The Ecological Costs of Hydropower: The Case of the Lower Subansiri Project

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Abstract- This article critically examines the Lower Subansiri Hydroelectric Project (LSHEP) as a case study of the ecological and political contradictions of India's hydropower development in Northeast India. Framed under the discourse of renewable energy and national progress, the project reveals deep environmental, social, and institutional failures, ranging from ecological degradation and biodiversity loss to governance breakdown and the marginalization of indigenous communities. Using the lens of political ecology, the article explores how development narratives driven by energy security often overlook the region's fragile topography, cultural landscapes, and the multi-functional role of rivers. It argues that environmental impact assessments (EIAs) and participatory governance have been weakened in the face of infrastructure expansion. The article calls for a paradigm shift in development planning, one that integrates decentralized renewable alternatives, ecosystem-based approaches, and inclusive decision-making. Ultimately, it questions whether India's energy ambitions can truly be green if they are built on fragile ecological foundations and the displacement of local knowledge and livelihoods.

Keywords- Lower Subansiri Hydroelectric Project, Political ecology, Hydropower, Sustainability, Environmental governance, Northeast India, Ecological displacement, River systems, Biodiversity

INTRODUCTION

While pandemics and wars are devastating, they seem to be transitory distractions compared to the magnitude of extreme poverty, inequality and environmental catastrophes that threaten our future. In this world of climate emergency, it becomes a low probability to achieve the envisioned goals of Sustainable Development by 2030. Additionally, although the global partners are making every effort through international conventions to address the climate change, the frequency and intensity at which human- induced catastrophes are taking places, is making such efforts diminish the hopes of millions (Liu et al 2024). With environmental crises taking various forms, each have its own set of causes and impacts. Ranging from extreme weather events such as hurricanes, floods to environmental pollution that are caused by industrial activities, agriculture and waste disposal, the threats facing the planet are diverse and interconnected (Nguyen et al 2023). Moreover, these crises often increase the existing inequalities, thereby disproportionately affecting the marginalized communities and further expanding the social tensions.

Stading as a paramount challenge of the 21st century, the world is experiencing multiple crises and within it the built of environment can either enhance or weaken the society's resilience. In this perspective, understanding the relationship between people and places becomes crucial. Although there is no denying fact that the existence of human beings depends on the multitude of services offered by the ecosystem, even then human activities continue to exert immense pressure on the environment, disrupting the delicate balance (Nguyen et al 2023). However, this relationship is not unidirectional and thus by working together along with embracing a shared commitment to environmental conservation, one can help to mitigate the harmful impacts of crises and thereby promote the well-being of both current and future generations. Further, stemming from this complex system of production, consumption, influence and practice, India, too is facing no less of a crisis in real time due to such environmental impact (Kumar and Majid 2020). From the erratic rains to deadly floods, India has been witnessing various dimensions of environmental crises at an alarming rate (Joshi and Kumar 2006).

INDIA'S ENVIRONMENTAL CRISIS: A SNAPSHOT

India, a land that demonstrates vast ecological diversity, perhaps is now, like any other developing countries, facing severe environmental deteriorations (Srivathsa et al 2023). Owing to the wave of modernization and industrialization, along with severe anthropogenic pressures, it has witnessed threats to sustain local ecology leading to a range of socio-economic consequences. Foremost of these is the pervasive issue of air and water pollution that has contributed to hazardous levels of environmental degradation (Dehkordi et al 2024). Intensive agricultural practices, such as monoculture farming and excessive use of chemical fertilizers and pesticides have further led to soil erosion and depletion of essential nutrients (Kaur et al 2024). This has not only diminished agricultural productivity but has also hampered the long-term dependence of communities on the land for resources (Kaur et al 2024). Additionally, expanding more forests for buildings and roads has led to the extinction of many plant and animal species creating a destabilizing effect on the entire ecosystem (Elisha and Felix 2023). In today's time environmental pollution has become a threat to our country and a widespread phenomenon in cities and towns. The large influx of rural populace to the urban centers has led to overcrowding and with this the entire landscape of the urban areas is also witnessing drastic change (Sarif and Roy 2024). Factors such as these have produced incremental effects on fragility of the ecosystem. Further, the unplanned developmental activities like the hydro-electric projects, road constructions, mining activities have led to calamities such as landslides, forest fires etc. Given the varied physiographic features of the country, the Northeastern region of India, known for its breathtaking landscapes and rich biodiversity, too faces myriad environmental challenges that demands urgent attention (Barua 2012).

