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Environmental and Climate Justice along the Brahmaputra River in Northeast India

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ABSTRACT

The glaciers of the Himalayas are the source of all of Asia's major rivers and are crucial to Asia's water supply, economies, and livelihoods. The Himalayan region is uniquely vulnerable to the impacts of anthropogenic climate change, while also becoming one of the most dammed regions in the world. This case study explores the unequal distribution of the impacts of climate change and dam building along the Brahmaputra River in Northeast India. It examines how the combined impacts of these two processes negatively affect local communities and explores environmental and climate justice issues. In discussing climate change impacts and hydropower development in Northeast India, this case study presents questions on the role of dams as a solution to climate change and as a form of sustainable development.

LEARNING OBJECTIVES

After completing this case study, students should be able to:

1. Describe current climate change threats in the Himalayan region and how they will impact the people of Northeast India;
2. Identify the factors contributing to hydropower development along the Brahmaputra River;
3. Explain and differentiate amongst the various environmental and climate justice issues relating to dam building along the Brahmaputra River;
4. Discuss the combined impacts of climate change and hydropower development on the riparian communities of Northeast India; and
5. Analyze and evaluate the role of hydropower development as an approach to address the climate change crisis and as a form of sustainable development, especially in areas where water resources are vulnerable to climate change impacts.

1. BACKGROUND

1.1. The Himalayas: "Asia's Water Towers"

The Himalayas are the highest mountain chain in the world. They are also a repository for the largest amount of ice outside of the poles, with Himalayan glaciers the source of all of Asia's major rivers (Figure 1). Rivers originating in the Himalayas are crucial to Asia's water supply, economies, and livelihoods[1]: Approximately 1.5 billion people rely on the runoff of these rivers in the Himalayan mountain region and further downstream in numerous countries including China, India, Pakistan, Nepal, Bangladesh, Vietnam, Burma, Thailand, and Lao PDR (Immerzeel et al. 2010; Xu et al. 2009). For this reason, the Himalayas are often referred to as "Asia's Water Towers."

1.2. The Brahmaputra River

The Brahmaputra River originates in the glaciers of Tibetan Plateau, in the Himalayas, and flows through Tibet, Northeast India, and Bangladesh, where it merges with the other rivers, before discharging into the Bay of Bengal (Figure 2). Its flow depends primarily on contributions from the South Asian summer monsoon[2] rains and the melting of Himalayan snow and ice, both of which occur between June and September (Goswami 1985). Throughout its course, the Brahmaputra supports a variety of different ecosystems from alpine meadows to tropical forests (Liu et al. 2012), as well as human communities.

The Brahmaputra is one of China and India's largest rivers both in terms of discharge and length (Shi et al. 2011), and is one of the most sediment[3]-charged rivers

