PANEL PRESENTATION HANDOUT

GEOG 412 201

BIG DAMS

PREPARED AND PRESENTED BY

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HISTORY OF BIG DAMS

3,000 BCE

The construction of dams has been recorded to have existed as early as 3,000 BCE. These ancient dams and many iterations that came after would not be classified as a "big dam" until the advancements of technology and engineering in the early 20th century that allowed for the construction of more large-scale projects.

1900S

The construction of dams has been recorded to have existed as early as 3,000 BCE. These ancient dams and many iterations that came after would not be classified as a "big dam" until the advancements of technology and engineering in the early 20th century that allowed for the construction of more large-scale projects. The early 20th century was a period where dams were viewed to be a pivotal advancement for many societies that comes with a litany of benefits such as cheap electricity, irrigation, and flood control. It was a symbol of the human domination of nature, where waterways can be conquered and tamed to serve the needs of man.

One of the earliest big dams of the 20th century was built in 1902 in Egypt called the **Aswan Low Dam** on the Nile by the British colonial settlers. The dam itself was praised to be a technological wonder that mitigated floods and provided irrigation for the arid region. However, it was loaded with colonialist and Orientalist undertones as the dam imposed a modernist bias that blamed the indigenous Arab communities for underutilizing nature, saying that the dam helped civilize the region. These colonial dam-building projects will continue to persist into to the late 20th century.

1930S-1960S

Big dams in Western nations was praised in the same light, with one of the most famous as well as earliest big dams in North America being the **Hoover Dam** on the border of Nevada and Arizona states, which was opened in 1936, was one of the biggest dams built during its period. It was a monumental infrastructure that during its construction during the Great Depression, it employed thousands of workers, and the dam itself can provide over 2000 megawatts of hydroelectricity. Eventually, the New Deal that came out of the Great Depression facilitated a multitude of water development projects to increase employment and services for electricity and agriculture, building several other big dams such as the Grand Coulee Dam alongside of Hoover. Hydroelectricity was also commended for its renewability.

1960S-1970S

Now nearing the latter half of the 20th century, the environmentalist movement that started in the 1960s 1970s begin to bring an alternative perspective on dambuilding, by bringing awareness to its adverse environmental, economic, and social consequences. Opposition from environmental groups were able to prevent several dam constructions projects, such as a dam proposed to be built in the Grand Canyon in Arizona. Anti-dam movements around the world, in particular in India, also began to come to the forefront in around the 1970s-80s.

1990S

In the 1990s, growing awareness of some of the costs of dams and growing polarization between dam proponents and opponents instigated the formation of the World Commission on Dams in 1998 that produced a comprehensive report on dams around the world and suggested guidelines for future hydroprojects.

21ST CENTURY

Now in the 21st century, particularly in North America and Europe, more and more dams are being decommissioned, or dams themselves are no longer considered feasible developments. Yet in other countries, in particular China, the government continues to preach more archaic beliefs of dams, such as its ability to prevent pollution and climate change, despite strong counter evidence against those facts.

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INTERNATIONAL POLITICS

DAM BUILDING AND STRATEGIC DEVELOPMENT

- **Urbanization trends.** Increasing population sizes and societal demand strains regional water resources. Strategically, nations may use dams to secure resources for anticipated rises in population growth, consumption, and water-intensive industry.
- **Climate change** is anticipated to generate a "net loss" of water resources. Motivation to build large dams is supported by rising levels of societal water demand paired with reduced availability of water.
- **·Regional hegemony:**Water is an essential resource for social and economic development, and control over water upstream can help consolidate regional power, as dams can improve a nation's economic standing, while delivering power and electricity.

TOOLS TO GOVERN DAMS ON TRANSBOUNDARY WATERSHEDS

Agreements, treaties and institutions that govern transboundary watersheds can help prevent and resolve disputes over water.

<u>INTERNATIONAL LEVEL:</u>

- 1997 Convention on the Law of Non-Navigational Uses of International Watercourses
- 1992 UNECE Helsinki Convention and the 2004 Berlin Convention

<u>REGIONAL LEVEL:</u>

Bi-lateral, tri-lateral agreements are concerned with issues like the water quantities discharged from dams in upstream nations, the quality of water released, and possibility of compensation for social and ecological impacts in downstream nations.