ENVIRONMENTAL VULNERABILITIES IN NORTHEAST INDIA

Encompassing the "Seven Sister States", the region is dominated by rugged mountains, lush forests, fertile valleys and meandering rivers (Menon 2019). The Eastern Himalayas forms the region's northern boundary, influencing its climatic patterns and contributing to its rich biodiversity (Chettri et al 2010). Millions of downstream communities rely on the eastern Himalayas' natural riches (Chettri et al 2010). Owing to their natural surroundings, the indigenous communities in the area have a diverse range of customs, including cultural, religious and regional ones. These communities depend on the forest resources for a variety of ecosystem functions. The key difficulty, though, is making sustainable use of these natural resources. Further, such diverse nature of ecology is however under threat from deforestation that is driven by factors such as shifting cultivation, logging and infrastructural developments (Duguma et al 2019). The impact of climate change on rainfall patterns and the frequency of extreme weather events pose challenge to the livelihood of the community. Given the diversity in which the community is embedded with, the results of rapid urbanizations and socioeconomic transformations have bought significant changes in the traditional lifestyles and land use patterns of the indigenous communities, endangering its resilience and the preservation of their cultural heritage (Duguma et al 2019). Additionally, in the surge of development, the region has experienced construction of dams that are located in high seismic zones, some of them even without a proper environmental impact assessment (Saikia 2013). This has consequently led to arable lands in a biodiverse hotspot getting submerged in water. Further, the accumulation of sediments behind these dams also prevents the downstream plains of essential nutrients and silt deposits that are a source of their fertility. Hence, such unsustainable developmental practices have caused the ecosystem of the region to collapse and carry a potential to uproot the indigenous people, who have historically remained the main proponents of conservation (Saikia 2013). Against this backdrop the article takes the case study of Lower Subansiri Hydroelectric Project, situated on the boarders of the northeastern states of Arunachal Pradesh and Assam to elaborate on the intersectionality between environmental issues and political dynamics.

DAMS AND DEVELOPMENT IN THE NORTHEAST: THE LOWER SUBANSIRI HYDROELECTRIC PROJECT (LSHEP)

The historical trajectory of conceiving "India's Future Powerhouse" project began in the late 1990s

(Vagholikar and Das 2010). The Lower Subansiri dam is a rock filled gravity dam situated twenty-three km upstream of the Gerukhamukh village of Dhemaji district of Assam (Borah 2019). The location of the dam site is an important biodiversity hotspot and has been subjected to significant environmental concerns and controversy (Borah 2019). While the proponents argue that the project will be a source of contribution towards India's renewable energy goals and help in providing electricity to millions, on the other hand, the critics have much to offer in this. They have pointed out the environmental and social issues associated with its implementation. There has been a major concern towards the potential impact on the region's biodiversity and disruption of aquatic ecosystem (Menon 2019). Moreover, concerns have been raised on the alteration of river flow patterns that could have downstream impacts on flood regimes (Menon 2019). Apprehensions over the project's social ramifications, such as the displacement of the communities, loss of livelihood and the disturbance of cultural norms have also been voiced. Analyzing on these grounds the article would dwell into the lens of political ecology to understand the environmental crises witnessed through the construction of India's largest hydropower venture in the region.

Fundamentally, political ecology studies the interaction existing between politics, society and the environment, with an emphasis on the ways in which institutions, power structures and ideologies influence resource management strategies and environmental concerns (Benjaminsen and Svarstad 2019). In the case of Lower Subansiri Project, the concept of political ecology sheds light on the complex interplay of interests, conflicts and contestations surrounding the project. Herein, the role of the state and corporate entities in supporting large-scale infrastructural projects as hydropower dams representing development and progress attracts attention. These actors prioritize economic growth and energy security over environmental conservation and social justice, leading to the marginalization of local communities and ecosystems. Further, the unevenness in the distribution of gains and losses and of the risk of vulnerability has sparked significant resistance from local communities and environmental activist (Stewart, Bacon and Burke 2014). They have often been excluded from the decision- making processes and consequently denied rights to the lands, resources and cultural heritage which they were part of before the construction took place. In this regard the opposition to the dam by the local communities indicate their resistance to the imposition of top-down development agendas that emphasize on the interests of state and corporate elites over the well being of the indigenous communities whose survival dependent on the ecosystem (Banerjee, Maher and Krämer 2021).

Furthermore, understanding the project through political ecology reveals the link that exists between the dam and the broader politico-economic forces shaping energy development in India. As the project is situated within the larger context of state-led efforts to exploit the unexplored region's natural resources for the purpose of economic growth and meeting the energy security needs, the hydropower produced in the Lower Subansiri is meant to be used elsewhere entirely, while Arunachal Pradesh, the "host state" would be compensated from the sales (Vagholikar and Das 2010). However, by solely catering to the energy requirements of the country, the sponsors have overlooked the serious threats posed to the livelihoods of the people who are dependent on the small-scale fishing and subsistence agriculture in the downstream of Assam and beyond (Vagholikar and Das 2010). What is equally important is the potential threat due to the geological hazards that are specific to the north-east India and would further impose burden on the region. In short, the Lower Subansiri Hydroelectric Project exemplifies the contradictions in the development paradigm, as the purported benefits of the clean energy outweighs against the loss of biodiversity, displacement of communities and disruption of livelihoods (Hazarika 2016).

