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Challenges of Hydropower Development in Ethiopia since 1991: An Examination of Inherent Factors

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ABSTRACT

This study examines the inherent factors that have hindered hydropower development in Ethiopia, drawing on qualitative data from 50 key informants in the energy, water, and foreign affairs sectors, as well as documents and secondary sources. The findings of the study show that hydropower development in Ethiopia since 1991 has faced multiple and mutually reinforcing challenges. These include geopolitical hurdles, financial barriers, limited private sector investment, vulnerability to climate change, and project delays. First, the trans-boundary nature of Ethiopia's rivers has led to geopolitical barriers, causing tensions and conflicts with downstream countries. These issues have delayed hydropower projects and discouraged lenders and the private sector from participating. Second, financial barriers arise from the high initial capital-intensive nature of hydropower projects and the reluctance of international financial institutions to finance large-scale developments due to socio-environmental concerns and trans-boundary impacts. Third, private sector investment remains limited. Fourth, Ethiopia's heavy reliance on hydropower makes it vulnerable to climate-related hazards, further complicating its development trajectory. Finally, project delays and long lead times further hindered the pace of hydropower development. Therefore this study suggests that to unlock the vast hydro potential of the country there is a need to address these challenges by establishing a legal and institutional mechanism for trans-boundary water management, incentivizing private sector involvement, investing in alternative energy sources to diversify the energy mix, and effective project administration to mitigate delays.

Key words: Ethiopia, Geopolitics, Hydropower Development, Water

INTRODUCTION

Ethiopia has the largest hydropower potential (45,000 MW) in Africa, the second largest next to Democratic Republic of Congo (Ashebir, 2022). However, hydropower development, which dates back to 1912, went slowly until it boomed with the turn of the millennium. It was under the Ethiopian People's Revolutionary Democratic Front (EPRDF) reign (1991–2018) that the power sector underwent a significant transformation, with the construction of mega hydropower projects such as Tekeze, Gilgel Gibe I, Gibe II, Gibe III, Beles, Amerti Neshi, Genale Dawa III, GERD, and Koyisha (Gibe IV). As a result, the installed capacity increased from 370 MW in 1991 to 5,256.5 MW in 2023, with hydropower sources contributing 4,820.2 MW (Ethiopia Electric Power [EEP], 2023). These developments have increased access to electricity, which has risen by approximately 50% (EEP, 2017; FDRE, 2019).

However, the development path has been met with opposition from diverse actors, making it contentious. The Grand Ethiopian Renaissance Dam (GERD) and Gibe III are clear examples of these contests (Fabricius, 2021; Schapper, Christine & Sarah, 2020; Carr, 2017; Beirne, 2014). Moreover, the rapid growth of the hydropower industry has not

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kept pace with energy demand or the hydropower development plans outlined by the government in its various policies. For example, during the first Growth and Transformation Plan (GTP I), the target was to increase the electricity generation capacity from 2,000 MW to 8,000 MW (National Planning Commission, 2016), but this target has not been achieved (National Planning Commission, 2016). Similarly, during the implementation of GTP II (2015/16-2019/20), the target was an increase in electricity generation capacity from 4,180 MW to 17,347 MW (National Planning Commission, 2016), but the actual generation capacity by 2021 was only 4,478 MW (Planning and Development Commission, 2021).

Despite these setbacks, which have far-reaching implications for energy security and the country's overall economy, it has not yet been studied thoroughly. The existing literature examines specific aspects such as hydropower potential and its development status (Solomon, 1998; Ashebir & Desta, 2020; Dagmawi, Weijun & Jian, 2015; Dessalegn, 2018; Ashebir, 2020). The study by Dereje *et al*. (2011) also provides insight into the hydropower potential and challenges of its development in the Abbay River Basin. Others also studied the climate impacts of hydropower development (Block & Kenneth, 2012) and specific projects (Abebe, 2000; Abbink, 2012; Beirne, 2014; Eldardiry & Faisal; Annys, Tesfaalem & Jan, 2020) but lack a comprehensive analysis of the challenges facing the post-1991 hydropower development. This study therefore aims to explore the challenges of hydropower development mainly from the perspective of the nature of hydropower in turn to fill the gap in the literature.