The terms of bi-lateral and multilateral agreements are not perfectly equitable: they are shaped by existing power asymmetries at regional and sub-national levels.

FOREIGN RELATIONS AND DAMS

- **Rapprochement**: Dam building and the treaty making process may bring co-riparian nations closer together. Dams which deliver benefits to several riparian states may deepen diplomatic ties and ease historical political tensions.
- **Conflict**: International disputes over issues discharge volumes, water quality, remediation costs, or siting of a dam can deepen or reignite historical diplomatic tensions between downstream and upstream nations. Water shortages, increased water salinity, or decreased fish harvests can breed resentment from governments and civil society and downstream, as industry, agriculture, and rural poor experience impacts of hydroengineering upstream.

KEY TERMS

- **Hydropolitics**: The politics of water allocation, use, and conservation between upstream and downstream nations.
- **Riparian States**: States which have a transboundary river flowing through its territorial boundaries, or states which contain a portion of a catchment area from a transboundary river.

PROS & CONS

<u>Benefits</u>

- Dam building and more integrated water governance may improve cooperation among riparian nations and increase resiliency to stressors such as climate change and societal demands.
- May catalyze improvements in the regional economy.

<u>Drawbacks</u>

- Terms of water treaties may replicate existing regional power imbalances.
- Water allocation does not have to be equitable.
- Upstream nations are often at a political advantage.

CASE STUDY: ILSU DAM

<u>BACKGROUND</u>

Turkey, Syria and Iraq are co-riparian states along the transboundary Tigris River. In 2018, Turkey's 1,200 megawatt Ilsu Dam along the Tigris River came online. The dam has lowered the volumes and quality of freshwater flow into Iraq (increased soil salinity, sedimentation, loss of fisheries, increase in drought, etc.)

<u>GEOSTRATEGY</u>

The Ilsu project is part of a push for Turkish Energy independence which became a policy priority after the Oil Crisis of the 1970's which threatened Turkish energy security. Ilsu also helps to secure water resources for anticipated growth in both population and in the Turkish economy. Turkey seeks to dramatically increase GDP, through expansion of agriculture. Further, Turkey projects 15% population growth in the next 30 years. Both trends will stress water resources.

<u>TRANSBOUNDARY GOVERNANCE</u>

Transboundary Governance: Turkey, Syria and Iraq have complex agreements related to water use in the Tigris-Euphrates Basin. Turkey and Syria have the Protocol on Economic Cooperation (1987) while Iraq and Syria have the Syrian-Iraqi Water Accord. Iraq lacks a direct dispute resolution channel with Turkey and has less bargaining power due to political instability and a comparatively weaker economy.

<u>FOREIGN RELATIONS</u>

As Iraq has been wracked by drought and open public protests over water quality, Iraqi diplomats have called on Turkey to discharge more water from Ilsu, which strains historical political tensions between the two nations. Turkey has resisted Iraq's proposed revisions to existing water governance agreements.

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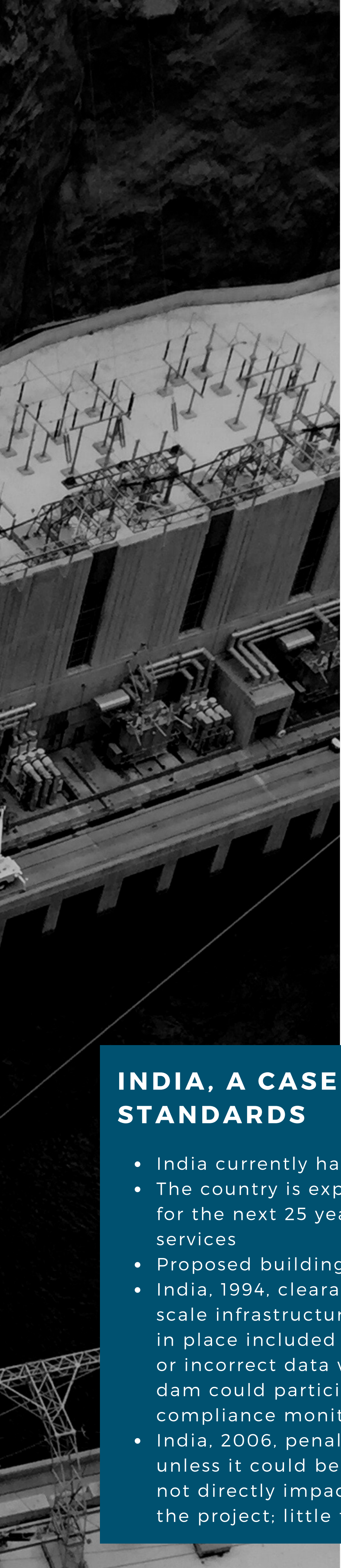

