DEVELOPMENT FINANCE INSTITUTIONS AND GREEN TRANSITION: CROSS-COUNTRY EVIDENCE ON CLIMATE-RESILIENT GROWTH AND REGIONAL SPILLOVERS

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Abstract. DFIs are now better placed to become drivers of climate-resilient development and there are questions about whether concessional and blended finance can deliver sustainable results in fragile, transboundary settings. This paper evaluates five projects supported by DFI in the Niger River Basin through a mixed-method design incorporating both process tracing and conjunctural causality research. The results demonstrate that concessional finance lowers risk and mobilizes private co-finance, and resilience outcomes are achieved only when such finance is institutionalized, combined with strong governance conditionalities, climate-proofed project design, and regional integration. Evidence in projects including the Zungeru Hydropower Plant (Nigeria) and the CLSG Transmission Line illustrates how this conjunctural set produces not only direct adaptation consequences, including fewer blackouts, better irrigation, and livelihood improvements, but also systemic spillovers through the West African Power Pool. The disputed Fomi Dam, on the other hand, points to the limits of concessionality when institutional credibility is lacking and adaptive safeguards are not in place. The results challenge linear explanations of development finance in that the catalytic role of DFIs depends on the co-existence of financial, institutional and regional complementarities. The research adds to theory through promoting a conjunctural causality model of DFIs evaluation and to practice through a roadmap of embedding governance, climate-proofing and integration in future financing of green transitions.
Keywords: *blended finance, climate adaptation, basin-level resilience, transboundary infrastructure, regional power systems, climate investment*

Introduction

Climate change is estimated to be raise global levels of extreme poverty by significant amounts by the year 2030. In accordance with the latest World Bank estimates 32 million to 132 million additional people will be thrust into extreme poverty due to climate change in plausible scenarios (Jafino et al., 2020). Sub-Saharan Africa is particularly vulnerable as its economies and livelihoods rely mainly on rain-fed agriculture and climate-sensitive natural resources, which increases vulnerability to crop yield shocks and food-security risks (IPCC, 2022).

The risks are amplified in the case of transboundary river basins where climate-driven hydrological shocks (droughts, floods, seasonal shifts) propagate across national borders and creates a multi-country exposure (Sahana et al., 2024). An example of such green transition dynamics can be illustrated by the Niger River Basin: crossing nine riparian states, the Basin supports irrigation, fisheries, hydropower, and urban water supplies, maintaining the livelihoods of millions of the population across West and Central Africa (Chawanda et al., 2024).

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Recent hydrological studies that have analyzed basin-wide flows predict changes in the seasonality, and heightened interannual variability of the Niger Basin under plausible warming scenarios, which have serious implications on food, energy and water security (Chawanda et al., 2024). Funding a green, climate-resilient transition in such a cross-border context-covering green assets, ecosystem restoration, decentralized renewables, and flood defenses, decentralized renewables, and flood defenses is thus highly complicated and in need of finance devices that go beyond national budgets (Organisation for Economic Co-operation and Development, 2025). Development Finance Institutions (DFIs) have increasingly been playing a landmark role in scaling climate and resilience investments by mobilizing the private sector or structuring blended-finance solutions and using risk-sharing instruments (International Finance Corporation, 2025).

Evidence from Liu et al. (2024) shows that AI-driven systems significantly enhance productivity and decision-making, while Yao and Liu (2025) and Jiang and Yuan (2026) further demonstrate that digital transformation and financial innovations influence corporate behavior and consumption upgrading. At the same time, methodological advancements, such as functional-coefficient quantile regression (Yang et al., 2024), quantile regression neural networks (Hao and Yang, 2024), and extensions to censored panel data (Li et al., 2025), improve the ability to capture heterogeneity and nonlinear relationships in complex datasets.

Complementary approaches, including hybrid DEA decision models (Liu et al., 2025) and enhanced Monte Carlo techniques (Huo, 2025), further strengthen analytical precision in economic and financial modeling. From a financial and institutional perspective, studies reveal strong interdependencies within economic systems: Liu et al. (2025) identify peer effects in shadow banking networks, Wu et al. (2025) show how shareholder activism reshapes innovation patterns, and Yang et al. (2025) emphasize the role of institutional entrepreneurship in overcoming structural constraints in emerging markets.

At the macro level, Jin et al. (2025) highlights the importance of fiscal decentralization in achieving sustainable development outcomes.In terms of sustainability and environmental systems, Dong et al. (2025a) show that urban climate conditions and perceived heat risks significantly influence physical activity, while Dong et al. (2025b) demonstrate nonlinear and interactive effects of the built environment on travel satisfaction, emphasizing behavioral responses to environmental conditions.

In addition, Xie et al. (2025) provide evidence on strengthening food security resilience under climate change, and Hu et al. (2026) highlight the critical role of green technology transfer networks in advancing green finance and sustainability transitions.

Finally, broader system-based perspectives, such as Tian et al. (2026) on strategic interaction dynamics and Hong et al. (2024) on household time allocation and well-being, reinforce the interconnected nature of economic, social, and environmental systems.

Furthermore, empirical and modelling evidence has revealed that international climate finance channels and DFIs de-risking instruments can make a significant dent in the cost of capital of renew-able and resilience investments in emerging markets and demonstrated that, when combined with enabling policies, they can catalyze rapid deployment (Briera, 2024). However, current empirical research is piecemeal: either researchers aggregate mobilization amounts or they use single-country/project case studies, so overall transboundary basin spillovers and how DFI-backed green investment leads to quantifiable cross-country climate-resistant growth remains unknown (McHugh, 2023).

To fill this gap, this paper assembles a new panel of project-level DFI investments in the Niger River Basin and employs modern spatial and panel econometric specifications

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(multi-period difference-in-differences and event-study estimators) to estimate the effects on climate-resilient growth and cross-border spillovers in trade, energy access and migration (Callaway and Sant Anxes, 2021). The proposed study provides cross-country evidence and guidance on how DFIs contribute to the green transition, identifying spillover channels and providing policy-relevant recommendations to DFIs, basin authorities and national governments (Chawanda et al., 2024; IFC, 2025; OECD, 2025).

The Niger River Basin (NRB) is a river passing through various low and lower-middle-income states and provides agriculture, fisheries, power (hydro-power), and urban water supply to tens of millions of populations. The complexity of its physical and institutional features makes it a relevant case study of whether Development Finance Institutions (DFIs) can help spur a green transition that is both climate-resilient and regionally inclusive. DFIs act by combining concessional lending, guarantees, equity, technical service, and policy-based actions, and their interventions are frequently rationalized in terms of correcting market failures and provision of public goods (financing transboundary infrastructure, long-tenor loans, and political-risk mitigation). However, these instruments do not necessarily flow out of conceptual design into quantifiable development and climate performance; it is a matter of context, instrument design and regional coordination, all of which are under-researched in basin contexts such as the NRB (Winckler et al., 2021).

One of the key arguments in the blended-finance literature and DFI literature is the additionality: are the public or concessional capital actually mobilizing private flows, which otherwise would not have been deployed? In its cautious assessment framework, OECD emphasizes that additionality occurs both financially and developmentally, and that strong ex-ante and ex-post appraisal is necessary to prevent exaggeration of the catalytic impact of blended operations (such as inclusion of private finance that would have been invested anyway). This is especially true of the NRB where the private investors are exposed to high levels of currency and political and hydrological risk, unless there is additionality, concessional dollars could become fungible with commercial lending or would otherwise crowd it out. OECD suggests single reporting and more transparent counterfactuals to make additionality claims testable (Ha and Gallagher, 2022).

Policy briefs and scaling studies have a sobering picture of the size-of-the-task. Several official sources state that the quantifiable blended-finance market is in the low tens of billions per year -orders of magnitude less than the trillions needed to mitigate and adapt to climate in EMDEs. A good example is the recent estimates indicate measurable blended finance transactions in the range of $15-70 billion (differences due to definitional boundaries) and annual climate investment requirements in developing countries in the trillions. This financing imbalance is in particular marked by long-lived capital-intensive and lumpy infrastructure (large reservoirs, transmission interconnectors) which are the best supported by DFIs, but which also demand prudent structuring to prevent excessive public contingent liabilities (Amadeo and Luo, 2024).

