EnviroLab Asia

Volume 1
Issue 3 *Science, Economics, and Policy*

Article 4

2017

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Recommended Citation
Los Huertos, Marc (2017) "Narratives about Energy, Megaprojects, and the Ecology of Tropical Rivers: The Baram River Dam Project," *EnviroLab Asia*: Vol. 1: Iss. 3, Article 4.
Available at: http://scholarship.claremont.edu/envirolabasia/vol1/iss3/4

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Cover Page Footnote

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Narratives about Energy, Megaprojects, and the Ecology of Tropical Rivers: The Baram River Dam Project

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Abstract: The conflict between development goals to build dams for hydroelectricity and indigenous peoples in Sarawak was set in motion in the 1970s. In spite of the potential ecological damage, hydroelectric development has been justified by developed and developing countries for decades. These impacts include changes in river geomorphology, water quality, and habitat value and access. Moreover, in the Bakun and Baram river watersheds, the Dayak people of Sarawak have poignantly demonstrated the socio-ecological disruption. For the time being, the construction of the Baram Dam has been halted.

Who would have known that the oil price shocks in the 1970s could potentially displace nearly 20,000 people from the Kayan, Kenyah and Penan communities in Sarawak rainforests some 50 years later?

Collectively known as the Dayak, these indigenous peoples correctly identified Malaysia's goals to diversify its energy sources as a threat to their social and cultural heritage and economic well-being. In the winter of 2016, some of their leaders invited students and faculty from the Claremont Colleges to share their experiences of living along the Baram River watershed and in some of the oldest rainforests in the world.

The price shocks of crude oil in the 1970s highlighted the vulnerability of relying on crude oil as an energy source. Developed and developing countries around the world identified the need to diversify their portfolio of energy sources – i.e. create energy security. In the United States policies and consumers focused on conservation efforts, e.g. improving automotive gas mileage efficiencies, while Malaysia developed began by developing national capacity to develop and refine petroleum. But after the second oil price shocks when supply decline as a result of the Iranian Revolution and Iran-Iraq War, Malaysia passed the National Energy Policy of 1979 to encourage an energy portfolio composed of petroleum, coal, natural gas, and hydroelectric, the "Four-Fuel Diversification" strategy (Abdul-Manan et al. 2015).

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Malaysia has been moderately successful in accomplishing this goal. Between 1980 and 2008, the country energy consumption has nearly doubled while the share of petroleum declined from 45% to 35%. Energy production and consumption has been the engine to Malaysia rapid development. To further increase the portfolio, Malaysia also began evaluating sites for hydroelectric generation and identified the rivers in Sarawak as early as the 1960s but concrete planning only occurred after 1979 (Ong et al. 2011).

The Baram River flows from the highlands of Sarawak to the South China Sea and the eastern Pacific Ocean, near the Malaysia-Brunei border. The Dayak people who rely on Baram River and live within the Baram River watershed are well acquainted to potential of dams to disrupt their cultural heritage and identity and economic stability.

Riverine Processes in Sarawak

Rivers carry water and sediment (eroded soil particles) from upstream to downstream locations and in the case of the Sarawak to the coastal zone and western Pacific Ocean. The volume of riverine flow depends on precipitation, which varies by location, between 1.5 and 4.8 meters of rain per year, and by a pronounced dry and wet season, ~80 mm/month in the dry season and ~2000 mm/month in the wet season. When the volume of water exceeds the capacity of a river's channel, water overtops banks and floods adjacent areas, i.e. the flood plain. Floods are a natural part of Borneo's ecological functioning, as indicated by observations and geographical studies in the 19th and early 20th century prior to human modification of major river basins (Knapen 1997).

Ecologists have appreciated the role of disturbance in ecosystems in the earliest self-cognizant development of the field of ecology. "Dynamic ecology" was coined for some time to emphasize the importance of environmental changes in response to disturbance, intentionally contrasting the "plant catalogs" and species lists as static pictures of an ecosystem (Clements 1916, Clements 1934, Lindeman 1942). First applied in forest and sand dunes, disturbance was understood as an internalized process that promotes and maintains vegetation patterns. And just like disturbances in forest, such as fires, rivers experience disturbances, terms of floods, which can be measured in terms of its magnitude and frequency (Resh et al. 1988, Pickett et al. 1989, Meurant 2012).