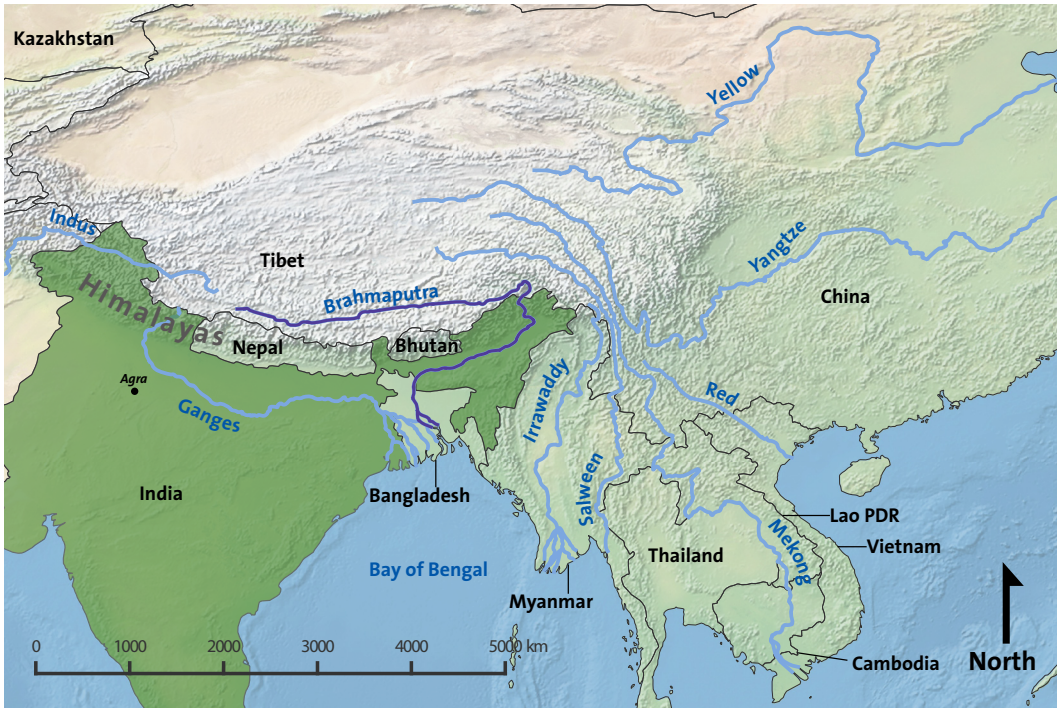


Figure 1. Asia's rivers with sources in the Himalayas.

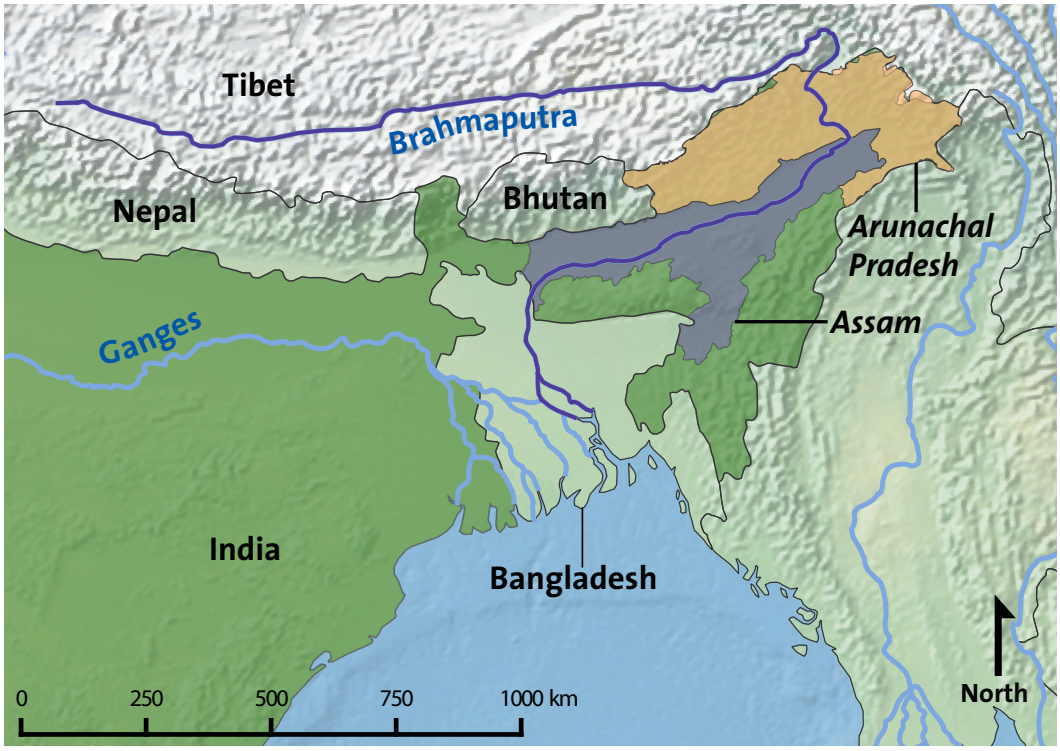


Figure 2. The Brahmaputra river basin with the Arunachal Pradesh and Assam states highlighted in orange and purple respectively, and labeled.

in the world (Goswami 1985). In India, the Brahmaputra River and its tributaries[4] are considered the "lifeline" of the Northeastern region and its people, a majority of whom depend on natural resources for their livelihoods (Vagholikar & Das 2010). Though the Brahmaputra river basin[5] drains all of the states of Northeastern India, except for Sikkim, a majority of its basin lies in the states of Arunachal Pradesh and Assam. In Arunachal Pradesh, the river and its tributaries traverse steep slopes as they go from the heights of Tibetan Plateau towards the Indian Ocean. In Assam, much of the power of the river gets dissipated and the river becomes highly braided[6] as it deposits vast amounts of silt and sand on the Assamese floodplains[7].

As a result of the unique topography of the Brahmaputra

Figure 3. Rice fields along the Dikrong riverbank, a tributary of the Brahmaputra, in Assam (photo credit: Costanza Rampini 2014).

river basin and the yearly onset of the South Asian summer monsoon—characterized by heavy rains—destructive floods are a recurrent and major challenge for the people of Arunachal Pradesh and Assam during the summer months. Summer floods cause tremendous damage to houses, fields, livestock, public utilities, infrastructure, and drinking water sources, and also lead to the spread of disease and the loss of human lives. At the same time, the Brahmaputra River provides countless ecosystem services[8] to the people of Arunachal Pradesh and Assam, including irrigation and fertilization of agricultural fields (Figure 3), groundwater recharge, transportation, food sources, and cultural services such as recreation and religious activities.