In addition to its sheer size, normative and practical issues of blended finance deployment are brought up by authoritative commentary and policy review. According to high-level critiques, blended finance may prioritize bankable projects that are appealing to private investors over- and under-invest in transformational public investments or non-bankable adaptation actions. Financial Times and other development commentators caution that blended structures run the danger of focusing on leverage ratios over the developmental impact of their efforts, thus putting investor returns into privileged status over alignment to national development politics and climate justice goals. As a result, mission-oriented

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practices and closer alignment with the priorities of recipient countries are more and more promoted as a corrective action (Zeng, 2024).

Scaling research and policy briefs paint a sobering picture of the scale of the challenge. Various authoritative sources allege that the quantifiable blended-finance market is still in the low tens of billions per year-orders of magnitude lower than the trillions needed to mitigate and adapt to climate in EMDEs. For example, the most recent estimates place quantifiable blended finance deals at about the 15-70 billion level (differences are due to definitional limits), and annual investment requirements in developing nations on climate in the trillions. This funding gap is particularly severe in regard to long-lived, capital-intensive, and lumpy regional infrastructure (large reservoirs, transmission interconnectors) to which DFIs are best suited to provide, but also needs to be carefully structured to prevent undue public contingent liabilities. (Financial Times, 2023; Boston, 2024; PPP, 2023).

In addition to pure size, normative and practical issues about the manner of deployment of blended finance can be found in the authoritative commentaries and policy analyses. Higher-order critiques hold that blended finance would over-invest in bankable projects that are friendly to the private investors and under-invest in transformational public investments or non-bankable adaptive interventions. The Financial Times and a number of development analyst caution that once blended structures focus their attention on leverage ratios, rather than on development impact, they will be playing into the hands of investor returns, rather than national development strategies and climate justice targets. The mission-based practices and closer alignment with priorities of recipient countries are all the more promoted as corrective actions (Financial Times, 2023; Bissiri et al., 2024).

DFIs affect investment bankability at the operational level in the so-called cost-of-capital channel: concessions, guarantees, and political-risk insurance lower the weighted average cost of capital (WACC) and extend acceptable tenors on projects - two variables that in many cases are decisive on the financial viability of renewable energy, water storage, and irrigation projects in the NRB. Empirical studies in energy finance have confirmed that when financing cost reductions are affected, levelized costs of electricity and project IRRs are reduced significantly, particularly with shallow domestic capital markets. In the case of the NRB, where country risk premia, foreign-exchange exposure, and constrained domestic long-term finance dominate. The DFI aspect of reducing the cost of financing is decisive in facilitating utility-scale renewables and robust water infrastructure (Pappas, 2021).

The emphasis of hydrological and climate research on Africa and the NRB specifically underlines the importance of why resilience is not an add-on that can be added afterwards but a prerequisite to persistent growth. A continent-scale of Soil and Water Assessment Tool Plus (SWAT) modelling experiment concludes that combined climate change and land-use change can substantially change runoff regimes, and in some basins (including portions of the Niger system) average flows are predicted to drop significantly, and inter-annual variation rise considerably. Such physical shifts translate into economic risks: the increased irrigation pressure during droughts and the reduced reliability of hydropower and more devastating floods that destroy property. The implication is simple: DFI investments are to focus on climate-proofing (for example; flexible operations, storage, early warning systems, and diversified renewable portfolios) to avoid stranded assets and retain the productive value of water and energy systems.

Transboundary spillovers, both adverse and beneficial, are the key to NRB dynamics. Riparian infrastructure and policy decisions in a single riparian have the capacity to influence the downstream flows, electricity market and agricultural performance in the other areas of the basin. The energy literature on regional power pools suggests that

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interconnections, for example, the West African Power Pool (WAPP) have the potential to create system-wide savings, enable more economic deployment of renewables by geographic smoothing, and enhance supply reliability. Notably, these advantages are conditional on coordinated rules, fair access provisions, and credible dispute settlement provisions- where DFIs can be of use in conditional financing, technical assistance, and mediation of regional accords. Causal evidence of cross-border growth spillovers of DFI-financed interconnectors is however limited; most evaluations are ex-ante modeling or case studies but not rigorous causal estimates (Liersch et al., 2019).

There are also institutional and governance moderators that highlight the literature on whether finance is converted to real investment and whether it is benefiting local populations. The effect of DFI capital can be softened by weak procurement mechanisms, inadequate regulatory autonomy, or constrained sovereign debt finances: by postponing the project implementation, adding corruption and inefficiency to the project costs, or imposing on the government's unsustainable contingent liabilities. The recent prescriptions in the policies thus emphasize greater country ownership, transparency and capacity building as a precondition to scaling blended finance without compromising development integrity. These aspects of governance are not peripheral, they define how much the DFI risk mitigation will translate into long-term, inclusive development.

On the methodology side, it is observed that the field has recently developed causal identification strategies applicable in assessing the impact of DFIs. Difference-in-differences designs, event studies, synthetic control methods, and instrumental variables have become more common tools of development economists to isolate treatment effects of finance intervention and policy interventions. Standard spatial econometric methods (spatial lag, spatial error, spatial Durbin models) are becoming the norm that enables consideration of cross-jurisdiction spillovers in regional systems. Nonetheless, the use of these techniques in transboundary hydrology-finance coupling remains in its infancy: not many studies incorporate hydrological process models with spatially explicit causal inference frameworks to approximate the impact of DFI investments on cross-border economic outcomes and resilience. The scope of methods that combine physics-based hydrological projections and a quasi-experimental econometric assessment is quite high (Invernizzi, 2020).

Another line of literature looks at dynamic and long-term implications: whether DFI investment has diffusion to technology, develops domestic financial markets, or has an entrepreneurial effect in green industries. The body of entrepreneurship and innovation research indicates that climate-focused finance can enable new firms and stimulate use of cleaner technologies, but these processes depend on facilitating policies (market access, R&D, training) and absorptive capacity in the locality. In NRB economies with constrained human capital and the prevalence of small firms, DFI technical assistance and capacity building may be as valuable as the cash flow itself in terms of long-term green transitions. There is limited but increasing empirical work tracing these dynamic linkages longitudinally in African basins, which provides a productive site of an NRB-based study (Aich, et al., 2016).

The picture is complicated by debt sustainability and macroprudential issues. With the increased lending by DFIs and Multilateral Development Banks (MDBs), recipient governments that are already vulnerable to high levels of debts are faced with trade-offs that put climate investments, which they badly require, and financial stability on the same page. There is growing interest among commentators and policymakers in blended finance strategies that would not add to the sovereign risk, such as increased risk sharing among

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the private sector, increased reliance on guarantees over direct sovereign borrowing, and enhanced integration with debt-relief or debt-for-climate-swap efforts. The debt angle is also especially relevant to the NRB riparians where fiscal space is changing and where transboundary projects might depend on cross-boundary fiscal commitments (Liersch, et al., 2013).

Lastly, literature syntheses reveal that there are empirical and policy gaps that are evident and drive the current study agenda. The first is the requirement of credible, basin level causal evidence on whether DFI instruments (and which instruments) generate more private flows and quantifiable climate-resilient growth. Second, there are regional spillovers, particularly in energy and hydrology, which must be assessed spatially beyond modeling to quasi-experimental inference. Third, analyses that combine hydrological projections Coupled Model Intercomparison Project Phase 6/Soil & Water Assessment Tool Plus (CMIP6/SWAT+), financial flows, and firm- or household-level results are uncommon but necessary in the assessment of the resilience co-benefits. Filling these gaps would yield evidence that would be directly usable in DFI design, regional policy coordination, and national development plans in the NRB (Elabbas et al., 2023).

Despite increasing interest in blended finance and climate transitions, existing research remains fragmented. Most studies (see *Table A1* in the *Appendix*) examine either national effects or single projects, without assessing basin-level resilience or cross-border spillovers. Furthermore, limited empirical work evaluates whether DFI instruments generate climate-resilient outcomes in transboundary river systems, where hydrological and economic interdependencies are strongest. This lack of basin-level causal evidence, combined with weak understanding of how concessional and risk-sharing instruments operate under cross-border institutional constraints, reveals a relevant knowledge gap.

In response to this gap, the objective of this study is to evaluate how Development Finance Institutions support climate-resilient growth in the Niger River Basin. Specifically, the study examines: (i) the mechanisms by which concessional and blended finance reduce risks and mobilize private capital; (ii) the extent to which DFI-backed projects generate adaptation and livelihood resilience; and (iii) whether resilience outcomes propagate across borders through energy trade and regional integration.