Additionally, the other facet of political ecology also enables to put emphasis on the importance of examining environmental issues through the perspective that takes into account the social, political and economic dimensions of inequality and power (Paulson, Gezon and Watts 2003). Through an analysis of the ways in which power relations influence environmental decision-making and resource allocation, political ecology offers valuable insights on possible pathways to resolve the environmental injustices and advance for a more equitable and sustainable development models (Paulson, Gezon and

Watts 2003). In the case of the Lower Subansiri Hydroelectric Project, this approach can extend hands to engage with local communities who are impacted and displaced from their comfort zones and further help to democratize the decision making so that indigenous people feel secured and safe once they have been uprooted from their area. It would also mean advocating for an alternative energy solution that would put social justice and environmental sustainability first.

Moving a step further, Lower Subansiri Hydroelectric Project sits at the crossroads of climate change, thereby showcasing a complex array of interaction that extends beyond its immediate environmental footprints (Čuček, Klemeš and Kravanja 2015). At the very core, the project's construction alters the natural flow of the Subansiri River, not only impacting the immediate ecosystem but also the local climate dynamics. The project impacts microclimates by generating a reservoir and altering land use pattern which may result in changes to the local precipitation patterns, temperature and humidity levels (Čuček, Klemeš and Kravanja 2015). Changes as these have the potential to disrupt agricultural practices and ecosystems that have evolved to the historical climate of the area, endangering traditional livelihoods and local biodiversity. Moreover, while hydropower is herald as a renewable source of energy, the Lower Subansiri Hydroelectric Project is not without its carbon costs (Patir et al 2023). The submergence of vast forested areas leads to the decay of organic matter underwater, releasing methane, a greenhouse gas (Barros et al 2016). In tropical and subtropical regions like Northeast India, this effect is significantly increased. Additionally, the carbon footprint associated with the dam's construction ranging from concrete production, machinery use, to road building, further challenges its "clean energy" label (Čuček, Klemeš and Kravanja 2015). What often escapes the public narrative is that the ecological alteration of a free-flowing river system also affects its natural role as a carbon sink, reducing the environment's capacity to absorb atmospheric carbon (Čuček, Klemeš and Kravanja 2015). Thus, while the dam may contribute megawatts to the national grid, it simultaneously undermines the climate resilience of the very ecosystem it interrupts.

THE CRISIS OF ENVIRONMENTAL GOVERNANCE

The Lower Subansiri Hydroelectric Project not only exposes the ecological contradictions of large-scale hydropower but also highlights deeper failures in India's environmental governance. While such projects are mandated to undergo rigorous Environmental Impact Assessments (EIAs), the procedural reality is far from rigorous. In the case of LSHEP, what should have been a precautionary and participatory process was marred by rushed approvals, inconsistent expert reviews, and a disregard for scientific caution.

EIAs are meant to function as safeguards, tools to weigh the ecological, geological, and social consequences of large infrastructure before implementation (George, Karatu and Edward 2020). However, over the years, they have increasingly been reduced to procedural checkboxes. For LSHEP, the EIA process revealed several troubling trends (Vagholikar and Das 2010). Multiple expert committees raised concerns regarding the dam's location in a seismically active region (Zone V), the potential for downstream flooding, and the disruption of aquatic ecology (Vagholikar and Das 2010). Yet these warnings were either sidestepped or diluted in subsequent reports. The fragmentation of responsibility among agencies such as the Ministry of Environment, Forest and Climate Change (MoEFCC), the Central Water Commission, and project developers like NHPC further allowed critical gaps in accountability to remain unaddressed (Vagholikar and Das 2010). One of the most telling examples of governance breakdown was the handling of public consultations (Vagholikar and Das 2010). In principle, public hearings are designed to incorporate local perspectives into decision-making, especially in projects with irreversible environmental impacts (ICNL 2020). In practice, however, these hearings were either delayed or conducted in ways that excluded meaningful participation from affected communities (Vagholikar and Das 2010). Reports indicate that downstream impacts in Assam were not adequately studied, and the people likely to face the brunt of altered river flows and flooding were left unheard (Vagholikar and Das 2010). This top-down approach reflects a broader trend in India's

environmental governance, where strategic infrastructure projects are insulated from democratic scrutiny under the guise of national interest.

Further, LSHEP's trajectory reveals how governance mechanisms, when subverted or weakened, can render environmental protections ineffective. The very institutions meant to ensure accountability are often undercut by political and economic imperatives (George, Karatu and Edward 2020). In such a landscape, science becomes negotiable, and caution is sidelined by urgency. The failure is not just in technical design or environmental management, it is institutional. Hence, If Indian has to commit to sustainable development, environmental governance must be reimagined. This means reasserting the autonomy of scientific committees, strengthening transparency in EIA procedures, and embedding ecological foresight into policy frameworks. It also requires acknowledging that infrastructure decisions made today will shape not only landscapes, but also political relations, risk exposure, and ecological legacies for decades to come.