2. CLIMATE CHANGE IN THE HIMALAYAS

As the world's highest mountain chain, the Himalayas are uniquely vulnerable to the impacts of anthropogenic climate change[9], with important implications for the communities and ecosystems that depend on Himalayan rivers. This section details some of the impacts of climate change on water resources in the region, particularly in the Brahmaputra river basin, and discusses climate justice[10] implications for local communities.

2.1. The So-Called "The Roof of the World is Melting"

Increasing anthropogenic emissions of CO_2 and other greenhouse gases[11] are expected to cause a 2–2.5 °C temperature rise in the Himalayan region between 2021 and 2050 (Immerzeel et al. 2013; Eriksson et al. 2009). Already, increased surface temperatures due to climate change are causing Himalayan glaciers and snowpacks to shrink (Immerzeel et al. 2013). This suggests that glacier-fed Himalayan rivers, such as the Brahmaputra, could experience an increased variation in flows and even become entirely seasonal in the near future (Cruz et al. 2007). As Himalayan glaciers shrink, Himalayan rivers will first experience an increase in runoff as a result of the added meltwater, followed by a rapid and long-term decline in river runoffs as glaciers move past a critical threshold[12] (Baraer et al. 2012). Himalayan glaciers are expected to reach this threshold around 2050 (Immerzeel et al. 2013), at which point the Brahmaputra may experience a decrease in the average upstream water supply by nearly 20% (Immerzeel et al. 2010).

The impacts on water supply for those people who rely on the river are two-fold. On one hand, the short-term increase in glacial melt and Brahmaputra River runoff can exacerbate the challenge of summer floods for local communities living in the river basin. On the other hand, the long-term decrease in glacial melt will be especially felt during the winter dry season when glacial melt contribution to streamflow is most important (Baraer et al. 2012; Cruz et al. 2007). During the winter season, people living in the Brahmaputra river basin rely on the river for irrigating winter crops and for other important purposes such as laundry, bathing, drinking water for animals, and recreational and religious activities. A reduction in winter season flows of the Brahmaputra River will affect the capacity of local people to rely on these important services during the winter months.

2.2. Climate Change Impacts on the South Asian Summer Monsoon

The Brahmaputra River hydrology is also heavily influenced by monsoon rains during the summer season (Thayyen & Gergan 2010), which coincide with the melt season of Himalayan glaciers. Anthropogenic climate change is altering the South Asian summer monsoon, and climate models project an increase in the frequency of heavy precipitation events and a decrease in the frequency of light rain events during the summer monsoon season (Hijioka et al. 2014). More frequent heavy rain events will exacerbate the challenge of floods (Apurv et al. 2015).

But the range of effects of climate change on the South Asian summer monsoon are still poorly understood, and remain the largest source of uncertainty in determining the future runoff of Himalayan rivers such as the Brahmaputra (Immerzeel et al. 2013). For example, different climate models disagree as to whether changes in the water cycle will compensate for a long-term reduction in glacial melt by increasing annual precipitation, or exacerbate the problem by decreasing precipitation (Immerzeel et al. 2013).

2.3. Climate Justice

Overall, climate change is an impending threat to Asia's water towers, with cascading negative effects on biodiversity, local livelihoods, water and food security[13], and the region's economies (Cruz et al. 2007; Crow & Singh 2009; Pomeranz 2009; Xu et al. 2009). Particularly important to the people of Northeast India will be the impacts of climate change on the flood regime of the Brahmaputra River, on flow levels during the dry winter season, as well as the potential long-term reduction in river flows.

The industrialization and economic growth of Western countries, beginning in the 19th century, is largely responsible for the emission of greenhouse gases that are causing anthropogenic climate change (Liverman 2009). Northeast India is one of the poorest and least industrialized regions in India, with 70% of the population dependent on agricultural livelihoods (ICC 2013), and hence bears little responsibility for past greenhouse gas emissions (however, the country as a whole is industrializing rapidly, and emissions levels have been steadily rising). Yet as warmer temperatures cause changes to the Brahmaputra River flows and flood regime, the people of Arunachal Pradesh and Assam will bear a disproportionate burden of climate change impacts. Approximately 40% of Assam's land surface is vulnerable to flood (NRSC 2011). Annually, the area of land affected by floods in Assam ranges from one to nearly four million hectares, and vast areas of both Assam and Arunachal Pradesh are affected by flood-related erosion (World Bank 2007).