Both terrestrial and aquatic plants and animals respond to these disturbances and in some cases, we provide adaptive advantages for some species. Thus, to regulate a river is to a river, to suppress fires, or stabilize sand dunes can disrupt processes that maintain these ecosystems. Since humans are part of these ecosystems, we might appreciate the role ecological disturbance has on our livelihoods and ascribe values as good or bad or both.

The hydrology and geomorphology of large rivers in throughout the world provide a wide range of examples where flooding expands the resources for fish that venture into the flood plain for food and often improves their growth rates and reproductive capacity (Galacatos et al. 2004).

DOI: 10.5642/envirolabasia.20170103.04

Some plants require flooding for establishment or adapted to tolerate flooding, thus excluding competitors (Bendix and Hupp 2000, Nilsson and Svedmark 2002). The reliance on flooding to renew and improve soil fertility for agriculture is well-documented as well (Janick 2000). The ecological value of flooding of large tropical rivers has been highlighted in “flood pulse concept” (Junk et al. 1989), where flooding as an endogenous process to the ecosystem.

Nevertheless, developing societies such as Malaysia have been on a mission to reduce river flooding, which allows settlements in historically flood prone areas. Building dams can be used to limit peak flows and store water for later uses. Deciding whether the motivation to build dams as flood control infrastructure is a response to protect or to promote the development of the flood plain is not easy to answer. However, the impact on a river is the same: dams dramatically alter a river’s hydrograph, the magnitude and variation of flow is dramatically altered.

This global impact is pervasive and massive, given that there are more than 50,000 dams over 15 meters in height around the world (Berga et al. 2006). While dams provide value as a source of national pride or symbols of development, the practical reasons to build dams are quite diverse and include flood control, irrigation, power generation, urban drinking water supplies, recreation or a combination two or more of these reasons. As one might guess, the hydrograph of the regulated river depends the dam’s purpose. The dams in the lower Colorado River in the western US release water based on energy demand, which in the Southwest is highest in the summer and afternoons when peak demand powers air conditioning. Other dams store water during the rainy season for use in agricultural irrigation or for drinking water supplies, so water releases might be unseasonably low during the wet season and relatively high during the dry season. Where these processes have been well studied, regulated rivers can dramatically alter ecosystems above and below dams – unfortunately, ecologists had to study these systems after the dams were built, so when the plans to build 12 dams in Sarawak was proposed in the 1980s, the literature that could be used to predict the ecological outcomes was quite limited. In fact, it was not until 1986 that the first journal dedicated to issues of regulated rivers-- entitled “Regulated Rivers Research and Management”--appeared.

Because of its socio-economic visibility, the impact of dams on fish and fisheries were some of the first studies published. In fact, the results of experiments to lift fish above high dams had already been published (Cobb 1925). By the 1950s, researchers have noted how velocities based on water releases can influence community assemblages (Young et al. 2011). Species diversity can also depend on the amount of flows, where in some examples high species diversity was associated with high flow conditions (Brown and Ford 2002). Unfortunately, little is known about how hydrography changes have influenced fish assemblages on Sarawak, even with existing dams, e.g. the Bakun Dam.

Even more poignant, our understanding how the riparian zone and floodplain function has been a more recent development – well after a majority of the world’s dams has been built. Riparian habitat depends on the hydrograph. Changes to the hydrograph will favor some species over others. These changes might be subtle or profound, but in each case, few projects have considered these impacts before construction (Richter et al. 2010). As in many counties, the use of the scientific data can inform the development of infrastructure through environmental assessment reports. In spite of references suggesting the existence of Social and Environment Impact Assessment (SEIA) reports, I found no dam assessment reports available online for Malaysia. Besides, Malaysia's use of SEIA have a mixed record anyway as biased documents to justify proposed projects, so its value might be limited (Briffett et al. 2004, Marzuki 2009).

Geomorphology and Dam Capacity

One of the first observations we made when traveling down the Baram River in January 2016 was the turbid waters. Brown and opaque from suspended sediments carried downstream from the headwaters to the ocean. With torrential rains, one might expect tropical rivers to be laden with soil particles as rainfall exceeds the infiltration capacity of the tropical soils. However, with dense vegetation, we might also expect to observe transparent waters, as soils remain protected by the energy of rains and vegetation filters soil particles before arriving in surface waters connected to the Baram River. Meanwhile deforestation, road building, and landslides leave massive amounts of vulnerable soils to erosion and transport into surface waters. Whatever the mechanism, the rivers in the state of Sarawak are clouded with suspended sediments.