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NATIONAL POLITICS

OVERVIEW

- The political economy of dam building has led to the top-down imposition of dam projects as states have sought and continue to seek secure international developmental aid
- There exists a history of top-down, technocratic dam management in nations, especially in former Soviet bloc countries in Eastern Europe
- Even when there exists the illusion of greater democratic processes in Western nations, such nations have simultaneously incentivized dam-building while regulating it, making the process less transparent and contributing to the disenfranchisement of potentially affected groups
    - ex: the US which promoted western development (within the nation) of dams for the sake of supporting industry growth while simultaneously writing the rules and regulations which allow such growth to occur with little impediment in the 1960s

- Two significant national reasons for dam construction:
    1. Large dams are often seen as a means for a head of state to secure international development funds
        - This incentivizes the heads of states to allow for the persistence of porous policies and loopholes which allow for conflicts of interest to exist
    2. Projections of future water demand can drive dam-building when other alternatives to water supply management are not explored
        - Such projections can be inaccurate due to a conflict of interests and thus in the future, nations may be stranded with partially completed, expensive dam projects which do not truly serve their intended economic purpose

- Issues of local government circumvention as a result of a central government pursuing a specific agenda

INDIA, A CASE STUDY OF INCREASINGLY MORE LAX STANDARDS

- India currently has the third-largest number of dams (over 4000) in the world
- The country is expected to greatly increase its number of dam and reservoir projects for the next 25 years in order to meet irrigation and urban center demands for water services
- Proposed building 300 more dams by 2030 to meet its energy demands
- India, 1994, clearance from the Department of Environment was required before large scale infrastructure projects, like dams, could be undertaken. Additional safeguards in place included the ability of regulatory agencies to cancel a project if insufficient or incorrect data was supplied regarding the project; any person interested in the dam could participate in public discussion about it; post-clearance and constructive compliance monitoring were necessary
- India, 2006, penalties for incorrect provision of information dropped completely unless it could be proven that misinformation had been deliberately supplied; people not directly impacted by a dam's construction were barred from public discussion of the project; little to no post-clearance monitoring of a dam project

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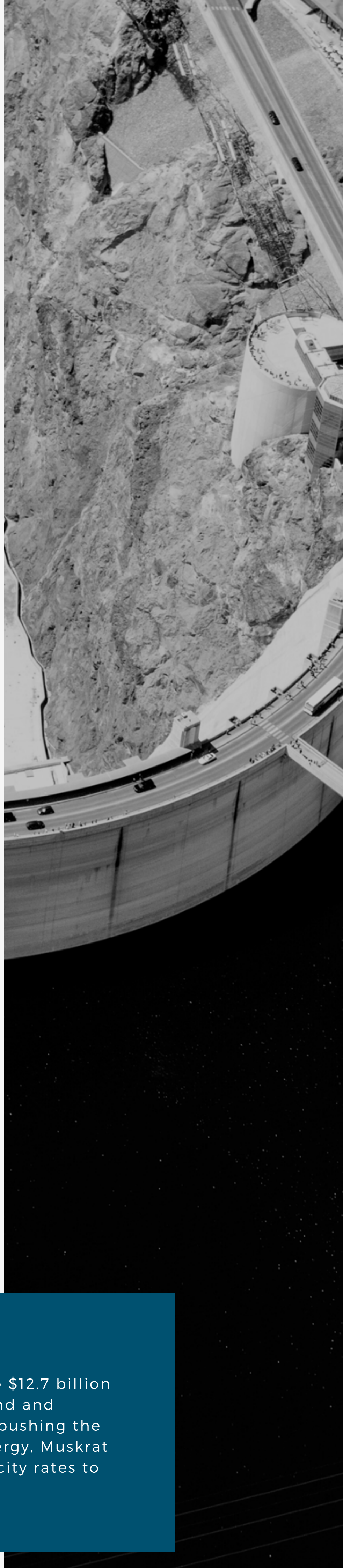
(DAM)AGING EVIDENCE? THE ECONOMICS OF DAMS