RESEARCH METHOD

Methodologically, the paper employs a qualitative research approach. Key informant interviews were conducted with 50 purposively selected informants from government institutions, regional organizations, academic institutions, and research institutes. Documents were also consulted which include water and energy policies, development plans, power sector master plans, Ethiopian Electric Power Newsletters, Annual Performance Bulletin, Facts in Brief, and Strategic Plans. Additionally, secondary sources were also consulted. The data gathered were also analyzed using thematic analysis.

Conceptual and Literature Review

Hydropower development is the process of harnessing water flow for electricity generation through the construction of dams and power plants (Adhikari, 2006). However, hydropower development has been the subject of intense debate worldwide due to the unbalanced socio-economic, environmental, and geopolitical gains and losses (Ansar, Bent, Alexander & Daniel, 2014; Huber & Deepa, 2015). This debate is particularly visible in the context of Ethiopia's massive hydropower development since 1991.

Since the beginning of the 20th century, Ethiopia has been developing hydropower. However, hydropower development has boomed since 1991. This has transformed the country's geopolitical position into an emerging hydropower state and electricity exporter. However, these developments have faced opposition from various stakeholders. GERD and Gibe III are a case in point. The former is a source of geopolitical tension among Ethiopia, Egypt, and Sudan (De Falco & Giulia, 2022). The Gibe III dam is also another bone of contestation involving local communities, the government of Kenya, local NGOs in Kenya, and International Governmental and Non-governmental Organizations (Schapper, Christine & Sarah, 2020; Carr, 2017; Beirne, 2014). These concerns, often rooted in the trans-boundary nature of the rivers, have hindered hydropower development and resulted in the withdrawal of financial support from international financial institutions (Schapper et al., 2020).

As a result of this simultaneous process of rapid hydropower development and its increasing contestation in the post-1991 era, the hydropower development of Ethiopia has been a subject of debate. Some scholars addressed the positive role of hydropower (Cascão & Alan, 2016; Dawit, 2013; Temesgen, 2018). In contrast, other studies have considered the same development as potential sources of political tension, human insecurity, ecological conflict, and geopolitical conflict (Schapper et al., 2020; Sharaky, 2018; Mohamed, 2013; Beirne, 2014). Others also studied Ethiopia's hydropower potential and its development (Solomon, 1998; Ashebir & Desta, 2020; Dagmawi, Weijun & Jian, 2015; Dessalegn, 2018; Dereje et al., 2011; Ashebir, 2020).

While the reviewed literature is significant, it overlooks the inherent challenges stemming from the very nature of hydropower itself. Additionally, the literature often adopts a state-centered perspective, neglecting the multifaceted nature of hydropower development at play that contributes to its contested nature. This study aims to address this gap by examining the challenges of hydropower development in Ethiopia since 1991 from a holistic perspective that considers the inherent nature of

hydropower. This perspective encompasses factors like the trans-boundary nature of rivers, the vulnerability of hydro to climate change, and the capital-intensive and long investment return nature of hydropower development. Accordingly, the following section explores these inherent challenges and their implications for Ethiopia's hydropower development.

RESULTS AND DISCUSSION

Geopolitical Hurdles

The trans-boundary nature of water resources, where a significant portion of Ethiopia's hydropower potential is located, has created geopolitical tensions that have hindered the country's hydropower development. Only 3 percent of the country's total annual water flow remains within its borders, with the remaining 97 percent flowing to neighboring countries (Assefa, Belete & Yilma, 2014). In addition, nearly 96.7 percent of the country's hydropower potential is found in the six river basins that flow to neighboring countries: Abbay, Omo-Gibe, Baro-Akobo, Genale-Dawa, Tekezze, and Wabishebelle (Ministry of Water Resources, 2002). The remaining 3.3 percent are found in the two boundary river basins, Awash and Rift Valley lakes. This geopolitical setting is a geographical legacy that poses a natural challenge to the development of hydropower in Ethiopia.