With the construction of a dam, sediments fall out of the water column and are stored behind the dam. Each year the reservoir behind the dam loses storage volume with deposition of sediment. Thus, the life span of any given dam depends on the amount of sediment being deposited from upstream. For the Bakun dam, the life span of the reservoir is approximately 50 years. River water released from the dam are low in suspended sediments and might even be sediment starved, thus eroding the channel. This might change channel bank formations and river migration and even down cutting the channel (incisement). Thus, the effects of dams redistribute sediments – blocking them upstream and eroding them downstream.

In the bottom of a reservoir, these trapped sediments are composed of mineral and organic matter. The organic matter is subject to decomposition. Decomposing organic matter consume oxygen and oxygen concentrations in the benthos and water column can become zero if the decomposition rates are low relative to the water mixing with the atmosphere. When the sediments have no oxygen or are anaerobic, bacteria in the water or sediments transform nitrate to N_2 or N_2O, organic carbon to methane, and sulfur compounds to hydrogen sulfide. Methane and nitrous oxide are greenhouse gases and to claim that hydroelectric, especially in the tropics, is a "trivial" emitter of greenhouse gases is patently false (Fearnside 2015). Hydrogen sulfide is toxic to many aquatic organisms.

Water entering the reservoir and the water leaving have different characteristics. Downstream water is often cooler, where release water is often taken near the bottom, where cooler water can be found. The oxygen concentrations might be low too. Depending on how the nutrient status of

DOI: 10.5642/envirolabasia.20170103.04

the reservoir, algae blooms may occur and, in some cases, these blooms may produce toxic compounds, which might also affect aquatic taxa in and below the reservoir.

Dams are barriers. Dams block the flow of water, but also block the movement of migrating animals. In some cases, fish require migration to reproduce or spawn, but with the presence of a dam, that upstream habitat is no longer available Fish in rivers are not adapted to lake conditions, thus many reservoirs find themselves subject to fish introductions, i.e. non-native fishes that are adapted to lake conditions. The populations of the migrating fish declines, while non-native fish populations increase. Unfortunately, the ecological impact of Dams on migrating fish has not been evaluated in the Sarawak. However, based on examples in the Colorado, Yangtze, and Amazon, some riverine fish are negatively impacted (Lees et al. 2016, Wang et al. 2016, Pine et al. 2017).

One of the most common ecological impacts downstream of dams is the lack of flooding. Although touted as a positive for most projects, i.e. lower flood risks for human communities, the impact on flood plain ecology is devastating. Floodwaters do not only deposit sediments and carry nutrients in the forests, but also fish get access to a dramatic increase in habitat area and food items. In some cases the fish allowed access to the flood plain can grow dramatically faster, which increase their survival rates and fecundity (Rayner et al. 2008).

Overall, the natural flow regimes define the Baram River's channel, vegetation, and animal life. No one argues that there will be no impact of the Dam, but until we understand what occurs in similar systems, it is difficult to evaluate the long-term impacts on a major dam on the Baram River.

Justifying Dams – Infrastructure and Development

The justifications for dams are as varied as the ecological value of disturbance. Each country and region finds ways to align certain interests to promote these projects. National identity and as a symbol of economic and political progress are some abstract justifications for dam building (McCully 2001). However, the concrete justifications yield pragmatic outcomes that can obfuscate these abstractions.

Like most dam project around the world, the political and economic justifications favor some and disrupt others. In fact, in recent years dam projects seem to generate more noise about the disruption for massive number of people living affected areas of a dam, most famously the Three Rivers Gorge Dam in the Hubei Province, China, where 1.3 million people were displaced (Tortajada et al. 2012).

Finally, as a justification for most dams, the flood risk for downstream residents is usually reduced. There are examples where risked are actually increased because the flood plain in colonized the capacity of the dam to prevent flooding was overstated or the dam fails completely. In might be better to describe that the flood risk is altered. This is particularly useful when you consider the impact of the Bakun dam on the Dayak, whose settlements were flooded by the dam. After public opposition originally halted the in the early 2000s, Malaysia turned its attention to the Bakun dam which was slated one of the 11 dams after the Baram dam was completed. The Bakun hydroelectric dam, completed in 2011, serves an excellent example of the failed promises of big dam projects (Sovacool and Bulan 2011): displaced residents remain antagonistic to their resettlement and a dramatic change to the river's ecology are undocumented.