FUN(DAM)ENTAL SHIFTS

Looking back
- More than $2 trillion USD in total investments worldwide in 20th century
- Construction of dams synonymous with development and economic progress
- Symbols of modernization and ability to harness nature
- Peak in 1970s, where an average of two or three large dams commissioned each day
- Benefits regarded as self-evident and justified as highly competitive option to development, though limited economic and financial indicators of profitability or efficiency at the time
- Little regard for social or environmental impacts in construction or operational costs

Moving forward
- Full cost of large dams have emerged as serious public concern
- End of any dam project must be the sustainable improvement of human welfare
- Imperative of integrating a triple bottom line approach: economically viable, socially equitable, and environmentally sustainable
- Better and continued monitoring and independent analyses of dams a necessity
- Improved project selection and operation of existing dams

COSTS: (DAM)NED IF WE DO

- Large dams require significant financial investments, may be largest single investment in a country
- High degree of variability of dams in achieving technical, financial, and economic targets
- Often incur substantial cost overruns and tendency towards delays, affecting delivery of services, revenue generation, and increasing interest payments
- Controversy around limits and ability of methods for economic assessment to fully capture and reflect economic performance, true profitability remains elusive
- Mismatch of benefits and costs between local communities and national governments

BENEFITS: (DAM)NED IF WE DON'T

- Dams are promoted as an important way to meet water and energy needs, supporting economic development
- Services produced by dams are considerable
- 12-16% of world food production, 19% of world electricity supply
- Large hydropower dams generally meet their financial targets with notable under- and over-performers
- Multiplier effect: Multi-purpose dams draw secondary and tertiary benefits such as food security considerations, local employment and skills development, rural electrification and the expansion of physical and social infrastructure from roads to schools

(DAM)NIFIED CASE STUDY: MUSKRAT FALLS

- 'Megaproject-turned-mega problem' from an original $6.2 billion price tag to $12.7 billion (CDN) investment in 'green' energy. The hydroelectric facility in Newfoundland and Labrador is a year behind schedule and has become an over-budget burden pushing the province towards the brink of bankruptcy. Promoted as a source of clean energy, Muskrat Falls will increase Newfoundland's gross debt by 50% and double the electricity rates to 23.3 cents per kilowatt hour into 2022, twice the Canadian average.

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ABIOTIC ENVIRONMENTAL IMPACTS

ALTERATIONS TO WATER FLOW

Hydrological infrastructure alters original hydrological nature and water regimes, including timing, amount and chemical composition of a river's flow:

- Upstream impacts include water stagnation at reservoir sites, associated with a rise in evaporative losses, seepage, erosion, periodic flooding, extension of water-land boundaries and consequential water quality declines. Additionally, groundwater flow and topography may be altered.
- Downstream impacts include a reduction in downstream flow including reduced peak flow, a decline in water quality, lack of seasonal variation in flow regime, reduced temperature of water discharge, and channel simplification.
- Dams have moderately to highly fragmented 60% of the world's large river basins, with controlled flows significantly altering floodplain ecosystems.

ALTERATIONS TO WATER COMPOSITION

Alterations to original hydrological nature via large bodies of stagnant water and reduced/minimal downstream flow alters water composition:

- Large dams contribute to sediment and nutrient pollution accumulation and subsequent discharge.
- Stagnant water contributes to organic decomposition and thus an increase in nutrient substances. Simultaneously, reservoirs hinder downstream sediment flow.
- Flooding large areas of terrestrial organic matter fuels microbial decomposition, contributing to additions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).
- Downstream impacts include altered thermal water conditions: dams create cooler discharge water in summer and warmer discharge water in winter.
- Large dams cause a permanent increase in water turbidity as a result of erosion and corrosion contributing to upstream accumulation and downstream discharge of toxic matters (toxic metals, agricultural runoff etc.).