First, in all trans-boundary river basins, there are no legal and institutional mechanisms that govern water use and management which has been a structural hindrance to their development (Dessalegn, 2018; Ministry of Water, Irrigation and Energy, 2013; Assefa *et al.*, 2014). Second, it has limited Ethiopia's ability to secure external resources, including finance, for hydropower projects (KII-21, April 2022). Because, development projects on Trans-boundary Rivers involve tension among riparians which discourages financial institutions from providing financial assistance (Cascão, 2009; Assefa *et al.*, 2014).

Third, the geopolitical complexities of these river systems have partly made hydropower projects highly contentious. This is evident in the GERD and Gibe III cases. The GERD project has ignited conflicts between Ethiopia, Sudan, and Egypt (De Falco and Giulia, 2022). It also drew attention from the Arab League, US, European Union, and UN Security Council after Egypt framed it as a national and regional[1] security issue via strategic securitization,[2] while Ethiopia framed it as a development rather than a security-cum-political project.[3] Similarly, the Gibe III project faced widespread opposition from environmental groups (Survival International, 2009; International River, 2013, 2010), UN agencies[4], and downstream communities over alleged socio-environmental impacts on local people and Lake Turkana (Beirne, 2014). Financial institutions like the European Investment Bank, African Development Bank, and World Bank also withdrew planned financing (KII-2, 5 January 2023).

Financial Barriers

The development of hydropower has also faces a major financial barrier due to its high initial capital-intensive nature. Financial resources are required at various stages of hydropower project development, including reconnaissance studies, pre-feasibility assessments, feasibility studies, detailed construction design, construction, and compensation and resettlement costs for affected communities, as well as the establishment of transmission lines, sub-stations, and distribution infrastructure.

Additionally, the reliance on imported electro-mechanical materials and foreign expertise for design, supervision, consulting, and contracting also contributes significantly to the overall increase in investment costs (KII-26, 12 May 2022; KII-28, 16 May 2022; Getahun, 1993). For example, the 1990 Ethiopian Electric Power Corporation's Yadot Small scale hydropower project estimated a cost of $4,800 per kilowatt (Getahun, 1993). Nevertheless, studies demonstrate a wide range of hydropower investment costs, varying from $400 to $3,000 per kilowatt, depending on the specific site and other relevant

[1]State Information Services (18 January, 2022). *UNSC holds open session on GERD in response to Egypt's request. Retrieved From* https://beta.sis.gov.eg/en/media-center/news/unsc-holds-open-session-on-gerd-in-response-to-egypts-request/

[2] Letter From Sameh Shoukry, Minister of Foreign Affairs of the Arab Republic of Egypt, to the United Nations Security Council (June 11, 2021).

3 Ethiopia's statement at the UN Security Council on the Grand Ethiopian Renaissance Dam, 29 June 2020. Retrieved From https://www.ethioembassy.org.uk/ethiopias-statement-at-the-united-nations-security-council-on-grand-ethiopian-renaissance-dam/

[4] World Heritage Committee, Decision 35 COM 7B.3 Lake Turkana National Parks (Kenya) (N 801bis). Retrieved from https://whc.unesco.org/en/decisions/4411/

factors (Bruckner *et al.*, 2011). Given this context, the financial constraint faced in hydropower development in Ethiopia is primarily a cumulative effect of several interrelated challenges.

One of the structural constraints is the limited national capacity to finance the construction of hydraulic infrastructure, covering all costs. The substantial gap between the investment costs and revenues generated (KII-24, May 2022) also further constrained the EEP to finance projects. The long-run marginal generation cost stands at 8.3 USC/kWh, while the current average tariff to cover generation, transmission, and distribution costs is below 3 USC/kWh (EEP, 2018; EEP, 2008). This indicates the extent how low electricity tariff hampers the company's ability to develop new power plants (KII-24, May 2022; KII-26, 12 May 2022). In addition, in projects like Genale Dawa III, the costs associated with resettlement and compensation exceeded the construction costs, raising further concerns (KII-27, 15 May 2022). This has led to debates among technocrats regarding the viability of building dams with higher investment costs than anticipated returns.