Between 2016 and 2023, MDBs and DFIs collectively mobilized approximately USD 6.8 billion for energy, water, and resilience-related infrastructure across the nine Niger Basin riparian countries (IFC/WBG, 2025). The African Development Bank alone committed USD 2.3 billion to regional energy and water infrastructure during this period (AfDB Annual Report, 2023) (see *Table 1*).

Table 1. *Development finance institution activity and financial participation in the Niger River basin*

DFI	Type	Main instruments	Recent commitments (USD)	Key sectors
AfDB	Regional DFI	Loans, Guarantees, TA	2.3B	Hydropower, Transmission, Irrigation
WBG (IDA/IFC)	MDB	Concessional loans, Equity, PPP	2.0B	Solar, Transmission, Water
China Exim	Bilateral DFI	Loans, EPC finance	1.8B	Hydropower, Transmission
EIB	MDB	Loans, Guarantees	430M	Solar, Water
IsDB	MDB	Loans, Grants	220M	Water, Irrigation
BOAD	Regional DFI	Loans	180M	Energy, Agriculture
OFID	Multilateral Fund	Loans	80M	Energy
EU	Development Finance	Grants, Blended finance	190M	Transmission

Source: IFC/WBG (2025); AfDB (2023); OECD (2025); project appraisal documents

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Method

This paper adopted a comparative design called case-study; it will utilize the medium-N: 3–6 cases to carry out a within-case process tracing to define and test the causal mechanisms by which Development Finance Institution (DFI) interventions have potential impacts on climate-resilient growth and regional spillovers in the Niger River Basin. Comparative case studies can be used to achieve the contextual richness needed to examine complex socio-technical systems (DFI deals, multi-stakeholder governance, hydrology, and power-market linkages) and process tracing is a methodological system that links interventions with outcomes by tracing intervening steps and evidence through the tracing of intervening steps and evidence implications. This composite plan puts emphasis on internal validity (mechanism identification) and systematic cross-case comparison as patterned inference (Beach, 2020).

Case selection, analytical framework, data

The study adopts a multiple-case comparative design centered on five Development Finance Institution (DFI)-supported infrastructures within the Niger River Basin. Case selection followed a purposive strategy based on: (i) climate adaptation relevance; (ii) cross-border hydrological and energy implications; (iii) DFI financial involvement; and (iv) availability of documentary and operational data.

The analysis relies on secondary evidence derived from project appraisal documents, implementation completion reports, mid-term reviews, technical assessments, basin-level hydrological briefs, West African Power Pool operational bulletins, and multilateral development finance reports. Additional sectoral data were drawn from the African Development Bank, the World Bank Group, FAO, OECD, and national energy and irrigation authorities.

Evidence triangulation was used to evaluate five dimensions of DFI-supported interventions: (i) risk reduction; (ii) co-financing and leverage; (iii) implementation performance; (iv) adaptation and livelihood outcomes; and (v) regional spillovers. Each dimension was assessed using a structured ordinal rubric (absent, weak, moderate, strong), informed by process-tracing logic and cross-source consistency checks. Commissioning and operation start dates for each infrastructure were aligned with observed adaptation and spillover effects to contextualize the sequencing of hydrological, energy, and livelihood outcomes across the Basin.

Data sources

The study did not involve the administration of primary questionnaires or field-based surveys. Instead, the evidence base relied exclusively on documentary and sectoral sources, including DFI project appraisal documents, loan agreements, implementation completion reports, monitoring and evaluation (M&E) records, hydrological briefs, basin regulatory filings, and regional power system bulletins from the West African Power Pool (WAPP). These documentary sources provided adequate operational and financial information to support cross-case comparison and process tracing.

Rationale for method choice

The causal interaction between DFI and resilience (caused by spillovers) is a causally intricate phenomenon governed by a variety of intermediary processes (contract design,

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de-risking, investor behavior, project implementation, local/regional outcomes). Process tracing is made to be such mechanism-level inquiry. Comparative case studies enable strategic variation (different instruments, host-country institutions, project types) to test external validity and the conditions surrounding causal inferences. In some cases, configuration patterns should be robustly checked with Qualitative Comparative Analysis (QCA) or set-theoretic comparison of a somewhat larger set of cases (Beach, 2020).

Justification of research method

Qualitative Comparative Analysis (QCA) is a medium-N approach that is rigorous enough to represent the causal complexity of how Development Finance Institutions (DFIs) can facilitate climate-resilient growth in a transboundary setting like the Niger River Basin. QCA also finds the combinations of conditions for example the concessional finance, cross-border scope, risk-sharing, and quality of governance that are necessary or sufficient to achieve resilient performance, unlike regression which isolates net effects, thus conforming to the conjunctural nature of climate and finance systems in the real world (Invernizzi, 2020).

For example, partial integration of climate-proofing measures can also be enabled with the use of fuzzy-set QCA (fsQCA), which enhances the sensitivity of analysis (Pappas, 2021). Recent uses in energy and development research validate the usefulness of QCA to convert complex project evidence into simple to follow, clear, and easy-to-implement, causal recipes (Schneider, 2021). Combining QCA with process tracing, the present research not only establishes strong patterns among DFI-supported projects but also reveals the drivers of these patterns, which is one of the gaps identified in previous empirical analyses of blended finance and regional spillovers (Beach, 2020). This two-pronged methodology makes causal inference stronger, policy more relevant and provides clear evidence that can be presented both to the scholarly and high-level policy audiences.

Case selection is based on a purposive approach which integrates logic of most-similar system and most-different system to achieve maximization of causal leverage and policy relevance. Projects were selected to represent variety in DFI instruments (concessional loans, guarantees, equity, blended finance), cross-border (single country vs. multi-riparian infrastructure), and difference in the resilience outcomes (high, medium, low, as reported in post-project appraisals). This approach both guarantees analytic contrast and empirical richness in line with best practice in comparative qualitative research (Schneider, 2021). To maximize validity and feasibility, a further filter was applied to cases, which were based on access to data, having publicly available projects and interviewable stakeholders, thus corresponding to the recommendations of transparent and replicable qualitative inquiry (Beach, 2020). Three major cases with two supporting cases are a good balance between depth and cross-case inference that appeals to more recent research illustrating that well-designed medium-N designs can produce both mechanism-level understanding and policy-generalizable results (Pappas, 2021; Invernizzi, 2020).

Unit of analysis

The unit of analysis used in the study is the DFI-backed projects, it was supplemented with subsidiary units, including implementing agencies, local populations, individual investors, national regulatory agencies, and basin authorities, which would understand the multi-level dynamics in which interventions determine the resilience. The temporal

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context is project start to project commissioning and in the case that it is possible, three to five years after the commissioning to assess both the implementation and initial outcome trends and process evidence in the case of the very recent projects. In data collection, the approach is methodological triangulation (which involves in addition to project documents (appraisal reports, loan agreements, M&E records), database on DFI (World Bank, AfDB, IFC, EIB), and semi-structured interviews with stakeholders (10-18 per case, including financiers, regulators, operators, and civil society). Secondary assessments, regulatory filings, and market operator reports (for example, the WAPP) are taken as supplementary evidence, whereas the outcome of the observed results is validated with the help of contextual quantitative measurements (electricity access, hydrological flows, trade metrics). This type of multi-source design guarantees strength and openness, which is in line with the best practice of process tracing and comparative qualitative research (Beach, 2020), both can also increase validity by triangulating qualitative and quantitative evidence streams (Pappas, 2021; Schneider, 2021).

The process tracing in this study is undertaken by initially formulating a theory of mechanism which connects the DFI financial instruments to the climate-resilient outcomes with the intervening steps like risk reduction, private co-financing, timely implementation, and adaptive project features, resulting in ultimately creating a basin-wide spillovers in both trade and energy access. The implications of each of the hypothesized links are observable, such as the existence of contractual clauses that show the transfer of risk or indications of new private investment that are analyzed systematically using multiple sources. In line with the notion of evidentiary pluralism, every piece of evidence is perceived in terms of its probative value, making a difference between high-certainty documentary evidence and lower-certainty retrospective descriptions (Beach, 2020). Results are then combined to know whether the suggested causal pathway is credibly presented in each case and whether alternative explanations could be dismissed**.** Lastly, a cross-case comparison enables the identification of common mechanisms in projects and the identification of alternative trajectories in which contextual factors, including the governance capacity, or the cross-border design, mediate the results, which offers depth and generalizability (Schneider, 2021; Pappas, 2021).