CLIMATIC IMPACTS AND CARBON CAPTURING

- Rise in evaporative losses resulting in microclimatic and regional climate changes through alterations in air moisture percentage, air temperature, air movements, and regional topography.
- Reduced carbon capturing occurs both upstream and downstream due to reduced vegetative cover associated with potential flooding and droughts, respectively.
- Hydroelectric dams require periodic flooding, resulting in CO_2 emissions from above-water vegetative decay.
- Reservoirs emit more N_2O than the forests they replace
- CH_4 forms when organic matter decays in oxygen poor environments at the bottom of a reservoir.
- Reservoir eutrophication and the release of carbon stores as a consequence of flooding contributes to GHG emissions.
- Reservoir nutrient loading and associated eutrophication leads to increased radiative forcing by reservoirs due to an increase of CH_4 emissions.

CASE STUDY: LA GRANDE HYDROELECTRIC COMPLEX

- In La Grande Hydroelectric Complex reservoirs, concentrations of total mercury (THg) in all fish species studied increased rapidly after impoundment.
- Biotic measurements of THg are representative of impacts on abiotic environmental components (water composition).
- A return to average THg levels representative of natural lakes was complete 10–20 years after flooding in non piscivorous species and 20–31 years in piscivorous species, if no additional flooding occurred.
- Expected average winter runoff rate increase of 52%, with 6% decrease in summer runoff rate

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BIOTIC ENVIRONMENTAL IMPACTS

There are ~50,000 large dams spread across the globe that the general society relies upon. (*height ≧15 m). All contribute to habitat and flow connection alterations to the Living parts of the surrounding ecosystem: plants, animals, and micro-organisms. Dams are known to be related to: destruction of organisms, fragmentation of populations > ultimately harming genetic variability in affected habitats. One of the most common forms of habitat modification is the construction of dams for the creation of reservoirs.*

UPSTREAM
- Impact widespread and varied (ex: dam structure, sediment, climate)
- Harmful clearing and repurposing of land.
- Disruption of free-flowing streams to artificial systems put the aquatic plants and animals at risk resulting in bottom-up related consequences needed for proper ecosystem function.
- Overall social and environmental changes regarding dam projects creates environmental degradation on the newly enclosed systems.
- Ex: Sivilay villages (near central Laos) forced to resettle 4km upstream, further away from necessary resources

.DOWNSTREAM
- Notable consequences of dams: stream-side environments, fish migration, and habitat sediment disruption.
- The quantity of water discharged, when it is discharged during diel and seasonal cycles relative to the river's natural flow pattern and abiotic characteristics of the discharge such as temperature, oxygen, turbidity, and water quality significantly affect downstream biodiversity.
- Stream-side environments
  - Riparian vegetation: boundary mixed environment between the land and river
  - Signifiucance: filter pollutant (nutrients and sediment)
- Fish migration
- Altering riverbed-> habitat River bottoms for fish spawn / invertebrates
- Depend on dam size, location, operation
- Impacts on aquatic biodiversity due to impossible environmental barrier between upstream movement and spawning areas and the overall cycle.
- Results in close contact with potentially harmful conditions.
- Subtle change has massive ripple effect havoc for ecological web
  - The increasing effects of consequent dams with overlapping environments with that of the next downstream. Further and larger downstream segments of the river may have decent numbers of species however this is only because of reduced habitat variety.

CASE STUDIES

QUEBEC, CANADA
La Grande River watershed (hydroelectric complex)
- One of the largest hydroelectric systems in the world
- In La Grande Hydroelectric Complex reservoirs,
  - Mercury concentrations (THg) grew rapidly in high numbers of fish species after impoundment.
- Consequences:
  - Destruction of salmon spawning activities
  - Destruction of wildlife habitats and wetlands
- A return to average THg levels representative of natural lakes was complete 10–20 years after flooding in non piscivorous species and 20–31 years in piscivorous species.* *no additional flooding occurred

CALIFORNIA, US
- Salmon and Trout have been found to be highly susceptible to impacts of dams (Through changes in migration between spawning and rearing habitats. Salmon path blockages have been traceable in ~ 45% of historical habitats in major rivers (percentages vary by location)

BRAZIL
- Case Study: Três Marias Dam (TMD) central Brazil,
- Large fish population in surrounding areas, risk of harm due to dam Consequence: Many of the migratory fish species are commonly relied upon in the commercial fisheries.