At the same time, Assamese and Arunachali farmers depend mostly on summer monsoon precipitation and sediment deposition from the river to provide irrigation and fertilization for their fields. Less than 17% of Assam's cropland is under irrigation schemes (Department of Irrigation 2013), and fertilizer use in both Assam and Arunachal Pradesh is low, with 63 kg and 3 kg of fertilizer used per hectare respectively, compared to the national average of 135 kg per hectare (ICC 2013). Changes in precipitation patterns and the long-term reduction in river flows pose a challenge to rain-fed floodplain agriculture in the region, making it increasingly difficult for subsistence farmers to sustain their livelihoods. Overall, climate change impacts on floods and water availability increase damages to traditional livelihoods, agricultural crops, and infrastructure, as well as an increase in human displacement and the number of climate refugees in the region (ICIMOD 2009).

The fate of the people of Assam and Arunachal Pradesh in the face of climate change impacts provides an important lesson for understanding the unequal distribution of benefits and losses as a result of climate change, an issue known as climate justice. While Assamese and Arunachali people have reaped few benefits from the industrialization of rich countries in the Global North[14] and even from the industrialization and economic growth of India, their largely sustainable agricultural livelihoods are directly threatened by the impact of anthropogenic climate change on key water resources.

3. DAMMING THE HIMALAYAS

The countries that make up the Himalayan region have plans to build over 400 hydroelectric projects along Himalayan Rivers, transforming the region into one of the most dammed regions in the world (Walker 2013).

3.1. Hydropower Development Along The Brahmaputra River In India

As of 2014, India is the world's second largest country in terms of population and the third largest contributor to global greenhouse gases (GHGs) emissions annually (World Bank 2016; Olivier et al. 2015). Therefore, the Indian government is confronted with the challenge of providing energy for a growing economy, while also facing international pressure to reduce its carbon footprint.

In the last decade, the Brahmaputra River has become the epicenter of India's renewable energy development efforts. The river has been identified as India's "future powerhouse" representing approximately 40% of India's total hydropower potential[15] when considering the hydroelectricity[16] generating potential of all Indian rivers (MDONER 2012). The amount of water and the force of the flows of the Brahmaputra river basin give it higher hydropower potential than all other river basins in India (CEA 2014), 87% of which remains unexploited (CEA 2014). This potential is concentrated in the northeastern state of Arunachal Pradesh, where the river and its north-bank tributaries flow across steep slopes as they go from the Himalayan Mountains to the flat floodplains of Assam.

As of 2012, the government of Arunachal Pradesh allotted contracts for 140 new dams along the Brahmaputra's north-bank tributaries—44 of which are mega-dams above 100 MW in capacity (MDONER 2012)—in an effort to meet India's growing energy demands, promote economic and sustainable development[17] (Verghese 2010), and curb GHG emissions from energy production (Government of Arunachal Pradesh 2008) (Figure 4).

4. DAMS AND ENVIRONMENTAL JUSTICE

Dam-building along the Brahmaputra, particularly in the context of climate change, exemplifies the unequal distribution of environmental costs and benefits across groups of people and across scales that is the focus of environmental justice[18] work. The government of

Figure 4: The Ranganadi Hydroelectric Project (405 MW) in Arunachal Pradesh (photo credit: Costanza Rampini, 2014).

Arunachal Pradesh profits from the allotted hydropower projects, India's urban centers largely benefit from the new energy supply, and the global community gains in terms of climate change mitigation. Meanwhile, the people of Northeast India, and especially Assam, are made to bear the social and environmental costs of hydropower development in the region. In addition, dam building amplifies the negative repercussions of climate change for downstream communities, thus creating "double losers."

4.1. Unequal Distribution of Costs and Benefits Between Arunachal Pradesh and Assam: Land Submergence vs. Flood Protection

The dams planned on the Brahmaputra River and its tributaries were initially conceived by India's central government for hydropower generation, irrigation, and seasonal flood control. However, in 2008, India's new Hydropower Policy prioritized attracting private investment in dam-building projects to speed up the development of hydropower resources in Northeast India (Water for Welfare Secretariat 2008). Private companies are now building approximately 90% of the new dams planned for the Brahmaputra river basin (Vagholikar & Das 2010). The entry of private investors in dam projects along the Brahmaputra led to a shift from multipurpose projects to run-of-the-river[19] projects, which have small reservoirs and little flood control capacity. Run-of-the-river projects maximize hydroelectricity production while minimizing the amount of land submerged by the dam reservoir and thus minimizing conflict with nearby upstream Arunachali communities, who would need to be compensated and relocated in order to accommodate for a large reservoir (Baruah 2012). However, these projects come to the detriment of the people living downstream of the dams, especially those living in the floodplains of Assam, who would instead benefit from upstream dams with large reservoirs that can help buffer floods.