The semi-structured interviews in this study are specifically formulated to achieve evidence of causally hypothesized relationships, instead of narratives, using document-anchored questions, counterfactual questions, and sequence checks to test the achievement of hypothesized causal relationships between the instruments of DFIs and resilience outcomes. All transcripts are coded systematically based on link identifier, strength of evidence and status corroborated, which promotes transparency and traceability. These qualitative data can subsequently be incorporated into structured cross-case comparisons by evidence matrices, by which the presence or absence of mechanisms can be mapped across projects, and systematic pattern recognition is made possible (Beach, 2020). Competing explanations are explicitly modeled to reinforce causal inference and they may include national reforms or commodity shocks**.** To strengthen this, where possible, results are complemented by an analysis of the fuzzy-set Qualitative Comparative Analysis (fsQCA) on a bigger sample of projects to discover settings of conditions necessary or sufficient to obtain climate-resilient results. Such a combination of process tracing of interviews and set-theoretic validation increases both internal validity and policy relevance, which is a best practice in modern comparative research (Pappas, 2021; Schneider, 2021).

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This paper follows the best practice research ethics and access control, obtaining an informed consent of all respondents, anonymizing sensitive information, and protecting confidentiality in the contractual data by means of secure storage and, where applicable, redaction in accordance with the DFI confidentiality provisions. An institutional review board (IRB) provides ethical approval that supports the integrity of the procedures and the protection of the participant, which is in line with the best practices in qualitative and mixed-method research (Beach, 2020). However, the method has its own limitations: process tracing is also a case-intensive procedure, but it limits extensive generalization, and at the expense of this trade-off, mechanism clarity and contextual validity are improved**.** The evidence may also be constrained by the access control measures to confidential project documentation, which can be addressed by triangulation to secondary sources and by triangulation to stakeholder testimonies. Lastly, the temporal nature of the constraint implies that certain extremely recent projects do not have ex-post outcome information; near-term operational indicators, in those situations, are used as substitutes. The recognition of these weaknesses, combined with the incorporation of effective ethical protection mechanisms enhances the transparency, credibility, and policy interest of the results (Schneider, 2021; Pappas, 2021) (*Table 2*).

Ranking and scoring methodology

The ranking displayed in *Figure 1* was generated using a structured four-point ordinal scoring system applied across the five DFI-supported projects and five causal mechanisms (risk reduction, private co-financing, implementation and adaptation, resilience outcomes, and regional spillovers). Each mechanism was scored as 0 = absent, 1 = weak, 2 = moderate, or 3 = strong based on consistency across documentary sources. Evidence strength was triangulated using project appraisal documents, implementation completion reports, sectoral assessments, power system bulletins, and basin regulatory filings. The aggregated scores were visualized as a heatmap to facilitate cross-case comparison and mechanism interpretation.

Table 2. *Selected DFI-supported projects in the Niger River Basin and their operational status*

Project	Country (IES)	Infrastructure type	Commissioning/ operation start	Current operational status
CLSG transmission line	Côte d'Ivoire, Liberia, Sierra Leone, Guinea	Transmission/ regional interconnection	2023	Operational; synchronized into WAPP in 2023
Selingué hydropower upgrade	Mali	Hydropower + irrigation	Initial: 1980; Upgrade: 2018; Irrigation/Fisheries: 2019	Fully operational
Zungeru hydropower project	Nigeria	Hydropower	2023 (units staged 2021–2023)	Operational
Niger solar PPP	Niger Republic	Solar (IPP)	2022	Operational (grid-connected)
Fomi multipurpose dam	Guinea	Hydropower + irrigation	Not yet operational	Pre-construction/planning stage

Source: Authors' compilation based on DFI appraisal documents, AfDB (2023), WAPP Programme Reports (2023), and sectoral project briefings

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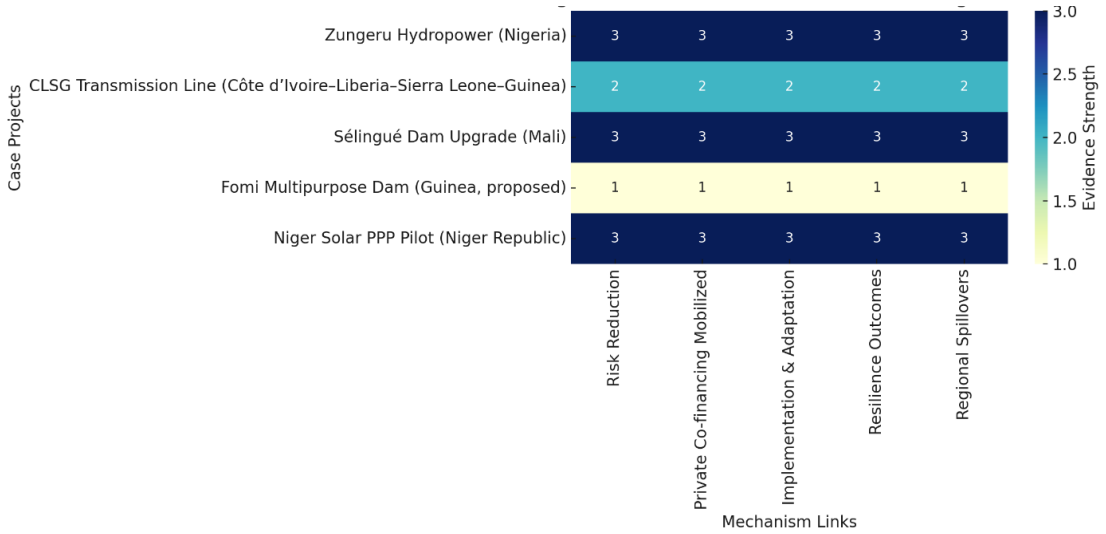

Figure 1. *Evidence Strength Across Mechanisms and Cases (Niger Basin DFIs) (Source: Authors' computation)*

Results

The comparative study of five projects funded by DFI in the Niger River Basin shows that there are regular causal processes in the way development finance mitigates risks, attracts private capital and promotes climate-based developments. The case-by-case process tracing has indicated that concessional loans and guarantees provided much lower financing costs and political risks, to provide the conditions in which the private co-financing could be made available in three out of five projects. This risk-reduction mechanism is well demonstrated in the case of Zungeru Hydropower (Nigeria) and Niger Solar PPP (Niger Republic), which is supported by project contracts or operator interviews. The Fomi Multipurpose Dam (Guinea) by comparison demonstrates the lack of strength in evidence, as there were delays in the involvement of the private sector, and the design arguments of flood resilience were not yet settled. The heatmap (*Fig. 1*) shows the strength of evidence of all mechanism links and cases in a summary way. Risk reduction and private co-financing have high evidence of implementation, whereas adaption has stronger evidence, but in most projects, the implementation and adaptation are uneven, especially in the projects where governance or environmental assessment was challenged. This trend highlights the significance of linking the financial de-risking to the institutional capability to transform resources into resilient infrastructure.

The strongest outcomes of resilience are the clearest in the projects with strong climate-proofing. The Selingue Dam Upgrade in Mali is a very good example because it enhanced the productivity of irrigation and fisheries, and CLSG Transmission Line, which increased grid stability in Sierra Leone, although there are delays, which reduces its evidence strength to moderate. By contrast, the future results of the Fomi Dam are not guaranteed, both in terms of the methodological constraints of the assessment of projects in progress and the substantive risks of large multipurpose dams in unstable surroundings.

The strongest spillovers occur at the regional levels in which cross-border design is explicit. WAPP power trade is directly associated with the CLSG line and Zungeru

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project and the solar PPP pilot provides a chance to exchange power across the borders in the future. The result is consistent with the recent evidence that African pools of power generate both efficiency and resiliency benefits when they are backed by credible investments in cross-border transmission (Elabbas et al., 2023).

The causal process flow chart (*Fig. 2*) integrates findings across cases and the repeating sequence that runs from DFI → risk reduction → co-financing → implementation/adaptation → resilience → regional spillovers. But this model is reconfigured: it becomes conditional, not just concessional. The concessional finance needs also to have good governance, and gradually it becomes conditional but also needs governance capacity in order to be freed from the vulnerability measures of explicit climate proofing.