Second, accessing external finance for hydropower projects has proven to be challenging due to three key factors. First, the megatrend in hydropower finance since the 1970s is that international financial institutions are unwilling to finance large-scale hydropower projects due to their adverse socio-environmental impacts (Saklani, 2021). This is further supported by an informant indicating that global financial institutions do not favor large dams because the creation of reservoirs can disrupt river ecosystems, affecting both fauna and flora (KII-4, 27 April 2022). Moreover, hydro is still not considered fully renewable by experts due to carbon emissions, particularly methane from decomposed plants in reservoirs (KII-31, April 2022), which is a further disincentive for financial institutions to provide funding.

Consequently, Ethiopia faces challenges in accessing funds for its large-scale hydropower projects from Western governments and institutions, as they have shifted their focus from large-scale to small-scale projects with private investment. An informant noted that "lenders, such as Norway, provided substantial support for hydropower studies in the early 1990s. However, funding gradually ceased, leaving Ethiopia with limited government resources for conducting studies" (KII-3, 20 April 2022). It appears that various lenders were interested in funding hydropower studies in Ethiopia, but they withdrew their funding when Ethiopia prioritized studying large dams over small hydropower projects (KII-35, April 20, 2022; KII-3, 20 April 2022). This is supported by an informant from ENTRO, who notes that:

> *They [international lenders] may initially fund the study and design of a dam, but their support is contingent on the project aligning with their interests, namely focusing on small-scale and private investments. If the study's outcomes do not align with their interests, they withdraw further financial support (KII-31, April 2022).*

Second, financial institutions are reluctant to fund trans-boundary water resource projects due to the potential for conflict among riparian states (Cascão, 2009). This is a significant challenge for Ethiopia, as 96.7% of its hydropower potential is located in Trans-boundary Rivers. Moreover, financial institutions such as the World Bank, the European Investment Bank, and the African Development Bank have strict rules regarding the social, environmental, and trans-boundary impacts of dams (NBI, 2012). Obtaining financing from these institutions can be challenging for Ethiopian hydropower projects, which often fall into the category of large-scale developments involving multiple actors and Trans-boundary Rivers. A senior engineer explained this as "a harness was made for us to prevent us from walking" (KII-2, 1 January 2023). This was visible in hydropower projects on the Abbay and Tekezze rivers, where the country proceeded to construct Tekezze[5] and GERD through its finance (KII-24, May 2022). Gibe III was also partly financed by China after the World Bank, European Investment Bank, and Africa Development Bank withdrew from financing the dam due to the alleged socio-environmental effect of the dam on Lake Turkana and downstream communities.

This complex interplay between limited domestic resource mobilization capacity, inherent issues associated with hydropower development, such as Trans-boundary Rivers, and the divergent interests of international lenders, has impeded the envisioned growth and fulfillment of hydropower development goals. For instance, financial constraints were one factor that contributed to the fallback in hydropower development compared to the targets set in the Power

[5] It is difficult to verify as different sources indicates that the project source of finance was kept secret, claiming that it was funded by China. *See* Probe International (23 November 2009). Ethiopia's Tekeze dam limps into operation. Retrieved from: https://journal.probeinternational.org/2009/11/23/ethiopias-tekeze-dam-limps-operation/

Sector 2025 Master Plan, GTP I and II targets (EEP, 2018). Financial constraints are also one factor for project delay. Even in some projects like Koyisha, there was a time when it was run without a budget (KII-2, 1 January 2023). Lack of finance along with hydro politics of the Nile River has also hindered the development of three hydropower projects that were identified in the EEP's least-cost generation plan for 2025. These are Karadobi, Beko Abo, and Upper Mendaya (EEP, 2018). These projects have comparatively low-cost units of 2-4 USD/KWh and could contribute over 28 percent of the country's total generation capacity by 2025, according to the EEP Power master plan. However, their development may further exacerbate hydro and geopolitical tensions with downstream countries. An EEP document acknowledges that their implementation may further downstream countries' grievances (EEP, 2018). In the worst-case scenario, the lack of external finance and opposition from downstream countries could further delay these projects. Thus, financial constraint is a structural factor that has continued to hinder the development of hydropower.

Limited Private Sector Investment

To address the increasing energy demand, the government has implemented a policy direction aimed at promoting private-sector investment in the hydropower sector. These include the Public-Private Partnership (PPP) policy which has been put in place to create a favorable environment for private sector involvement in infrastructure projects, including renewable energy (Ministry of Finance and Economic Development, 2017, 2018).