In the case of the Bakun Dam, the indigenous people displaced by the project are still struggling to eke out a living over a decade after they were resettled. About 10,000 people were resettled to the town of Asap in 1998, surrounded by areas licensed for oil-palm plantations. Dayak people expected to be compensated with land and housing, but the discrepancy between the actual compensation is dramatic. Instead of getting two houses, each family got one. Instead getting 22 acres of land, they receive 3 acres (Lee et al. 2015) Many went into debt to pay for additional housing. Many received only three acres of rocky, sloped or sandy soils that are too small, of too poor quality to generate a living, and too far from Asap to manage effectively. On their traditional lands, the Dayak could fish in the river, hunt, and gather forest products. In the resettlement areas, they have no access to forests.

For the Dayak people of the Baram, the lessons learned by the resettlement of the Bakun River watershed provides a dire warning – of failed promises for compensation, loss of social cohesion, and the irreversible forfeiture of cultural heritage.

Energy for Monopolistic Transnationals

Malaysia has argued that the construction of 12 hydropower dams will decrease Malaysia's dependence on crude oil with diversified sources of energy – crude oil, coal, natural gas, and hydroelectric Recently, the "Four-Fuel Diversification" strategy has given way to the "Five-Fuel Diversification" strategy to include renewable energy sources (Abdul-Manan et al. 2015). Certainly, these are positive steps, but the construction of hydroelectric capacity was designed on the assumption that energy demand and GDP were closely linked. Unfortunately, the optimistic expectation that GDP would continue to grow at 8% and then require 166 Mega tons of oil equivalents (Mtoe) by 2020 is far from the reality. Instead, Malaysia's energy demand is only 51.6 Mtoe in 2013 (Energy Commission 2015). To boost the demand, the government has worked tirelessly to attract (with cut-rate energy prices) various energy-intensive, heavy industries, most notably bauxite processing for aluminum.

Energy scarcity and energy poverty describe how populations have inadequate access to energy, usually in terms of electricity. Currently, most estimate that about 5-10% of the population is located in inaccessible locations for the power grid – thus, the Bakun and Baram are inappropriate projects for these communities. In other words, the projects like the Bakun and Baram were not designed for those who might be described as energy poor; if addressing energy

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poverty was the goal, the government would develop very different projects, i.e. small scale and widely distributed – e.g. mini hydro (Oh et al. 2011, Ong et al. 2011, Mongabay 2015).

Social and Environmental Justice

The evaluation of projects for their potential social and environmental impacts is evaluated through SEIA reports in Malaysia. Yet Sarawak Energy Berhad, the state energy monopoly, claimed that the assessment could not be completed because of protests, releasing the following statement:

> Sarawak Energy's ability to commence and complete the feasibility studies and SEIA reports to ensure community issues and points of view are taken into account, have been disrupted by the ongoing protests.
>
> While we respect the right of individuals and organisations to express their point of view, it should be done in a manner that is lawful and does not place their safety or the safety of others at risk. The behaviour of the NGOs protesting at Baram in the past has breached both these basic principles.

In the case of the Dayak communities, the alignment between social and environmental justice and ecological protection converges on the "Stop the Baram" campaign. Evidence is on their side: socio-ecological impacts of the dam would be devastating for their way of life and dramatic changes to the river ecology. With international support from "Rivers International" and thoughtful engagement with various groups of interest, such as the EnviroLab scholars of the Claremont Colleges, the Dayak effectively used the media and a blockage to force the government to shelve the Baram Dam (McAlpine 2017).

When announcing the government's decision, Chief Minister Datuk Patinggi Tan Sri Adenan Satem articulated a view that the Baram protesters would regret their victory:

> There have been many protests and blockades by the people who voiced their disagreement to the building of the Baram dam. If you don't want the dam, fine. We will respect your decision. I hope you understand the impact for refusing it, as you will be missing out on related projects which are beneficial, such as roads and other necessities.
>
> One day, you will find that not building the dam has given some disadvantage and as a result of this, you suffer. That is in your own hand. It is your decision (Ruekeith 2015).

To keep these development projects going, the Malaysian government now has pinned its hopes on construction on one of the other 12 dam projects – Baleh Dam located in the in the upper Rejang basin in central Sarawak. The rainforest in this part of Southeast Asia has some of the highest rates of plant and animal endemism (Sodhi et al. 2004), i.e. species which are found only in that region, and the ecological damage from the proposed dam will be considerable even though the severity of its impact cannot be known at this time. As the Dayak people's successful resistance to the Baram River dam project reveals, those who live within the Baleh watershed will need to be vigilant and persistent in their opposition if they hope to protect the human and ecological communities that inhabit that region.

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