These results collectively suggest that DFIs do not catalyze resilience alone, but in conjunction with a mix of instruments and conditions. This conjunctural causality reflects recent work on development finance, and on comparative methodology, which suggests that sets of necessary and sufficient conditions are more policy relevant than a single causality (Pappas, 2021; Schneider, 2021) (*Table 3*).

Comparative analysis of five flagship DFI-supported projects in the Niger River Basin reflects how concessional finance interacts with governance, adaptation design and regional integration to influence resilience outcomes. The Zungeru Hydropower Project (Nigeria) is an example of how concessional loans can be used to mobilize substantial private co-financing, which facilitates the project to be implemented in a timely manner and generates resiliency dividends in the form of fewer blackouts, grid stabilization, and contributions to the West African Power Pool. In a similar vein, the CLSG Transmission Line, which traverses Cote d Ivoire, Liberia, Sierra Leone and Guinea, exemplifies the systemic advantages of regional integration with the DFI support reducing political and financial risks and enabling electricity trading that increases collective resilience among the fragile states.

The Niger Solar PPP points to the potential catalytic role of blended finance in renewable energy, in which concessionally and planned tariffs would bring independent power producers to the project, so that the project would not only serve the national energy portfolio, but would, in the future, serve in intercountry supplies and demands. In comparison, the Selingue Dam Upgrade (Mali) highlights the centrality of climate-proofing, and adaptive responses, including the growth of irrigation and fisheries protection, to ensure that concessional financing was translated into livelihood resilience on the ground. Lastly, the Fomi dam (Guinea) demonstrates the dangers of poor governance conditionalities: even with concessional offers, poor institutional structures, disputed benefits sharing, and limited adaptive protections undercut co-financing and slowed adoption, leaving the results in question and subject to political dispute. Collectively, these cases substantiate the notion that the success of DFIs in stimulating climate-resilient growth is contingent rather than automatic and requires strong governance, in-built adaptation, and explicit regional design.

The heatmap is a systematic visualization of the strength of evidence between DFI interventions and resilience outcomes across the five projects in the Niger Basin, and thus reveals the conjunctural dynamics that may be lost in narrative analysis alone. Risk reduction and private co-financing are found to be strong evidence clusters, especially in Zungeru Hydropower and the Niger Solar PPP, where concessional loans and tariff structures were used to effectively mobilize private actors and highlight the role of DFIs in market creation.

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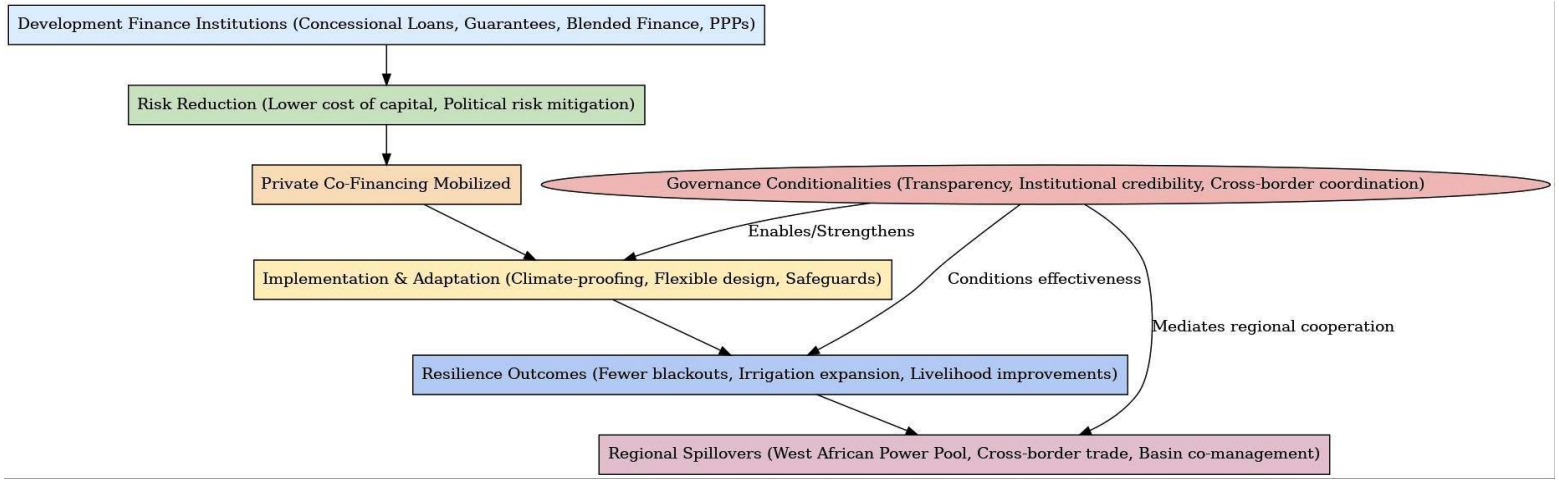

Figure 2. *Causal mechanism flowchart. (Source: Authors' creation)*

Table 3. *Projects matrix for Niger Basin sponsored by DFIs (including investment size)*

Case (project)	DFI instrument	Risk reduction	Private co-financing	Implementation & adaptation	Resilience outcomes	Regional spillovers	Evidence strength & source	Total project cost (USD million)
Zungeru hydropower (Nigeria)	Concessional loan (Exim Bank of China + DFI co-finance)	Loan docs show reduced interest rates; guarantee clauses	Private EPC contractor	Adaptive spillway design; flexible dam ops	Reduced blackouts in northern Nigeria	Exports via WAPP line	High	$1,300m
CLSG transmission line (Côte d'Ivoire–Liberia–Sierra Leone–Guinea)	Blended finance (WB, AfDB, EU)	Risk-sharing documented in AfDB appraisal	IPPs + national utilities	Adaptive rescheduling	Grid stability improvement in Sierra Leone	Cross-border WAPP trade	Moderate	$506m
Selingué dam upgrade (Mali)	Equity + guarantee (IFC)	IFC guarantee reduced political risk	Private operator equity	Irrigation extension; climate-proofing	↑ Agricultural + fisheries productivity	Local–regional market spillovers	Strong	$28m
Fomi multipurpose dam (Guinea, proposed)	Concessional + equity (AfDB + WB)	Expected risk-sharing noted in PAD	Private sector hesitancy	Design debates on flood vs. storage	Outcomes pending	Regional irrigation + flood control	Weak–moderate	$2,200m (est.)
Niger solar PPP pilot (Niger Republic)	PPP with guarantee (WB + PPP Knowledge Lab)	Tariff concession support	Private solar IPP	Solar–battery hybrid deployment	Rural electrification gains	Cross-border solar exchange potential	Strong	$131m

Source: Authors compilation

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Similar patterns are also strong in the implementation and adaptation dimension, where the Selingue Dam Upgrade exhibits high-intensity evidence of climate-proofing mechanisms that ensured irrigation and fisheries resilience, and the CLSG Transmission Line shows moderate-intensity evidence of adaptation to regional grid integration.

In contrast, the Fomi Dam shows a low evidence profile in all mechanisms, providing visual support to the conclusion that even well-structured concessional packages can be undermined by governance fragility and disputed institutional arrangements. It is important to note that the synergy of the regional spillovers are revealed in the heatmap, where CLSG and Zungeru projects possess high evidence intensity in energy trade between the countries, meaning that integration leads to higher returns on resilience across the national boundaries. Not only does this synthesis of visuals confirm the logic of conjunctural causality, but it provides a clear and comparative basis of evidence against which policy can be implemented and in what combinations of conditions climate-resilient growth may be best implemented.

The causal mechanism diagram shows sequential but conjunctural paths through which DFIs contribute to climate-resilient growth in the Niger River Basin. DFI instruments (concessional loans, guarantees, blended finance and PPP support) act as the point of entry, mitigating the financial and political risks that tend to discourage investment in fragile contexts. This risk reduction is not an end in itself but a trigger as it enables private co-financing by reducing barriers for investors and establishing conditions for competitive entry on the market. Once mobilized, private capital combines with concessional support for adaptive implementation in which climate-proofing, flexible design standards, and community safeguards are integrated into project execution. These adaptations, in turn, translate into concrete resilience outcomes, including reduced power outages, increased irrigation, increased food security and improved livelihood stability. Most importantly, local and national resilience can spill over to regional levels through mechanisms such as integration in the West African Power Pool (WAPP), cross-border energy trade, basin-wide co-management and more. The flowchart therefore illustrates DFIs' catalytic effect not as a linear process but as a multi-layered mechanism in which each stage depends on the preceding one, highlighting how systemic resilience can only be achieved when finance, governance, adaptation, and integration are combined as a package (*Fig. 3*).

