THE FRAGILITY OF HYDROPOWER DUE TO A CHANGING CLIMATE IN UNDERDEVELOPED COUNTRIES: INSIGHTS FROM SURINAME

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Overview

Hydropower plays a vital role in supplying renewable energy to underdeveloped countries. It is affordable, sustainable, and reduces dependence on fossil fuels. However, its reliability is increasingly at risk because of climate change. Stable electricity production from hydropower depends on steady and predictable water flows, but extreme weather events are disrupting these systems. In particular, the reliance of these systems on stable water flows makes them inherently vulnerable to the variability of climatic patterns (Yang et al., 2023). In Suriname, hydropower generates over 90% of the country's electricity, with the majority coming from the Afobaka Dam, built in the 1960s. In recent years, the dam has faced significant challenges due to changing weather patterns. Its dependence on consistent water levels and the region's exposure to unpredictable weather patterns highlight the urgent need to address hydropower's fragility in the face of a changing climate (Sterl et al., 2020).

Hydropower, which depends on stable and predictable water flows, is increasingly vulnerable to disruptions caused by climatic changes. Prolonged droughts are becoming more frequent, leading to shrinking rivers and reservoirs, which in turn reduce electricity generation and water availability for hydropower plants. Intense rainfall events, although seemingly beneficial, pose their own challenges, such as overwhelming infrastructure, causing sediment buildup, and damaging aging systems (Hou et al., 2024). Rising temperatures exacerbate these issues by accelerating water evaporation, further lowering reservoir levels and impacting energy production.

Methods

This paper explores how climate change is making hydropower fragile, especially in underdeveloped nations like Suriname, where resources for modernization and adaptation are limited. This study examines how climate change affects hydropower systems in underdeveloped countries, using Suriname as a case study. The analysis highlights how these challenges are particularly severe in underdeveloped countries like Suriname, where hydropower infrastructure is often outdated, and resources for maintenance or upgrades are limited.

Results

As climate change continues to intensify, there is an urgent need for modernization, diversification of energy sources, and the implementation of adaptation strategies to ensure the resilience and sustainability of hydropower systems. Heavy and long-lasting rainfall can cause the reservoir's water levels to rise significantly. In early 2022, the spill gates of the Afobaka Dam had to be opened to control these high water levels. This release was essential to prevent overflow and protect the dam's structure. Worldwide, extreme rainfall events have become more frequent and intense due to climate change. This creates challenges for dam safety, as dams must handle larger amounts of water to avoid overflow and damage to their structure. In addition to the heavy rainfalls, rising temperatures can increase water evaporation from the reservoir, reducing the water available for generating electricity (Donk et al., 2018).

Prolonged heat can also weaken the dam's materials and structure, leading to more maintenance. Although studies specific to the Afobaka Dam are limited, research shows that extreme heat can reduce the safety and efficiency of dams. Another pressing issue is the aging infrastructure of the Afobaka Dam. Built in the 1960s, the dam was designed based on historical climate data that no longer reflects current realities. Its capacity to handle the increasingly variable inflows caused by climate change is limited, which can lead to inefficiencies and potential operational failures (Sterl et al., 2020). As infrastructure ages, maintenance costs rise, further straining Suriname's

limited financial resources for energy development. Suriname's heavy reliance on hydropower for over 90% of its electricity is also a source of vulnerability. With such a high dependency on a single energy source, any disruption to hydropower systems has a significant impact on the country's energy security.

Addressing the effects of climate change on Suriname's hydropower system requires a well-planned approach that combines research, analysis, and practical solutions tailored to the country's needs. Given Suriname's limited financial and technical resources, the focus should be on strategies that are achievable for a developing country, while also seeking support from international partners. The first and most critical solution to Suriname's energy vulnerability is diversifying its energy sources. Currently, the country is heavily dependent on hydropower, which is increasingly unreliable due to climate change-induced fluctuations in water levels. Reducing this dependence is essential, but Suriname faces significant barriers, including a lack of financial resources, limited technical expertise, and inadequate infrastructure to support the expansion of renewable energy options such as solar and wind power.

Solar power presents a particularly promising opportunity for Suriname. With its geographical location near the equator, the country receives abundant sunlight year-round, making it ideal for harnessing solar energy. Large-scale solar farms could provide a consistent and renewable energy source to supplement or replace hydropower during periods of drought. In addition to utility-scale projects, decentralized solar systems could be deployed in remote and rural areas, providing electricity to communities that are currently underserved or disconnected from the grid. This would not only enhance energy security but also promote social and economic development in these regions. Similarly, wind power could be a viable alternative, especially in coastal areas where wind speeds are consistent and strong enough to support wind turbine installations. Together, solar and wind power could form a robust and sustainable energy mix for Suriname, reducing its reliance on hydropower and fossil fuels (Pourasl et al., 2023).

To implement these renewable energy solutions, Suriname would need to begin with feasibility studies to identify optimal locations for solar farms and wind turbines based on the country's climate, geography, and energy demands. These studies would provide critical data to guide decision-making and ensure that investments are both cost-effective and impactful. Following these studies, small-scale pilot projects could be launched, such as solar farms in rural areas or wind turbines along the coast (Sterl et al., 2020). These pilots would serve as proof of concept, demonstrating the technical and economic viability of renewable energy solutions in Suriname. Improving the infrastructure and management of the Afobaka Dam is another priority. External experts and international funding will be needed to assess the dam's condition and recommend upgrades to handle extreme weather. Reservoir management must also be improved to account for changing rainfall patterns. This includes better systems for releasing water during heavy rains to prevent flooding and conserving water during droughts.

Conclusions

This dilemma highlights the urgent need for Suriname to diversify its energy sources. Investing in renewables like solar and wind could provide cleaner, more sustainable solutions. However, financial and technical constraints make such investments difficult, leaving Suriname dependent on unsustainable fossil fuels in the face of worsening climate impacts.

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