietnam's primary product is rice (fig. 2), which is extremely water intensive, and production is on the rise (World Bank, 2015). FAO statistics say that 97 percent of all land sown to rice in Vietnam is irrigated (FAO, 2016). Cassava, however, is a much heartier staple crop, and since it is already grown in Vietnam, it is a good candidate for a transition into less water intensive agriculture. Its resistance to various conditions will be an asset in the future climate.

For Vietnam, more heat waves, increased temperatures, increased winter rainfall, and decreased autumn rainfall are predicted (The World Bank Group, 2016). Another main concern for Vietnam is sea level rise, leading to coastal shrinkage and increased flooding which interrupts agricultural processes and causes deadly mudslides in mountainous regions (The World Bank Group, 2016).

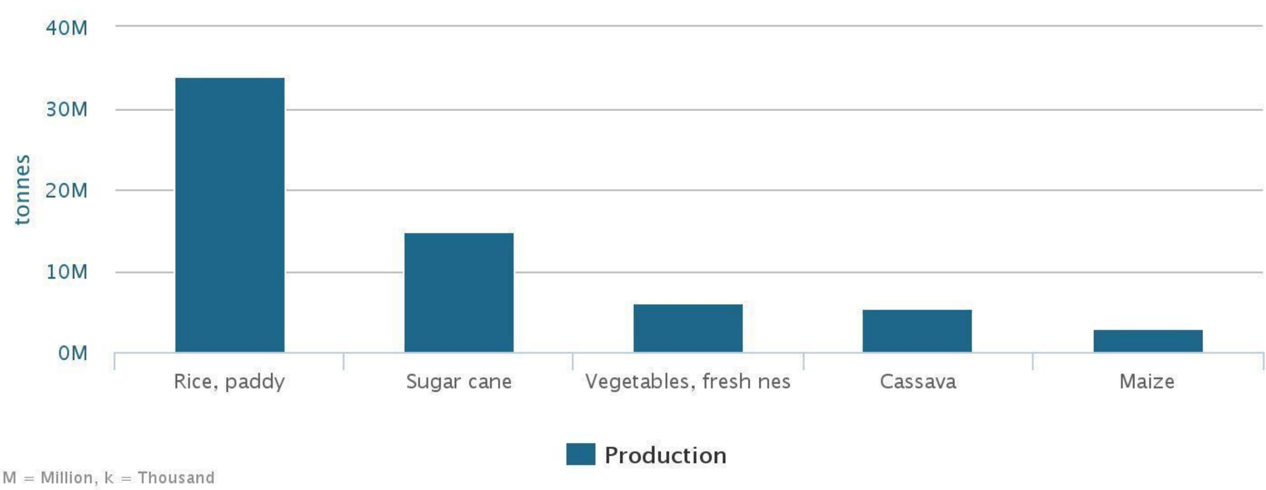


Figure 2. Production in tonnes of Vietnam's top 5 crops. Reprinted from FAOSTAT, by Author First Initial. FAO, 2015, Retrieved from http://faostat3.fao.org/browse/FB/BC/E

4.2.3 Lao

Indicator		Original Data	Score	Risk Level
A	Renewable Energy in Energy Profile	86.5	0.54	Normal
B	Water Risk Index	2.8	2.8	High
C	Water Withdrawal for Agriculture/Cultivated Land	2.386397608	1.156643	Medium
D	Prevalence of Undernourishment	21.8	4	Severe
E	Percentage of Agricultural Land	10.1	3.596	Severe
		Current Resilience Index Score	1.90	High

Table 4. Lao People's Democratic Republic's Baseline Score Results

Lao PDR has unfavorable standing in both of its food risk indicators. The comparatively small percentage of land used for agriculture indicates that they must intensify their agricultural practices. However, using more water would not be an ideal first response since that would increase Indicator C. Instead, it would be better to increase the efficiency with which the water is used. Indicator D was the highest out of all four countries. Child malnutrition is prevalent in Lao PDR, particularly in rural areas (Prabang, 2013). This must be addressed through assistance and education in schools. The National School Meals Program, which was established in 2012, has already made a positive difference in increasing the health of children in the pilot schools as well as the amount of children attending class (Global Partnership for Education, n.d.); the establishment of this program was funded by foreign aid.