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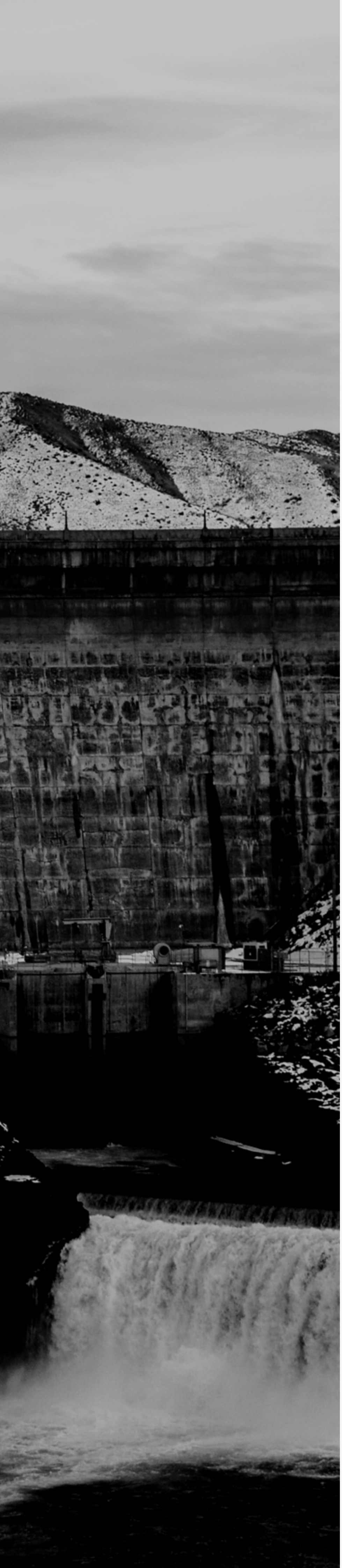

Connor Byron

SOCIAL IMPLICATIONS

CASE STUDY COMPARISON

Virtually any decision that is made by governments across the globe, the topic of building dam sites has caused for some major backlash on both a local and international stage. When looking both locally and Blinded by the potential financial gains, dams are continuing to disrupt land and take away natural resources and residences to both humans and wildlife. Pending the completion of construction, the Site C Dam would flood nearly 100 kilometers of land and cause permanent disturbance to local First Nation territory as well as local fish and animal species. Considering the negative affects on local landscapes are so severe, it is no surprise that this project has been on hold since the 1970's. The building of the dams breaches international treaties that were established with Indigenous groups in the late 1800's and uses aboriginal land without full consent. As of 2017, there had already been 2 billion dollars spent on the site C Dam, with an estimated total cost being 9 billion dollars. Because of that, petitions and protests have been ongoing to stop the construction of the dam since it was approved by the British Columbia and Canadian government in December of 2014. Hunger strikes, protests and a countless amount of organizations have been created to raise public awareness towards the negative affects that the Site C Dam can cause if it gets the full go ahead.

On an international scale, the Three Gorges Dam - rooted from the heart of the Yangtze River - has displaced over one million people and 40 million square meters of housing property since the projects approval in 1992. In the process, the dam has affected 14 cities and over 1000 villages through out central China. In moving people out of there homes, China has seen a rise in low income households as the shift from rural to urban living has made it difficult for families to find new jobs and adapt to a new life style. From an economic standpoint, the project is the worlds largest hydroelectric project and is believed to have cost north of 23 billion dollars. Positives from the dam include that it has been meeting its goal of producing pollution-free electric power, but that does not mean that this dam has not produced other forms of pollution. Since the dam began running, environmentalists have felt major concern for the sightings of garbage build up, abundance of landslide build up and the overall change to some of China's stunning natural landscape.