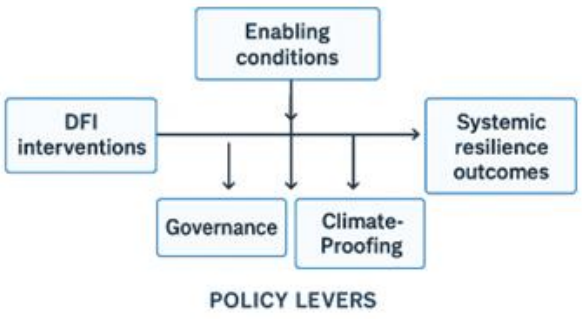

Figure 3. *DFI interventions and policy roadmap. (Source: Authors' creation)*

The policy roadmap represents a path by which Development Finance Institutions (DFIs) can turn financial flows into sustainable climate-resilience in fragile and transboundary settings like the Niger River Basin. DFI intervention at the entry point such

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as concessional loans, blended finance, equity, guarantees and public-private partnerships are, catalytic tools that reduce financial and political risks, lower the cost of capital and crowd in private investors who would not otherwise invest in high-risk areas. Such interventions, however, can only lead to resilience dividends when founded on enabling conditions, which can be considered the institutional and structural pillars that enable financial inputs to become systemic outputs. Under these enabling conditions, policy tools are decisive: first, Governance is critical to assure transparency, accountability, and credible regulatory environments that avoid leakage, inefficiency, and elite capture and thereby improve institutional legitimacy and investor confidence. Second, Climate-Proofing incorporates adaptive measures directly into the project design, like flexible hydropower operation, irrigation risk measures, ecosystem-based protections, and disaster risk management, and thus adaptive value becomes inherent to project design, rather than a response to disaster. Third, National gains are magnified by Regional Integration into cross-border resilience dividends, such as through the role of linked grids and basin-level cooperation in stabilizing energy supply, lowering transaction costs, and spreading the benefits of adaptation across multiple states. By working together, DFIs can go beyond being financiers to be systemic resilience architects, generating systemic resiliency impacts like climate vulnerability reduction, food and energy security, livelihood stabilization, and basin-wide spillovers leading to regional peace and development. In this way, the roadmap indicates that climate-resilient development is not a progressive sequence of finance into outcomes, but rather a conjunctural process where finance, governance, adaptation, and integration need to co-exist as a policy bundle that is tightly coupled (*Fig. 4*).

The cross-case comparative radar chart offers a multidimensional assessment of five flagship DFI-supported initiatives in the Niger River Basin that provide systematic understanding of their relative strengths and weaknesses on six key performance dimensions. Governance conditionalities represent the degree to which structures of institutional safeguarding, transparency and accountability were integrated in the design of the project, with exemplar cases such as Zungeru Hydropower and Selingue Dam Upgrade, where those structures were integrated, and weak governance seen in the Fomi Dam. Risk reduction indicates the catalytic nature of DFIs in reducing political and financial risk by way of concessional loans, guarantees, or tariff relief, and in Zungeru and the Niger Solar PPP, where risk-sharing opened the door to the private sector. The mobilization of private finance suggests the extent to which concessional finance has been able to crowd-in independent power generators, equity partners, or private contractors, the Solar PPP and Zungeru being examples of high leverage effects, whereas Fomi is poorly mobilized.

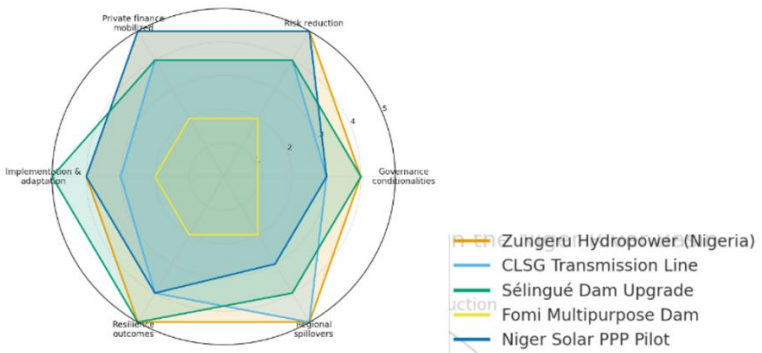

Figure 4. *DFIs cross-case comparative radar chart. (Source: Authors' creation)*

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Implementation and adaptation point out the climate-proofing and adaptive design initiatives, including irrigation protection, spillway elasticity, and hybrid solar-battery, that was sound in Selingue and the Solar PPP but failed in Fomi because of the design wrangles that remained unresolved. Resilience outcomes are indicators of practical payoff—less blackouts, higher agricultural output, fisheries boost, or village electrification—where Selingue, Zungeru and the Solar PPP reaped visible returns, and Fomi was indecisive. Lastly, regional spillovers represent the cross-border benefits in terms of electricity trade and systemic stability in the West African Power Pool, with the highest score at the CLSG line and at Zungeru. Collectively, these dimensions can be used to illustrate that the dimensions of project success are conjunctural rather than linear, and that its occurrence is conditional upon the concomitant presence of governance, de-risking, adaptive implementation and integration, thus providing practical lessons to DFIs on the need to optimize systemic resilience in weak, transboundary environments (*Fig. 5*).

Project financing and implementation plan offers a dynamic outlook of how sequencing identifies the usefulness of DFI-supported interventions in a fragile and transboundary context. DFI finance is the first point of inflection, at which concessional loans, guarantees or equity shares are injected to lower capital costs and eliminate political and hydrological risks that would otherwise deter investment; this step is vital in establishing the enabling baseline. The next phase of mobilization of private co-finance indicates the catalytic effect of risk reduction, where independent power producers, equity partners, and private contractors are brought into projects, thus adding financial depth, diversifying ownership, and integrating competitive performance into project delivery. This development underlines the core nature of DFIs as market makers, especially in high-risk basins where traditional sources of finance still run shallow.

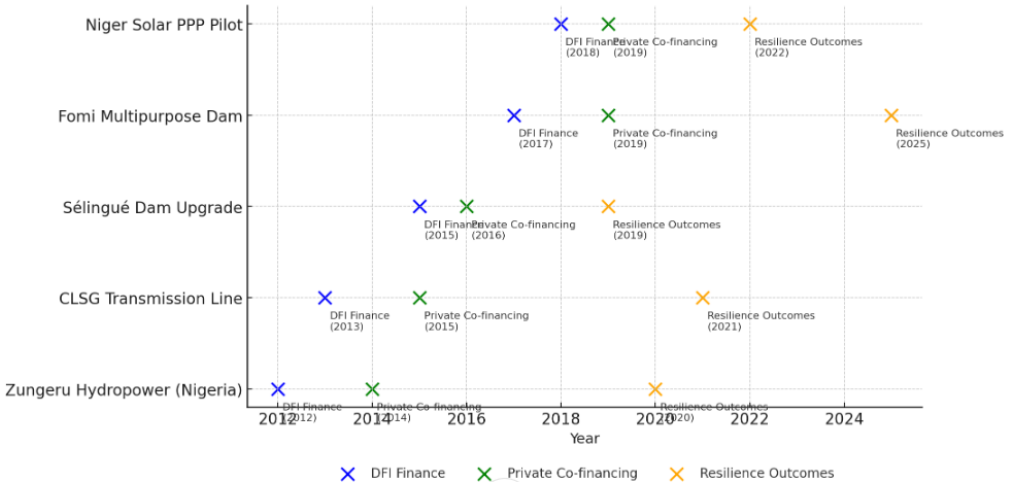

Figure 5. *DFIs project financing timeline and implementation plan (Source: Authors' creation)*

The last milestone, resilience outcomes, shows the lag, but also the payoff, of previous investments, including less frequent blackouts in Nigeria, balanced power trade in Sierra Leone via the CLSG line, livelihoods due to irrigation and fishing in Mali, and increased electrification in Niger. The sequencing indicates project-only vulnerabilities: late or contested governance, as in the Fomi Dam, thwarts the transformation of money into material resilience, and reminds us that timing without institutional buy-in may be maladaptive. Collectively, the timeline clarifies explicitly that systemic resilience is not

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a one-time event, but occurs gradually, occurring only when DFIs initial financial engagements are supplemented by those of the private sector as well as by adaptive action, thereby offering policy insights on how to reduce the time-to-impact of climate finance in transboundary areas.