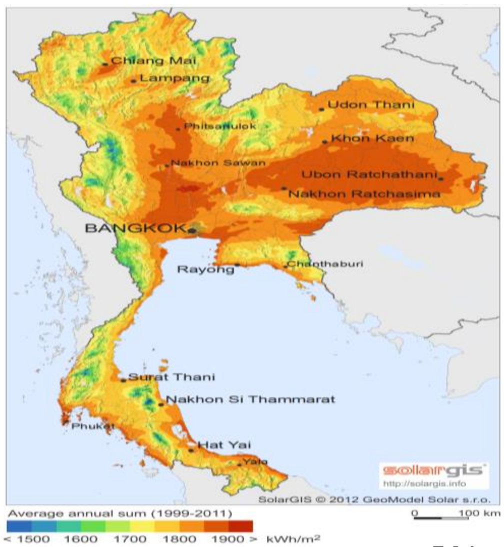
The climate change projections for Lao PDR include increased rainfall throughout the country and higher temperatures with the southern and eastern regions seeing the greatest increase (The World Bank Group, 2016). The complications caused by flooding will become even more severe.

4.2.4 Thailand

Indicator		Original Data	Score	Risk Level
A	Renewable Energy in Energy Profile	23	3.08	Severe
B	Water Risk Index	2.4	2.4	High
C	Water Withdrawal for Agriculture/Cultivated	2.725789474	1.32114	Medium

	Land			
D	Prevalence of Undernourishment	6.8	1.247706	Medium
E	Percentage of Agricultural Land	43.3	2.268	High
		Current Resilience Index Score	1.77	High

Table 2. Thailand's Baseline Score Results



The renewable energy percentage of Thailand's energy portfolio is low in comparison to the three other countries. As the country grows its energy sector, it would be beneficial to incorporate more renewable sources, particularly solar. As shown in Figure 3, Thailand receives intense radiation. This is spread throughout the year due to its proximity to the equator, making the area ideal for solar energy capture.

Figure 3. Thailand Solar Irradiation Map.Adapted from Solar GIS, 2012, Retrieved from http://solargis.info/doc/free-solar-radiation-maps-GHI. Copyright 2012 by GeoModel Solar s.r.o.

4.2 Future Scenarios

4.2.1 Cambodia

Scenario	Improves	Costs and Trade-offs	Revised Score	Intervention Impact
Reuse treated wastewater in urban areas.	B -0.6	Additional wastewater treatment facilities would need to be built. If the focus is only on urban areas, less piping infrastructure will have to be installed.	2.29	Moderate
Utilize seawater in coastal cities.	B -0.3	Minimal treatment would be necessary for seawater use in toilets. However, installation of non-corrosive piping would need	2.23	Moderate

		to be arranged.		

Table 3. Cambodia Scenarios.
Note: the intervention impact indicated the effectiveness of the interventions, 0-1 is moderate, 1-2 is significant, 2-3 is high.

4.2.2 Vietnam

Scenario	Improves	Costs and Tradeoffs	Revised Score	Intervention Impact
Switch a portion of the rice production to cassava.	C -1.3	Cassava growing would need to be incentivized through education or subsidization, since many people with preexisting rice paddies will be very resistant to change. Rice and cassava have similar seasons.	1.39	Significant
Increase irrigation efficiency through education and assistance.	C -0.9 D -0.4	An education program designed to outreach to farmers and educate them on more efficient practices would need to be developed. There would also need to be a reward for using these practices, and since there is no real control on water consumption from the river. This would be extremely difficult to encourage.	1.32	Moderate

Table 3: Vietnam Scenarios
Note: the intervention impact indicated the effectiveness of the interventions, 0-1 is moderate, 1-2 is significant, 2-3 is high.

4.2.3 Lao

Scenario	Improves	Costs and Trade-offs	Revised Score	Intervention Impact
Increase federal funding to the National School Meals Program.	D-1.5	The amount invested in providing food for the school meal program and incorporating nutrition into the curriculum is proportional to the benefits seen. With	2.15	Significant

		increased domestic funding, the program could be extended to even more schools.		
Increase irrigation efficiency	C-0.9 D-0.4	An education program designed to outreach to farmers and educate them on more efficient practices would need to be developed.	2.11	Moderate

Table 3. Lao People's Democratic Republic Scenarios

Note: the intervention impact indicated the effectiveness of the interventions, 0-1 is moderate, 1-2 is significant, 2-3 is high.