Following these policy changes, as shown in Table 1, the Ministry of Finance and EEP have identified hydropower projects to be developed by Independent Power Producer (IPP) (PPP Directorate General, 2021). These projects have been approved by the PPP Board in 2021. The EEP's plan was to procure power from IPPs and distribute it to customers (KII-24, May 2022). However, "there are no IPPs in the hydropower sector as they have no interest in investing in this sector" (KII-24, May 2022). The lack of private sector investment in the hydropower sector can be attributed to several factors.

Table 1: Planned Hydropower Projects for Independent Power Producers

Hydropower Plant Name	Installed Capacity		Estimated cost (in million USD)	Expected Year of Commission/Generation (E.C.)	Remark
	MW	KWh per year			
Gebe I and II	372	1749	572	2018	
Birbir	467	2759	1231	2019	
Genale Dawa 6	256	1542	588/ 793*	2018	
Genale Dawa-5	100	--	387		
Halele Werabersa I and II	422/424*	2028.6 2,034*	886	2018	
Dabus	798	3433	740	2015	stage 1&2 plant
Chemoga-Yeda stage 1 and 2	280	1089/1087*	729.2/429*	2015	

* denotes the numeric value in the Ministry of Finance document titled PPP PROJECT PIPELINE 2020/21 which was prepared by the Public-Private Partnership Directorate General

Source: Compiled from EEP, 2010; Public Private Partnership, Directorate General; 2021

First, the nature of hydropower investments presents challenges that discourage IPPs from investing. Factors such as high initial capital costs, long payback periods, socio-environmental impacts, and geopolitical tensions related to trans-boundary water resource projects (International Renewable Energy Agency, 2015) act as deterrents for private sector involvement. An informant noted that "the private sector is not typically involved in long-term cost-return businesses. They want to cook and eat quickly" (KII-2, January 1, 2023). Another informant mentioned that "the profits from hydro are not immediately accessible. The process takes time due to recurring costs involved" (KII-6, May 16, 2022).

In addition, private investors are required to provide feasibility studies, which can have negative implications for their participation (Getahun, 1993). They may be reluctant to invest substantial amounts in projects whose feasibility is yet to be determined, as hydropower projects require significant investment and nearly two years for project studies (Getahun, 1993). Second, environmental concerns and hydro-politics associated with hydropower projects also contribute to the lack of private sector interest (KII-26, May 12, 2022). Finally, hydropower projects may involve hydrological and construction risks, making them less attractive as feasible business sectors for private investors (Getahun, 1993). Due to these factors, IPPs are more inclined to invest in other renewable energy sources such as solar, wind, and geothermal (KII-26, 12 May 2022), which have shorter construction periods and fewer controversies. In Ethiopia, the average construction period for hydropower projects is six years, compared to three years for wind, two years for solar, and five years for geothermal (EEP, 2010). Hence, the growth of the hydropower sector is constrained by the limited involvement of the private sector.

Hydropower's Vulnerability to Climate Change

Ethiopia is highly dependent on hydropower for electricity generation, with over 90% of its power coming from this renewable energy source (Amsalu, 2022; EEP, 2023). Yet, due to its complex relationship with climate change, the country's hydropower development is highly susceptible to climate hazards such as drought, El Nino, and flood. The impact of climate change on hydropower development in the country is evident through various indicators. One of the most significant impacts is rainfall fluctuations and reductions in the quantity of river discharge, which has in turn reduced power generation capacity. For instance, in the 2002/3 period, frequent power disruptions were caused by drought-induced water shortages that directly affected the power generation capacity of existing hydropower plants (World Bank, 2006). It was estimated that each day of power interruption during that time resulted in a loss of 10-15% of the Gross Domestic Product (GDP) for that particular day (World Bank, 2006).