4.2. Unequal Distribution of Costs and Benefits Between Arunachal Pradesh and Assam: Hydroelectricity and Changes to River Flows and Ecology

Because nearly all of the new dam projects for the Brahmaputra river basin are located in the state of Arunachal Pradesh, Arunachali people will be compensated for land submergence and the Arunachal Pradesh state government will receive both large down payments for the projects and a fixed amount of free hydroelectricity from each dam. Assam, on the other hand, must secure purchase agreements with the hydropower companies in order to receive hydroelectricity from the dams built just upstream of its territory. In addition, while the impacts of the dams on river flows and ecology will be felt by all communities downstream (regardless of state), riparian[20] communities in Assam could bear an even greater burden than those in Arunachal Pradesh (Baruah 2012). Assam's agriculture is centered around tea plantations, rice, silk farming, and

Figure 5. Children fishing in the Dikrong River in Assam (photo credit: Costanza Rampini, 2014).

fishing. Rice agriculture in Assam's floodplains depends on the transport and deposition of sediment by the Brahmaputra River and its tributaries for fertilization. As dams alter the flow of sediments in the Brahmaputra river basin, they will affect the fertility of Assam's floodplains (Vagholikar & Das 2010). In the winter, when people rely on the river for irrigating their winter crops and other important services, dams reduce river flows and cause unnatural daily fluctuations in flow levels as the water behind the dam is released only during certain hours to meet peak electricity demand (Vagholikar 2011). Additionally, as dams change river flows, they degrade wetlands downstream and block fish movement, which negatively impacts fish species in the Brahmaputra river basin and the food security of Assamese people, as fish play an important role in their diet (Figure 5).

4.3. Exporting Hydroelectricity from Northeast India to India's Mainland

The building of new dams in Arunachal Pradesh could bring development to Northeast India through jobs and infrastructure development, and is hence promoted as an engine of prosperity for this marginalized and largely rural region (Government of Arunachal Pradesh 2008). However, a majority of the hydroelectricity produced by dams built in Arunachal Pradesh will be transported to other parts of the country to satisfy the growing energy needs of India's urban centers (Baruah 2012), while the social and ecological costs of the dams are felt locally by the people of Arunachal Pradesh and especially Assam. Plans to build a large-scale power grid to transport the abundant hydropower resources of Northeast India to load centers located far away are already in the works. For example, a 6,000 MW transmission system from Assam to Agra, a city of 1.3 million inhabitants nearly 2,000 kilometers away in the northern state of Uttar Pradesh, was completed and commenced power flow in September 2015 (India Infoline News Service 2015; MDONER 2014), and more will be built as more hydropower projects are completed.

Additionally, India's National Hydro Policy and Tariff Policy allow for 40% of the electricity generated by a private hydropower project to be sold at market price rather than to pre-identified customers under long-term power purchase agreements (Vagholikar & Das 2010; Bhaskar 2013). This allows hydropower developers to sell energy to the highest bidder and is unlikely to benefit the relatively poor Northeastern states and their people, who will be unable to compete with richer states in an open market. Finally, while local Assamese and Arunachali people hope to benefit from employment creation, low levels of literacy in both states, and particularly in rural areas (Government of Assam 2003; Rajiv Gandhi University 2006), make it improbable that they will gain access to the high-level long-term jobs within the hydropower companies that are building dams along the Brahmaputra.

5. CONCLUSION: DAMS, CLIMATE CHANGE, AND THE PEOPLE OF NORTHEAST INDIA

Dams are promoted as a means to mitigate global climate change and promote the sustainable development of Northeast India. The labeling of dams as a form of sustainable development has already been critiqued for various reasons, including their significant ecological and social impacts, methane emissions from dam reservoirs, and the reduction in hydroelectricity generation as climate change reduces river flows (Giles 2006; Vicuna et al. 2008). Furthermore, in the case of hydropower development along the Brahmaputra, dams also increase the vulnerability[21] of riparian communities in Arunachal Pradesh and Assam to the impacts of climate change and diminish their capacity to adapt to those changes.