4.2.4 Thailand

Scenario	Improves	Costs and Tradeoffs	Revised Score	Intervention Impact
Finance purchase of solar panels for independent communities.	A-1.5	Communities currently out of infrastructural reach could apply to this program for financial assistance in purchasing solar power generation equipment. There would be an initial expense, but over time the money would be repaid according to the agreement.	2.26	Significant
Offer "rental" of solar panels for an annual fee.	A-1.5	The government would provide access solar power generation equipment on an annual basis. The equipment would be owned and maintained by the government according to the contracted agreement. This is more involved for the government, because they must have a team ready to travel to service and transport the equipment.	2.26	Significant

Table 3. Thailand Scenarios

5. Conclusions

Use of the Resilience Index to examine water, food, and energy risks of Mekong region could help policy makers in the development of science-based resource management program scenarios. This research provides information on strategies for tackling the trade-offs between local water, energy, and food security costs. These nexus issues require a multi-interdisciplinary and holistic approach to accommodate the interlinkages between water, food and energy. This will be the key to sustainable development of countries in the Mekong River Basin. A brief synopsis of the Resilience Index analysis results for each country, and the changes suggested based on these analyses, follows.

5.1 Recommendations of Each Country

Cambodia

Cambodia scored highest out of the four countries with a Resilience Index of 2.19. The Water Risk Index and Prevalence of Undernourishment were the top two indicators. To address these issues, the following recommendations were made:

- Reuse treated wastewater in urban areas
- Utilize seawater in coastal cities.

Vietnam

Vietnam scored a 1.17 on its Resilience Index. It had a higher Water Withdrawal for Agricultural Use/Cultivated Land Area compared to the three other countries. To address this risk contribution, the following recommendations were made:

- Switch a portion of the rice production to cassava.
- Increase irrigation efficiency through education and assistance.

Lao PDR

The Resilience Index of Lao PDR was 1.9. The Prevalence of Undernourishment and Percentage of Agricultural Land, both food security indicators, were the outstanding risk factors. To improve these, the following recommendations were made:

- Increase provincial funding to the National School Meals Program.
- Increase irrigation efficiency through education and assistance.

Thailand

Thailand had an initial Resilience Index of 1.77. Of the four countries, it had the lowest percentage of renewable energy in its energy profile. To improve energy security, the following recommendations were made:

- Finance purchase of solar panels for independent communities.
- Offer "rental" of solar panels for an annual fee.

5.2 Limitations and Recommended Future Work

The current indicators were highly influenced by data availability. More abundant data for the addition or modification of risk indicators could contribute in developing a more insightful analysis tool. Ideally, data would be collected as a response to more specific indicators from the communities currently relying upon the Mekong River.

It would also be beneficial to study the WEF nexus at a riparian level, since the Resilience Index improvement strategies of upstream countries could potentially affect downstream countries. In the likely event that this is extended to all five Mekong countries, including China, the tradeoffs of building the hydropower infrastructure to keep up with the energy demand versus the insuring water and food security for downstream communities will deserve closer examination and analysis.

Climate change will put extra stress on food, water, and energy security as well as endangering the lives of members of riparian communities, themselves. Giving the fact that, the Mekong countries are high vulnerable to the impact of climate change, more relevant data/information of water, food and energy security under the threats of climate change should be examined and analyzed in the next phase study.

References:

Bouapao, L., & Eckman, K. (2012). FOOD SECURITY AND VULNERABILITY IN THE LOWER MEKONG RIVER BASIN. (cover story). Water Resources Impact, 14(6), 6-9. Retrieved from http://lib-ezproxy.tamu.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=enr&AN=82582210&site=eds-livehttp://lib-ezproxy.tamu.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=enr&AN=82582210&site=eds-live

Eastham, J., Mpelasoka, F., Mainuddin, M., Ticehurst, C., Dyce, P., Hodgson, G., Ali, R., and
Kirby, M.: Mekong River Basin Water Resources Assessment: Impacts of Climate Change, Water for a Healthy Country National Research Flagship report, CSIRO, 2008.