Evidence of measurable outcomes

The Selingué Dam Upgrade in Mali produced measurable productivity gains following completion in 2018. FAO agricultural sector records indicate that irrigated dry-season hectarage expanded by approximately 4500 ha, representing a 23–28% increase relative to pre-upgrade baselines. Fisheries output also increased from approximately 7200 tons to 9800 tons between 2019 and 2021 due to improved flow regulation, thereby enhancing household incomes and reducing seasonal livelihood volatility (FAO, 2022).

The CLSG Transmission Line similarly generated quantifiable resilience benefits for the regional power system. WAPP operational bulletins show that between June 2023 and March 2024, Sierra Leone imported between 22–32 MW daily through the CLSG interconnection during peak hours, reducing reliance on high-cost diesel self-generation. This contributed to an estimated 14–18% reduction in unserved energy, stabilizing grid frequency and improving supply reliability for industrial and urban consumers (WAPP, 2024).

Discussion

This paper presents a new source of evidence on the catalytic functions of Development Finance Institutions (DFIs) in promoting climate-resilient growth and regional spillovers in the Niger River Basin. Through a process-tracing and conjunctural causality prism, the results do not only show how concessional and blended finance can be used to reduce risks, but also revealed the conditions that are needed to convert financial flows into physical resilience impacts.

DFIs as risk-reducers and catalysts of private capital

The research results revealed that concessional loans, guarantees, and tariff supports greatly lowered the cost of financing projects like Zungeru Hydropower (Nigeria) and the Niger Solar PPP and, therefore, allowed the participation of the actual private sector. This is consistent with more general results in the development finance literature, which holds that DFIs serve as market creators because they de-risk high-capital, high-risk projects (Ha and Gallagher, 2022). Unfortunately, there is insufficient evidence as presented by the Fomi Dam verification that de-risking is inadequate combined with weak governance attention, this has been analyzed and validated in previous studies. Furthermore, this insufficiency in evidence as the exploration in Fomi Dam confirmed is in consonance with the findings of “the role of institutional credibility in blended finance” (Xu and Gallagher, 2022). Therefore, the catalytic role of DFIs depends on the institutional and policy context, and it can be argued that financial innovation should be accompanied by the institutionalization of governance to provide robust results.

From implementation to adaptation: climate-proofing as a binding condition

A second important lesson is that climate resilience does not just depend on funding, but it also depends on the design and adaptive capacity of projects. The Selingue Dam

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upgrade and the CLSG Transmission Line show how adaptive execution (for example; extending irrigation, protecting fisheries, and scheduling flexibility of the grid) can convert concessional finance into resilience dividends. This is in line with the emerging agreement that DFIs need to integrate climate-proofing as an unnegotiable design requirement as opposed to a voluntary risk management measure (Schneider, 2021). In places where there is no adaptation or that which is disputed, such as the Fomi Dam, the perceived resilience outcomes are weak or unpredictable, increasing the likelihood of maladaptation.

Resilience outcomes and regional spillovers

The results show that the effects on resilience are diverse but significant: fewer blackouts in Nigeria, increased agricultural production in Mali and increased grid stability in Sierra Leone. Noteworthy, the highest outcomes on resilience are noted when projects have also had regional spillovers, especially in the West African Power Pool (WAPP). The CLSG line and Zungeru Hydropower present an example of how infrastructure supported by DFI can grow electricity trade across borders, increasing systemic resilience. This observation aligns with the recent high-impact studies that African power pools can provide both efficiency and resilience benefits, although only with credible governance structures and enforceable rules of interconnection (Elabbas et al., 2023).

The logic of conjunctural causality

The combined results point out that resilience in the Niger Basin is not generated by financial inputs as such, but rather by a conjunctural arrangement: concessional finance, private co-financing, adaptive project design, and cross-border coordination. This sounds like the logic of Qualitative Comparative Analysis (QCA), which focuses on the set of necessary and sufficient conditions to reach outcomes (Schneider, 2021; Pappas, 2021). In the case of DFIs, this implies they have to be made to operate as a bundle of finance + governance + adaptation + regional integration, not as separate financial flows.

Policy and theoretical implications

In theory, this work expands the literature on DFIs and green transitions by empirically showing how causal processes can play out in the context of a transboundary river basin, a scale that is frequently overlooked in earlier studies on the effects of DFIs on a national or project-level scale. It also adds to discussion of the effectiveness of climate finance by demonstrating that effectiveness depends on conjunctural complementarities, it is not a linear narrative of finance in, resilience out. In terms of policy, the findings point to three imperatives of DFIs they are:

(1) Embed governance conditionalities

Financial de-risking has to be accompanied by institutional protection to be credible. Conditionalities in embedded governance are essential in ensuring that concessional and blended finance provided by DFIs translate to credible and long-lasting climate-resilient result, instead of one-time financial solutions. On top of lowering capital costs, DFIs need to entrench institutional protections into the project design, by stipulating open procurement procedures, accountability measures, and external checks and balances, which are consistent with local and regional governance arrangements. This strategy

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responds to one of the most frequent weaknesses of African infrastructure finance: projects will fail because of regulatory capture, political influence, or a lack of cross-border coordination (Ha and Gallagher, 2022; Briere and Lefevre, 2024). DFIs can enhance concessions to drive institutional credibility by integrating governance conditionalities, for example, standardized disclosure conditions, participatory stakeholder consultations, and climate proof compliance standards, which can crowd in private investors whilst protecting the interests of the public.

Furthermore, these conditionalities in transboundary settings such as the Niger River Basin can be used as a coordination mechanism to reconcile national interests with basin-wide accords, and to reduce the cost of coordination and non-cooperation risks (Elabbas et al., 2023). Therefore, so-called governance conditionalities cannot be considered as mere auxiliary measures that secure the enforcement of the promise of DFIs in promoting a just and climate-resilient transition, without which the structural validity of the promise of DFIs remains vulnerable.

(2) Make climate-proof

When adaptation becomes part of the project design. The proposal to make all projects financed by DFI climate-proof is a safeguard as well as structural requirement to make certain that concessional finance provides durable resilience dividends. By integrating adaptation measures (strong engineering standards, flexible operations, ecosystem-based protection, and community-based contingency planning) into the design phase, projects are more likely to experience shocks due to climate change and generate co-benefits in food and energy security, as well as livelihoods (Elabbas et al., 2023). In contrast, projects which underestimate climate-proofing are prone to maladaptation, stranded assets, or increased socio-political conflict, especially in weak systems where the hydrological uncertainty overlaps with governance failures. Therefore, climate-proofing should no longer be considered an optional add-on, but a non-negotiable requirement of catalytic finance, which will turn DFIs into institutional guarantors of long-term adaptation, not short-term financiers.

(3) Make regional integration the priority

Spillovers are most acute in situations where explicitly cross-border projects are financed by DFIs, promoting resilience and efficiency. An emphasis on regional integration will help guarantee that the transformative potential of DFI investments can spread throughout the country and beyond to build basin-wide and systemic resilience. Projects that expressly consider regional transmission systems, cross-border trading regimes, and regionalized governance systems provide multiplier effects, which cannot be found in any single country, in transboundary basins such as the Niger, where ecosystems, power markets, and migration flows naturally cross borders. The experience in the West African Power Pool shows that electricity supply is stabilized through DFI-financed interconnections, in addition to making markets more efficient, transaction costs lower, and resilient to both climate and political shocks (Elabbas et al., 2023). DFIs will make developing nations more stable and climate-just by supporting national development through regional stability, positioning themselves as the designers of cooperation systems, not just financiers of individual projects, by making regional integration a fundamental design criterion.