RETHINKING DEVELOPMENT MODELS FOR NORTHEAST INDIA

The experience of the Lower Subansiri Hydroelectric Project offers a compelling case for re-evaluating how development is envisioned and implemented in Northeast India. The dominant model, centered around large-scale hydropower generation, prioritizes national energy goals over the ecological integrity of the region. Yet, this energy-centric narrative overlooks the region's complex topography, ecological sensitivities, and the multi-functional nature of rivers in the Eastern Himalayan landscape (Baruah 2012). Rather than repeating a model that has shown its limits, both environmentally and institutionally, it is time to reconsider development strategies that are better suited to the region's realities.

Northeast India is home to one of the most biodiverse ecosystems in the country (Upadhyay and Upadhyay 2025). Rivers such as the Subansiri are not just energy sources but living systems that support agriculture, fisheries, forests, and cultural practices (Upadhyay and Upadhyay 2025). Treating them as engineering challenges to be tamed and harnessed fails to appreciate their broader ecological and social roles. Development planning in such contexts must begin with a river basin perspective, considering cumulative impacts across interconnected tributaries rather than assessing each project in isolation (World Bank 2020). Despite recommendations by environmental committees, cumulative impact assessments remain largely absent or are undertaken as post-facto exercises (Vagholikar and Das 2010). Alternative models already exist and can be adapted to the Northeast. Decentralized energy solutions, such as run-of-the-river micro-hydel systems, rooftop solar grids, or hybrid energy setups, offer cleaner and less intrusive options (Jain, Khalid and Jindal 2023). These systems are not only more compatible with the ecological character of the region but are also better suited to serve the dispersed populations of hill and riverine communities (Jain, Khalid and Jindal 2023). Unlike mega-projects, decentralized systems can be more easily integrated with local governance structures and maintained with lower capital costs (Jain, Khalid and Jindal 2023). They also reduce the risks associated with large reservoir submergence, displacement, and loss of biodiversity.

Additionally, the focus on infrastructure-led growth must be balanced with ecosystem-based planning. This involves recognizing rivers, wetlands, and forests as integral to regional resilience. Incorporating environmental limits into planning frameworks is not an obstacle to growth but a necessary safeguard. Long-term sustainability demands that infrastructure investments do not undermine the very ecosystems that support livelihoods, mitigate floods, and preserve soil and water quality. Policy imagination also needs to shift from a narrow view of energy production to one of ecological well-being and regional equity (Haddad et al 2022). For too long, development in the Northeast has been externally planned, driven by distant energy demands rather than internal ecological and social priorities. Planning must be participatory, knowledge-inclusive, and sensitive to the region's socio-cultural fabric. This does not mean halting development, but doing it differently.

Finally, rethinking development also involves institutional reform. Strengthening environmental regulation, restoring the autonomy of appraisal committees, and ensuring public accountability in infrastructure projects are critical steps (Vagholikar

and Das 2010). Laws and safeguards already exist, but without institutional integrity and enforcement, they become symbolic gestures. The LSHEP experience makes it clear that what Northeast India requires is not more power, but more careful planning, one that is ecologically literate, regionally appropriate, and just. In imagining a development model for the Northeast that respects both its people and environment, the question is not whether the region should develop, but how. The challenge is to craft futures where rivers continue to flow freely, forests stand intact, and communities thrive, not in spite of development, but because of it.

CONCLUSION

The Lower Subansiri Hydroelectric Project stands as a powerful example of the contradictions inherent in India's pursuit of "green" development. While framed as a solution to rising energy demands and climate imperatives, the project reveals the extent to which ecological systems are compromised, governance structures bypassed, and local contexts overlooked in the name of national progress. In regions as ecologically sensitive and geopolitically complex as Northeast India, the costs of such development are not easily reversible, they are embedded in altered river courses, lost biodiversity, and disrupted ecosystems. What this article has attempted to show is that hydropower in the Northeast cannot be understood merely through the lens of electricity generation. It must be analyzed within a broader framework of ecological logic, long-term sustainability, and ethical planning. The reliance on large dams as instruments of development reflects a deeper policy inertia, one that continues to privilege scale and speed over suitability and care.

As India positions itself as a global leader in renewable energy, it must confront the paradox that not all renewable energy is sustainable in ecological or social terms. Development that interrupts nature without accountability or foresight is unlikely to yield lasting benefits. The future lies not in scaling up hydroelectric megaprojects, but in rethinking what development means in regions where rivers are lifelines, not just resources.

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