Energy Investment At Risk. (2010). Asia Monitor: South East Asia Monitor Volume 1, 21(5), 7-7. Retrieved from http://lib-ezproxy.tamu.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=49176015&site=eds-live

FAO. (2016) AQUASTAT Main Database. Food and Agriculture Organization of the United Nations (FAO). Retrieved April 17, 2016, from http://www.fao.org/nr/water/aquastat/data/query/results.html

Global Partnership for Education. (n.d.). Lao PDR: An Innovative School Meals Program. Retrieved April 22, 2016, from http://www.globalpartnership.org/success-stories/lao-pdr-innovative-school-meals-program

http://lib-ezproxy.tamu.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=49176015&site=eds-live

Hoang, L. P., Lauri, H., Kummu, M., Koponen, J., van Vliet, M. T. H., Supit, I., . . . Ludwig, F. (2015). Mekong River flow and hydrological extremes under climate change. *Hydrology & Earth System Sciences Discussions, 12*(11), 11651-11687. doi:10.5194/hessd-12-11651-2015

Jimenez, B., & Asano, T. (2008). Water Reuse: An International Survey of Current Practice, Issues and Needs (Scientific and Technical Report No. 20). London: IWA Publishing.

Prabang, L. (2013, August 29). As Laos prospers, child malnutrition persists. Retrieved April 22, 2016, from http://www.irinnews.org/report/98659/analysis-laos-prospers-child-malnutrition-persists

Varis, O., Kummu, M., and Salmivaara, A.: Ten major rivers in monsoon Asia-Pacific: an assessment of vulnerability, Appl. Geogr., 32, 441–454, doi:10.1016/j.apgeog.2011.05.003, 2012.

Västilä, K., Kummu, M., Sangmanee, C., and Chinvanno, S.: Modelling climate change impacts on the flood pulse in the Lower Mekong floodplains, Water Climate Change, 1, 67–86, 2010.

MRC. (2010). State of the Basin Report 2010. Vientiane: Mekong River Commission. http://lib-ezproxy.tamu.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=enr&AN=82582210&site=eds-live

The World Bank. (n.d.). Issues and Dynamics: Urban Systems in Developing East Asia. Retrieved April 22, 2016, from http://siteresources.worldbank.org/INTEAPREGTOPURBDEV/Resources/Cambodia-Urbanisation.pdf

The World Bank Group. (2016). Climate Change Knowledge Portal [Data Collection]. Available at http://sdwebx.worldbank.org/climateportal

Globserver. (2015). Vietnam Energy Profile. Retrieved from http://globserver.cn/en/vietnam/energy

Kawasaki, J. (2015). Thailand's Rice Farmers Adapt to Climate Change. Retrieved from http://ourworld.unu.edu/en/climate-change-adaptation-for-thailands-rice-farmers

Ministry of Energy, T. (2016). Thailand Energy Report 2015. Retrieved from http://www.eppo.go.th/index.php/en/energy-information-services/report-2015

Pillai, G. M. (2014). *Lao PDR National Sustainable Energy Strategy Report on Enabling Environment and Technology Innovation Ecosystem for Affordable Sustainable Energy Options* Retrieved from http://www.unescap.org/sites/default/files/Lao%20PDR%20National%20Sustainable%20Energy%20Strategy%20Report.PDF

Portal, W. B. C. C. (2016). Laos Dashboard Overview. Available from World Bank Retrieved April 22nd, 2016, from World Bank p://sdwebx.worldbank.org/climateportal/countryprofile/home.cfm?page=country_profile&CCode=LAO

UnitedNations. *Cambodia Energy Sector Strategy*. Retrieved from http://www.un.org/esa/agenda21/natlinfo/countr/cambodia/energy.pdf

WorldBank. (2016a). Cambodia's Dashboard Overview. World Bank climate change portal Retrieved April 22nd, 2016, from World Bank climate change portal http://sdwebx.worldbank.org/climateportal/countryprofile/home.cfm?page=country_profile&CCode=KHM&ThisTab=Overview

WorldBank. (2016b). Vietnam Dashboard Overview. Available from WorldBank Climate Change Knowledge Portal Retrieved April 22nd,2016, from WorldBank http://sdwebx.worldbank.org/climateportal/countryprofile/home.cfm?page=country_profile&CCode=VNM&ThisTab=Overview

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