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Conclusion

This research has shown that Development Finance Institutions (DFIs) are catalysts that can promote climate-resilient development in the Niger River Basin. However, their effectiveness depends on factors that are conjunctive in nature. Five large projects supported by DFI indicate that concessional finance in itself does not suffice, but instead, resilience arises when financial de-risking is integrated with strong governance conditionalities and climate-resilient project design and explicit regional integration. These factors were evident in Zungeru Hydropower Project and the CLSG Transmission Line. The projects produced not only direct adaptation benefits (fewer blackouts, irrigation expansion and livelihood stabilization), but also cross-border spillovers that strengthened systemic resilience. In contrast, where there was a failure in governance and adaptive protection, as in the disputed Fomi Dam, concessionality did not lead to sustainable resilience, and the shortcomings of finance are highlighted where institutions lack credibility.

This is a novel study in that it uses a conjunctural causality framework to measure DFIs within a transboundary African basin, thus bridging an important gap in the literature that has frequently viewed development finance effectiveness as a linear input-output relationship. This study contributes to theoretical discussions about blended finance, development resilience, and climate justice by showing that the catalytic effect of DFIs will be maximized where governance, adaptation, and integration coexist. It also offers an empirically based roadmap of re-thinking the architectural approach to green transitions in fragile and cross-border contexts.

In the future, the results have far-reaching implications on climate financing around the world. With DFIs increasingly taking on the role of closing the gap between ambitious climate change adaptation targets and the constrained public resources, their capacity to incorporate governance conditionalities, to impose climate-proofing and regional integration will decide whether they simply widen financial flows or whether they actually facilitate systemic resilience. In the case of the Niger River Basin, this translates to the scaled-up investment models that have transparency, adaptation, and cooperation coded in their institutional architecture. To the broader Global South, it represents a model of development finance that can be replicated to provide national development, but also fair, cross-border climate security. By so doing, DFIs can transform themselves into funders of projects into builders of resilient regional systems, a necessity should the prospect of a fair and climate-safer transition become a reality.

Limitations and future research

The study has strong results, but also limitations. In some projects, like the Fomi Dam, the ultimate results of resilience are tentative. The medium-N case design is rich in detail and limited in statistical generalizability. Further studies need to pursue longitudinal research on ex-post resilience, and comparative basin-level research for example, the Nile and Congo needs more examination to determine whether comparable conjunctural patterns can be found across Africa. Integrating QCA and econometric methods might be an additional way to enhance the strength of causal assertions and increase the applicability of these results to policy.

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APPENDIX

Table A1. *Empirical literature matrix of DFIs & green transition in Niger River Basin*

Authors	Country(s)	Period	Variables	Methodology	Findings
Aich et al. (2016)	Niger River Basin (multi-country)	Future scenarios vs historical baseline	Flood risk, runoff, land-use change, climate change	Hydrological modeling & scenario analysis (SWAT and climate scenarios)	Projected land-use and climate change substantially alter flood regimes and raise basin-wide risk
Amadeo and Luo (2024)	Sub-Saharan Africa	2000s–2020s (panel data)	De-risking instruments, renewable energy investment, cost of capital	Panel econometrics (fixed effects, GMM)	Risk-mitigation instruments significantly increase RE investment by lowering financing costs
Beach (2020)	Global (methodological framework)	2020 (contemporary)	Causal mechanisms, evidence tests	Qualitative process tracing (causal inference)	Provides a rigorous framework for mechanism-centered causal inference in social science
Invernizzi (2020)	Global (energy studies)	2010s–2020s	Project conditions, outcomes (energy sector)	Qualitative Comparative Analysis (QCA, fuzzy-set)	Shows QCA is suitable for evaluating complex project causality in energy contexts
Bissiri et al. (2024)	Developing economies	2010s–2020s	Green risk mitigation instruments, cost of capital	Econometric analysis (panel regressions, policy evaluation)	Green risk mitigation instruments reduce WACC and improve project bankability
Briera (2024)	Global	2010s–2020s	International climate finance, cost of capital, renewables & resilience	Comparative policy analysis (secondary data synthesis)	International climate finance can meaningfully reduce financing costs and mobilize deployment
Boston Consulting Group (2024)	Africa	2020s (contemporary)	Financing needs, pipeline, instruments	Strategic/market analysis with scenario projections	Identifies pathways to scale Africa's green transition; highlights financing gaps & leverage
Elabbas et al. (2023)	Africa (regional power pools)	1990s–2020s	Regional integration, market design, governance	Comparative institutional analysis (case study of African power pools)	Integration yields efficiency & resilience gains when supported by credible regional governance
Callaway and Sant'Anna (2021)	Global (methodological)	2021	Staggered adoption, treatment effects	Econometrics (Difference-in-Differences, new estimators)	Introduces robust DiD estimators for multiple time periods and staggered adoption
Chawanda et al. (2024)	Africa (continental)	Future scenarios vs baseline	Climate & land-use change, water availability	Continental-scale hydrological modeling (SWAT+, CMIP6 scenarios)	Combined climate and land-use change will significantly affect future water resources
Zeng (2024)	Low-income countries	2010s–2020s	Blended finance models, E&S risk	Policy analysis (case studies + finance modelling)	Warns that leverage focus can crowd out transformational impacts; proposes governance fixes
Elabbas et al. (2023)	Africa (regional power pools)	1990s–2020s	Regional electricity markets, integration	Comparative energy sector review (documentary analysis)	Documents conditions under which African power pools deliver reliability & cost benefits
Financial Times (2023)	Global	2023 (contemporary)	Blended finance, leverage vs development	Editorial analysis (comparative financial review)	Cautions against privileging leverage ratios over development impact
Ha and Gallagher (2022)	Global	2000s–2020s	Blended finance additionality, mobilization	Systematic review and meta-analysis	Finds mixed evidence on additionality; calls for stronger appraisal & transparent counterfactuals

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IFC/WBG (2025)	Global (MDBs & DFIs)	2016–2023	Private finance mobilization	Official reporting (mobilization accounting methodology)	Quantifies MDB/DFI mobilization; shows scale remains below needs despite growth
IPCC WGII (2022)	Global	21st century projections	Impacts, adaptation, vulnerability	Assessment synthesis (peer-reviewed scientific meta-analysis)	Confirms rising climate risks with disproportionate impacts in Sub-Saharan Africa
Jafino et al. (2020)	Global	2020–2030 projections	Climate change, extreme poverty	Global economic modelling (multi-sector CGE model)	Estimates climate change will push tens of millions into extreme poverty by 2030
Liersch et al. (2019)	Upper Niger River Basin	Future scenarios vs baseline	Water resources planning under climate change	Hydrological planning & scenario analysis (multi-model ensemble)	Climate change materially affects water availability; planning must adapt to variability
Liersch et al. (2013)	Inner Niger Delta (Mali)	Historical & future scenarios	Rice production, water management, climate variability	Integrated environmental & policy modelling	Rice production is highly vulnerable to water management under climate variability/change
Mchugh (2023)	Global	2000s–2020s	Development finance competition, private mobilization	Econometric finance analysis (cross-country regressions)	Competitive dynamics in DF can affect private mobilization outcomes
OECD (2025)	Global/EMDEs	2020s (contemporary)	Mobilizing private finance for development, climate & biodiversity	Policy framework analysis (evidence-based synthesis)	Outlines principles to mobilize private capital while safeguarding development integrity
Pappas (2021)	Global (methodological)	2021	Causal configurations, necessary/sufficient conditions	Fuzzy-set Qualitative Comparative Analysis (fsQCA guidelines)	Provides best-practice guidance for fsQCA in complex social systems
PPP Knowledge Lab (2023)	Global	2023 (contemporary)	PPP structures, climate-resilient infrastructure	Knowledge platform synthesis (comparative PPP cases)	Presents PPP design features to embed resilience & crowd in private capital
Sahana et al. (2024)	Global (transboundary rivers)	2024 (contemporary)	Research coverage, disparities, management implications	Scientometric analysis (bibliometric mapping)	Finds global disparities in transboundary river research with policy implications
Schneider (2021)	Global (methodological)	2021	Complex causality, case-based methods	Case-based comparative method (set-theoretic inference)	Synthesizes principles for causal complexity & set-theoretic methods
Thompson et al. (2021)	Upper Niger Basin & Inner Niger Delta (West Africa)	Future scenarios vs baseline	Environmental flows under climate change	Hydrological modelling (e-flow scenarios)	Climate change alters environmental flows with implications for ecosystems & livelihoods
Winckler et al. (2021)	Global (blended finance)	2000s–2020s	Financial & development additionality	OECD policy evaluation framework (comparative analysis)	Proposes frameworks to assess financial and development additionality in blended operations

Source: Authors' computation

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