Similarly, following the 2009 El Niño-induced droughts, power interruptions compelled the government to install 60 MW of diesel in Adama, which was felt as a costly energy source (KII-1, July 2023). Additionally, in the 2015 budget year, the EEP had planned to generate 11,385 GWh but could only generate 10,464 GWh, which accounted for 92 percent of the target (EEP, 2009). This shortfall was attributed to a shortage of rainfall caused by the El Niño, leading to reduced water levels in various reservoirs. Consequently, the hydropower generation from Tekezze was 40.67%, Melke Wakena 49.72%, Koka 48.88%, Awash II 57.67%, Awash III 55.67%, and Neshi 31.2%. Collectively, these dams had not generated a total of 1,547.47 GWh (EEP, 2009). To mitigate the power outage problem, the EEP generated an additional 626.13 GWh from other hydropower plants, primarily relying on Gibe III (EEP, 2009).

Second, climate change hazards such as floods and droughts can also cause conflict among multiple water users, making the hydropower sector more contested. Notable examples of this include the GERD dispute, Gibe I, Gibe III, and Koka. Although the GERD dispute is primarily political and geopolitical, it also has a technical aspect, such as the amount of water to be released during the drought season, which has been one of the most contentious points of negotiation among the three countries. In dams such as Gibe III, Gibe I, and Koka, there is intense conflict between local communities and the central government over the volume of water to be released from the reservoir during drought and flood season. Moreover, heavy rain and floods can also have a devastating impact on the health, sustainability, and energy production of hydropower plant infrastructure due to high sediment and silt deposition. For example, "floating islands" transported by floods have been a major constraint on the Tana Beles power plant (KII-2, 1 January 2023). Third, the increasing threat of climate change may also increase water demand across sectors and borders, making hydropower development more contentious as multiple water users compete for the same limited resources.

Project Delays and Long Lead Times

Long lead times and project delays are significant factors that hamper the speedy growth of the hydropower sector. The long lead time in the context of hydropower development refers to the extended period between project initiation and completion, which can range from 5 to 15 years depending on the context (NBI, 2012; IEA, 2021). Lead times may be longer for hydropower projects that involve multiple cross-sector and cross-border water users, or if the site is ecologically sensitive (NBI, 2012).

Several factors contribute to these long lead times, stemming from the complex nature of hydropower investments. These include pre-feasibility and feasibility studies, planning, design, construction, social and environmental impact assessments, consultations with policymakers and stakeholders, lengthy and complex permission and approval

regulatory processes, land acquisition, resettlement, environmental impact mitigation measures, procurement processes, and resource mobilization (IEA, 2021; International Renewable Energy Agency, 2015).

In the Ethiopian context, the best sites for hydro are located in trans-boundary water resources, which can involve potential conflicts with downstream countries. These sites are also often in remote and challenging environments, such as high-altitude mountains or deep gorges. In addition, Ethiopia relies on the importation of electro-mechanical equipment. These are additional factors that can make construction difficult, and expensive, and contribute to delays.

Project delays were evident in the cases of the GERD, Gibe III, and Genale Dawa III projects (EEP, 2018). The GERD project was initially planned to be completed in five years with a budget of 80 billion Ethiopian birr at the time of its commencement in 2011.[6] However, the project has now entered its thirteen years and is still unfinished. By April 2019, the total cost incurred was reported to be 98.7 billion birr[7]. Factors such as financial constraints, disputes with downstream countries, corruption, and regional instability have been attributed to project delays.

The commissioning of Genale Dawa III, which has now taken place, was also partly delayed due to financial constraints and resettlement problems (KII-27, 15 May 2022). The costs of resettlement and compensation outweighed the construction cost, leading to difficulties (KII-2715 May 2022). People were unwilling to leave the reservoir area even after receiving compensation, demanding additional payments (KII-27, 15 May 2022; KII-2, 5 January 2023). This resulted in lengthy discussions with the local community and local government, hindering the filling of the dam.

Furthermore, projects that were assumed to be committed as per the GTP and power master plan have also not progressed as planned. For example, the construction of projects scheduled for commissioning in 2025, including Karadobi, Beko Abo, and Upper Mendaya in the Abbay River, has not yet commenced. Furthermore, except for Koyisha, the other fourteen projects identified for construction during the GTP II period have not yet begun. These include Geba I and II, Genale 6, Sor, Upper Dabus, Birbir, Halele-Werabesa, Chemoga Yada I and II, Genale 5, Tams, Wabishebele, Lower Dabus, Lower Dedesa, Tekezze II, and Gojeb (EEP, 2018).