As mentioned before, an increase in the frequency of severe floods is predicted to occur as a result of climate change. On one hand, increasingly severe floods can compromise the safety of dam infrastructure and potentially cause dam failures, with serious downstream implications (Blackshear et al. 2011). On the other hand, by transforming river flows, ecosystems, local livelihoods, and local economies (WCD 2000), dams influence the capacity of local communities to cope with increasingly severe floods as a result of climate change. Along the Brahmaputra, dams are causing floods to become more abrupt, as floodwaters are released suddenly from behind the dam floodgates with little to no warning to downstream communities (Vagholikar & Das 2010). These flashfloods are making it harder for downstream communities to prepare for the arrival of floods and it is rendering traditional adaptation methods, such as

banana rafts, increasingly futile in the face of ever more destructive floods. Similar to climate change impacts, the building of over 140 dams in the Brahmaputra river basin will make it increasingly difficult for the people of Arunachal Pradesh and especially of Assam to live with recurrent summer floods, and may push a segment of the population to abandon their riparian livelihoods to seek wage labor in larger towns and cities, where they will become incorporated in a more carbon-intensive economy.

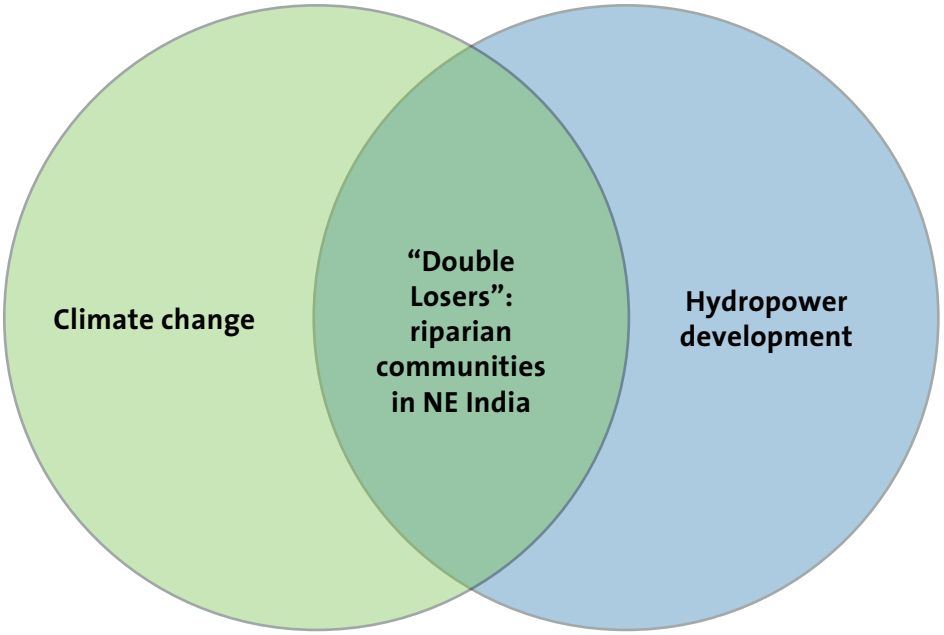
Dams along the Brahmaputra will benefit the global community by curbing the overall amount of GHGs emitted into the atmosphere, as well as India's national and state governments, its energy sector, and its large urban centers that will import the hydroelectricity generated in Arunachal Pradesh. Yet dams exacerbate the vulnerability of people of Northeast India to climate change impacts by further worsening floods, while undermining their adaptive capacity[22] to floods. This overlap of negative outcomes relating to climate change and dam building along the Brahmaputra is creating a "double loser" scenario for riparian communities in the river basin (Leichenko & O'Brien 2008): people living downstream of the dams in Arunachal Pradesh and especially in Assam bear both a disproportionate burden of climate change impacts in the form of more severe floods, and a disproportionate amount of the costs of dam building efforts (Figure 6). The question still remains as to whether the historically marginalized northeastern region of India will reap any benefit at all from the damming of its rivers via local job creation, electrification, and overall infrastructure development.

6. DISCUSSION QUESTIONS

Following guidelines from your instructor, discuss answers to the following questions:

1. Explain the various environmental justice issues related to the building of dams along the Brahmaputra and its tributaries in Arunachal Pradesh and Assam. Consider economic, ecological, and climate change related issues in your answer. What solutions could be employed to mitigate the local ecological and social impacts of dam building efforts and help redistribute some of the costs and benefits from hydropower development in the region?
2. The building of dams is heralded both as a solution to the global challenge of climate change and as a path for sustainable development. Using Northeast India as an example, explain in which ways hydropower development can be mitigate global climate change and how it can be considered a form of sustainable development. In which ways might hydropower impacts contradict notions of sustainable development?