TIMELINE

- **2014** - The government of Canada and the government of British Columbia granted the site C Dam environmental assessment approval.
- **2015** - Members of the treaty 8 First Nations camped out at an entry point of the Peace Valley as an attempt to stop BC Hydro from construction. Environmentalist David Suzuki joined them by the middle of January
- **2016**- Vanier Park Vancouver, "Grab a paddle campaign" in hopes to raise awareness and money for treaty 8.
  - Waste of taxpayer money
  - Infringes first nations rights.
- **2017**- New provincial leader, John Horgan after proving that it wasn't worth it, decided to go through with it, ppl outraged.
- **2019** - August 2019: First Nations renew legal fight against Site C dam. (West Moberly First Nations group. Confirm a court appearance for 2022

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Kevin McCallum

ENVIRONMENTAL INNOVATION FOR BIG DAMS

When looking forward to the future of sustainable hydroelectricity there is no single answer to all our problems. Humans continue to use electricity and demand is still on the rise. We are also not dealing with a clean slate. There are thousands of dams that have already been built and dams around the world are currently being planned. Therefor there are three main pathways for achieving truly sustainable hydropower; re-operating existing dams, new regulations and policies for building dams, and alternative generators of hydroelectricity.

The first topic is the **re-operation** of existing dams. The term comes from the 2010 UNESCO conference on the future of dam building. Re-operating refers to more than just maintaining the dams. It refers to adding new structures or making large changes to expand the uses of a dam and to minimize its environmental impacts. Re-operation for flood management looks at the downstream from the dam. Actions like recreating floodplains can restore biodiversity while simultaneously protecting infrastructure from floods. The re-operation of dams for power purposes considers the negative practices of dams today. One major problem with power dams is **hydropeaking**, an action done by dam operators where they increase the flow during peak electrical usage hours to ensure that everyone has access to energy. The problem with hydropeaking is the effects that daily flooding has on the downstream ecosystem. Riparian organisms are not adapted for flooding of such frequency so there are damages to root structures, egg, and other organisms that exist right on the boundary between earth and water. Measures to prevent damage of hydropeaking include creating cascades of dams, each catching the runoff from the last, and inserting dykes or reservoirs right at the bottom of the dam to slow any sudden flow. In re-operating for water supply dams there is an increased emphasis on maintaining some of the natural hydrological cycle intact. This is achieved by creating pathways for groundwater to pass under the dam, allowing an amount of groundwater through the resembles the environment's natural **hydrograph**. Groundwater is extremely important for the vegetation of an ecosystem and the lack of groundwater can lead to increase in sinkholes. Therefore, it is in the best interest for both humans and nature to have the ground water at an appropriate level. Another reoperation that can be done to dams is the linkage between functions. Many dams have a single purpose: hydroelectricity, water management, or flood prevention. By altering a dam to perform multiple of these tasks it maximizes the benefits of the dam while keeping the environmental impact the same.

The next way to manage dams in the future is changing the design and planning of future dam projects. The first and most important step is to empower environmental impact assessments. Right now, most EIAs work for the dam companies and have very little say in the process. EIAs need to be empowered enough to be able to cancel the plans of new dams and be supported by an independent (or governmental) organization. As a part of the EIA and the new dam designs, the entire **catchment** must be considered. Effects of the dam both downstream and upstream can be understood through modern technology and case studies of past dams, allowing us to add design elements similar (or even more effective than) to the re-operating of existing dams. Add proper designs to ensure that downstream and groundwater resemble natural environment is essential for minimizing environmental impacts.

Even with modern innovations and design changes the impact of dams on the environment is massive. For this reason, engineers and innovators are seeking new ways of generating hydroelectric power. A new kind of **hydrokinetic generator** is the instream turbine. These turbines are put into the centre of a large stream to collect energy relative to the speed of the river. They have less of an impact on the environment because they are place over the river, not altering the shape or flow of the river. They are also beneficial because they can be put into remote locations as an "off grid" source of power. With minimal repairs they can sustainably provide energy for a whole community while allowing the natural riparian ecosystem to live unaltered. Instream turbines are still in the prototype stage but they represent the future of decentralized hydrokinetic energy.

KEY WORDS

Reoperation: the refurbishing of an already existing dam to lessen environmental impacts and increase its uses
Hydropeaking: increasing the flow through a dam in order to match the daily increases in energy consumption
Hydrograph: a graph visualizing the amount of water going through a particular point Environmental impact assessment: an assessment done by a certified individual that describes the environmental impacts of a proposed building site along with options for alternatives and ways to minimize impacts **Catchment**: an area through which the natural drainage of water travels through Instream turbine: a generator that has a spinning turbine placed into a stream in order to collect hydrokinetic energy
Hydrokinetic generator: a generator that acquires its power from the force of moving water

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BIG DAMS PANEL HANDOUT

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