As a result, long lead times and project delays have been major obstacles to hydropower development, particularly in the context of growing electricity demand. They can also have negative implications. Firstly, long lead times and project delays lead to increased construction costs due to inflations and currency exchange fluctuations. These economic implications can strain the financial viability of hydropower projects and hinder their overall economic benefits.

Secondly, delays in hydropower projects can exacerbate energy supply shortages. This can lead to increased reliance on expensive and less sustainable energy sources, impacting the country's energy security and hindering its development goals. For instance, in the EEP power sector assessment, reducing electricity exports to and importing power from neighboring countries were recommended as measures to be taken by the EEP during times of power deficits due to project delays and other factors (EEP, 2018). Additionally, one EEP document recommended postponing power purchase agreements with neighboring countries until the commissioned power generation projects are operational.

Thirdly, project delays can have adverse social and environmental consequences. Affected communities may experience prolonged uncertainty and disruption, while environmental impacts may persist without the implementation of mitigation measures. Lastly, long lead times may discourage private investors as they make hydropower projects less competitive compared to other energy sources, such as solar and wind power.

CONCLUSION AND RECOMMENDATION

In conclusion, the challenges facing hydropower development in Ethiopia since 1991 are multiple and interrelated and include geopolitical hurdles, financial barriers, limited private sector investment, vulnerability to climate change, and project delays. Geopolitical tensions due to the trans-boundary nature of Ethiopia's water resources have been a historical legacy and geographic barriers to hydropower development, leading to complex negotiations, geopolitical tensions and conflicts with downstream countries. These tensions not only impede progress but also discourage external financial support, adding to Ethiopia's financial burden, as evidenced by the Gibe III, Tekezze,

[6]https://hornaffairs.com/2011/04/02/ethiopia-great-dam-on-nile-launched/

[7]https://ethiopianembassy.org/finalizing-gerd-key-priority-says-pm-dr-abiy-april-01-2019/

Koyisha, GERD, and many other planned hydropower projects on the Abbay, Gibe-Omo, Genale-Dawa, Wabishebele, and Baro-Akkobo rivers. They also contribute to project delays, as evidenced by projects such as GERD and the three dams upstream of GERD - Karadobi, Beko Abo, and Upper Mendaya - planned for 2025.

Hydropower development is also hindered by financial barriers, including high investment costs, limited national capacity to finance the construction of hydropower infrastructure covering all costs, and difficulties in accessing external finance. The reluctance of international financial institutions to finance large projects due to socio-environmental concerns and trans-boundary impacts further complicates the financing landscape. The investment cost of hydropower projects, which is around 8.3 US cents/kWh, exceeds the revenue generated as the current tariff is less than 3 US cents/kWh, further limiting Ethiopian Electric Power's ability to build new hydropower plants.

Efforts to encourage private sector involvement through PPPs in hydropower have been hampered by several factors, including the long-term nature of investments, environmental concerns, and trans-boundary tensions. This limited involvement of the private sector underlines the challenges of diversification of investment sources and mobilization of financial resources for hydropower projects.

In addition, Ethiopia's heavy reliance on hydropower makes the country particularly vulnerable to climate change which affects energy supply and security including the power export. This includes droughts, El Niño, and floods. These factors affect the availability of water in reservoirs, the generation capacity of hydropower plants, and lead to conflicts with downstream water users during floods and droughts.

Project delays in the form of long lead times and construction setbacks are also an impediment to the growth of the hydropower sector. These delays not only increase costs. They also disrupt the energy supply, exacerbate social and environmental impacts, and deter private investors.

Addressing these challenges requires a multi-faceted approach, including comprehensive trans-boundary water management mechanisms like legal and institutional frameworks to reduce geopolitical tensions over Ethiopia's hydropower development, incentive packages to encourage private sector involvement in the hydropower sector, investment in alternative energy sources such as solar and wind to diversify the energy mix, and effective project administration to mitigate delays. By holistically addressing these challenges, Ethiopia will be able to unlock its vast hydropower potential and move forward with sustainable energy development to meet the growing electricity demand and support economic growth.

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