Figure 6. Venn diagram of climate change impacts, impacts of hydropower development, and the "double losers," suffering from both.



3. Should harnessing the hydropower potential of the Brahmaputra River for mitigating climate change take precedence over the current uses of the river by local communities? Choose a position and support your argument with information from the module, or from cited, outside sources.
4. How are dams and climate change producing "double losers"? Who are these "double losers" and what are they "losing"? To answer this question, create a Venn diagram (see Figure 6). In one circle, list the impacts of climate change on river flows, floods, and ecosystems. In the other circle, list the impacts of hydropower development on river flows, floods, and ecosystems. In the overlapping middle, describe how this is creating "double loser" and what the combined impacts are for local communities living in the river basin.
5. Since the 1930s, dams have become synonymous with modernization and development. Jawaharlal Nehru, India's first Prime Minister after India's independence from the British Empire, famously proclaimed dams the "temples of modern India." Similarly, hydropower companies and the Indian government accuse anti-dam activists in Northeast India of being anti-development and slowing the country's economic growth. How might you argue against them on this point?

GLOSSARY

1. **Livelihood**: a set of activities that allows a person to secure the basic necessities of life including food, water, shelter, and clothing.
2. **South Asian summer monsoon**: a season of heavy rains caused by the movement of moist, cool air from the oceans towards the warmer landmass, due to the changing of seasonal wind patterns. The South Asian monsoon occurs between the months of June and September and causes devastating floods through much of South Asia, including India. The Himalayan Mountains play a key role in the South Asia summer monsoon by acting as a vertical barrier to the movement of moist air, causing the air to rise and cool, therefore leading to precipitation (see Figure 7).
3. **Sediment**: solid material, such as rocks, minerals, and organic material that has eroded and is transported and deposited to a new location by water, wind, or ice. Sediment often deposits nutrients onto the soil, increasing its fertility.
4. **Tributary**: or affluent, is a freshwater stream that flows into a larger stream or river.
5. **River basin**: the area of land drained by a river or stream and all its tributaries.
6. **River braiding**: when a river deposits large amounts of sediments causing it to divide into various channels that split off and rejoin each other, giving it a braided appearance.
7. **Floodplain**: an area of land nearby a river or stream that is prone to flooding. Floodplains are usually very fertile as a result of the deposit of nutrient-rich sediment from the river, and therefore are also generally heavily populated by human communities.
8. **Ecosystem services**: benefits people obtain from ecosystems often grouped into four categories: 1) provisioning services

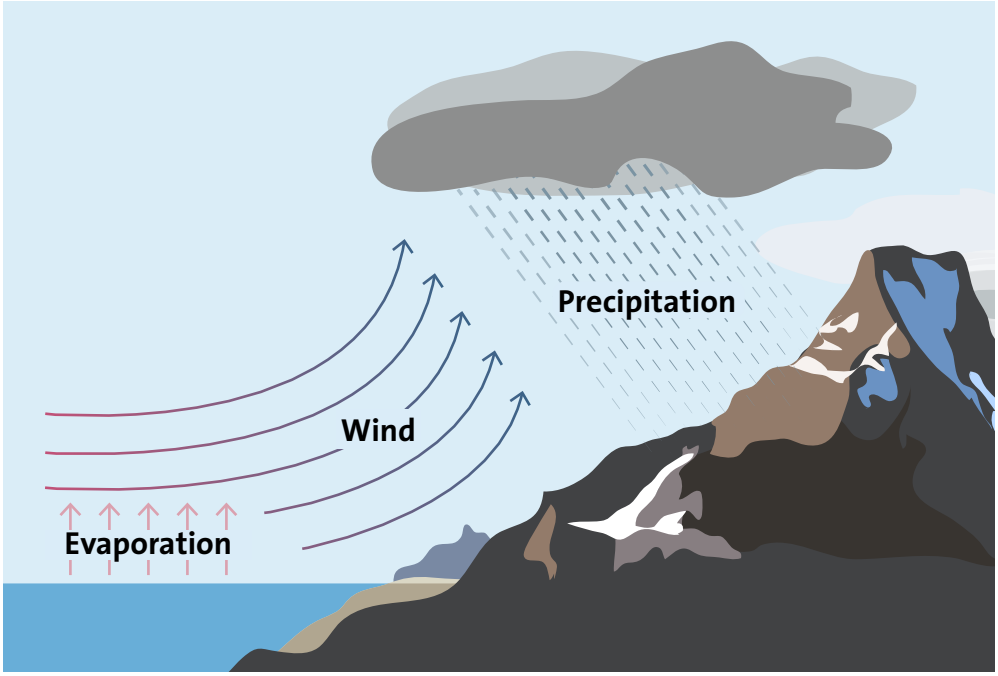


Figure 7. Diagram of the role of the Himalayas in the South Asian summer. The warm waters of the Indian Ocean evaporate and are transported towards the land by the wind. As the air faces the physical barrier of the Himalayas, it rises and cools down, and causes precipitation of fresh water in higher elevations (illustration: Nadav Gazit).

such as food and water, 2) regulating services such as flood control provided by wetlands and mangrove forests, 3) cultural services such as spiritual and recreational, 4) and supporting services, such as nutrient cycling.

9. **Anthropogenic climate change**: the addition of greenhouse gases (see 11) into the atmosphere as a result of human activities, such as the burning of fossil fuels and deforestation, leading to the intensification of the greenhouse effect (see 13), and thus the warming of Earth's climate. Anthropogenic climate change is largely attributed to the advent of the Industrial Revolution in the 19th century.
10. **Climate justice**: a body of work and a social movement that is primarily concerned with the equity dimensions of climate change. By recognizing the difference in resources use, development paths, and emissions contributions between rich and poor countries (as well as between groups of people), this concept acknowledges the differentiated responsibilities of nations and people for causing anthropogenic climate change, as well as the unequal distribution of benefits and costs as a result of climate change impacts. Climate justice is a component of environmental justice (see 16).
11. **Greenhouse gas (GHG)**: a gas in the atmosphere that absorbs infrared radiation from the Earth's surface, producing the so-called "greenhouse effect" which warms Earth's surface. The main GHGs include water vapor, carbon dioxide, methane, and chlorofluorocarbons (CFCs). The addition of greenhouse gases to the atmosphere as a result of human activities, such as the burning of fossil fuels and deforestation, intensifies the greenhouse effect, thus warming Earth's climate (see 9).
12. **Threshold**: critical values or limits, which, if crossed, can generate serious or socially unacceptable environmental change and/or irreversible consequences. In the case of a glacier-fed river such as the Brahmaputra, the glaciers that are the source of the river are considered to have crossed a critical threshold when the river begins experiencing a decrease in dry-season discharge.
13. **Food security**: people are food secure when they have physical, social, and economic access at all times to sufficient, safe, and nutritious food that meets their dietary needs and preferences for a healthy life.
14. **Global North**: a term used to describe countries that have a high ranking in the United Nations Development Programme's Human Development Index (which uses indicators such as income per capita and life expectancy), as opposed to countries (including India) that rank low, which are defined as the Global South.
15. **Hydropower potential**: the hydro-electrical power potential of a river or stream. It depends largely on the amount of water flowing in the river/stream and the gravitational force of the falling or flowing water. The hydropower potential of a river/stream is measured in Watts.
16. **Hydroelectricity**: the electrical power produced by harnessing the force of falling or flowing water.
17. **Sustainable development**: development that meets the needs of present generations in ways that do not exhaust natural resources, so as to safeguard the ability of future generations to also meet their own needs. Sustainable development entails balancing social, economic, and environmental objectives and needs in the process of decision-making to ensure long-term benefits. The concept has been the subject of various critiques for being too vague, for promoting corporate "greenwashing" and development activities, such as dam building, that in fact have significant social and environmental impacts.
18. **Environmental justice**: broadly defined, environmental justice is a body of work and a social movement that is concerned with and critical of the unequal distribution of environmental costs and benefits between groups of people, especially as a result of race, ethnicity, and income.
19. **Run-of-the-river dam**: a dam with little or no water storage behind the dam, and which relies primarily on the natural flow of the river for power generation.
20. **Riparian**: of, relating to, or situated near the banks of a river or stream.
21. **Vulnerability**: the degree to which a social or ecological system is exposed to and adversely affected by a hazardous event. Conventional risk assessments examine vulnerability as a result of exposure and damage, while other approaches have drawn attention to how characteristics such as ethnicity, religion, caste membership, gender, age, political power, and access to resources make some groups more vulnerable than others.
22. **Adaptive capacity to climate change**: the capacity of a social or environmental system to adapt to climate change and its effects. Diversity, flexibility, memory, and novelty are important components of adaptive capacity. In social systems, information and knowledge, good institutions, and overall development (e.g., poverty eradication, food security, access to resources, literacy, equity, livelihood diversification) are all considered key to improving adaptive capacity.

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