



## Science Forum (Journal of Pure and Applied Sciences)

Journal Homepage: <https://atbuscienceforum.com.ng/index.php/jpas>



### Policy and Governance Gaps in Green Hydrogen Development: Implications for Nigeria's Low-Carbon Energy Transition

**Innocent Ulinane Ejeh, B. A. Gana, & Haruna Lumi Zamani**

*Department of Environmental Studies Sustainable Procurement, Environmental and Social Standard Node Centre of Excellence  
Abubakar Tafawa Balewa University, Bauchi, Nigeria*

#### Abstract

Nigeria's northern zones receive some of the highest solar irradiance in West Africa, with an estimated annual green hydrogen production potential of 6,271 TWh. Yet, as of 2025, the country had commissioned no green hydrogen facilities. This study examines the policy and institutional factors behind this gap and considers its implications for Nigeria's transition to a low-carbon energy system. It uses qualitative policy analysis of peer-reviewed research, international agency reports, and Nigerian federal policy instruments published between 2015 and 2025. A four-dimension governance framework, thematic coding, and SWOT analysis are applied to three national instruments: the Energy Transition Plan (Federal Republic of Nigeria, 2022), the Climate Change Act (Federal Republic of Nigeria, 2021), and the third Nationally Determined Contribution (Federal Republic of Nigeria, 2025). Evidence from Morocco, South Africa, Namibia, Egypt, and Kenya provides comparative benchmarks for identifying gaps in Nigeria's governance framework. The findings suggest that stalled deployment reflects neither inadequate solar resources nor unproven electrolysis technology. Rather, key institutional foundations are missing: a dedicated national hydrogen strategy, hydrogen-specific licensing and certification rules, and financing arrangements capable of mobilizing private investment at the required scale. These gaps reinforce one another: concessional finance needed to close the cost gap depends on governance credibility that has yet to be established. Green ammonia production in the northern states emerges as a promising near-term application, with potential to ease land pressures associated with farmer-herder tensions. The study concludes with six policy recommendations, beginning with adoption of a binding national hydrogen strategy and creation of a blended-finance mechanism. It contributes to low-carbon transition research by showing that, in resource-rich but institutionally constrained states such as Nigeria, governance reform is a precondition for deployment.

#### Keywords

Green hydrogen;  
Energy governance;  
Nigeria;  
Low-carbon energy transition;  
Green ammonia;  
Climate security;  
Regulatory policy;  
ECOWAS



## Introduction

The global shift toward cleaner energy systems has moved green hydrogen from a peripheral concept to a core instrument of decarbonisation policy. By 2022, at least 45 countries had adopted national hydrogen strategies, and the International Renewable Energy Agency had identified green hydrogen as indispensable to net-zero pathways in sectors where direct electrification remains impractical, including heavy industry, long-haul transport, and fertiliser manufacturing (International Renewable Energy Agency [IRENA], 2022). For sub-Saharan Africa, green hydrogen represents both an export opportunity, driven substantially by the European Union's import target of ten million tonnes by 2030 (Ballo et al., 2022), and a domestic tool for addressing energy poverty and agricultural productivity shortfalls.

Nigeria occupies a paradoxical position within this landscape. The country possesses the solar resource base, economic scale, and institutional infrastructure required to become a significant green hydrogen producer. Solar irradiance in its northern zones ranges from 5.7 to 6.5 kWh/m<sup>2</sup>/day, placing these areas among the most competitive locations for solar-powered electrolysis in the region (Marvin & Sarkinbaka, 2024). Technical assessments place the country's annual green hydrogen production potential at approximately 6,271 TWh, third highest within the Economic Community of West African States (ECOWAS) (Marvin & Sarkinbaka, 2024). Yet as of 2025, Nigeria has deployed no green hydrogen capacity. No standalone national hydrogen strategy exists, no hydrogen-specific regulatory framework has been enacted, no fiscal incentives are in place to close the production cost gap, and no financing architecture has been established to mobilise the investment that pioneer projects require (Ballo et al., 2022; Shari et al., 2024).

This divergence between resource endowment and deployment outcome is the empirical puzzle this paper investigates. Existing scholarship on

green hydrogen in Nigeria has concentrated heavily on technical dimensions, generating modelling studies of solar irradiance, production cost estimates, and electrolyser capacity projections (Marvin & Sarkinbaka, 2024; Shari et al., 2024). The governance dimension has received comparatively little systematic attention. This paper addresses that gap through a structured policy analysis of Nigeria's energy transition governance framework, identifying the specific institutional shortfalls that keep green hydrogen confined to policy aspiration rather than operational reality, and situating these findings within the wider question of how Nigeria can achieve a credible low-carbon energy transition.

The paper also extends the governance analysis into a security dimension that existing literature has not yet examined. The areas of Nigeria's highest solar resource endowment correspond closely with the areas of most acute climate stress, where desertification, agricultural land scarcity, and farmer-herder conflict are most severe (Löhr et al., 2022). Green ammonia produced from green hydrogen in these zones could reduce dependence on imported fertiliser, raise per-hectare agricultural productivity, and ease the land competition that drives conflict. This security co-benefit lends the governance question an urgency that extends beyond energy economics.

The empirical record on green hydrogen deployment worldwide points consistently to a single finding: countries that have achieved meaningful progress share a pattern in which governance design preceded and enabled investment, rather than the reverse (Dekeyser & Medinilla, 2024; IRENA, 2022). South Africa's Just Energy Transition Partnership, Morocco's export corridor strategy, and Kenya's domestic green ammonia programme all originated from deliberate institutional design choices made before commercial investment commitments materialised. The governance functions that appear most critical include

regulatory certainty, which gives investors' confidence regarding licensing, certification, and compliance obligations; fiscal incentives, which offset the cost disadvantage of green hydrogen relative to fossil alternatives during the pre-parity period; financing architecture, which lowers the cost of capital through blended finance instruments and development bank participation; and institutional coordination, which resolves the jurisdictional fragmentation typical of multi-agency energy regulatory systems (Ballo et al., 2022; Isah et al., 2023).

The theoretical lens most relevant to this paper is the Multi-Level Perspective advanced by Geels (2002), which conceives of energy transitions as unfolding across three levels: landscape pressures, such as global climate targets and falling technology costs; the incumbent energy regime, comprising existing infrastructure and entrenched institutional interests; and niche innovations, such as green hydrogen, that hold transformative potential without yet achieving commercial dominance. In Nigeria, landscape pressures are clearly present: the Paris Agreement, the Energy Transition Plan, and European import demand all push toward transition. The incumbent fossil fuel regime, however, remains deeply entrenched: approximately 80 percent of grid electricity is generated from natural gas, and oil and gas interests actively shape the governance space within which hydrogen development must compete (Isah et al., 2023). The Multi-Level Perspective suggests that, absent a deliberate governance intervention to create room for this niche innovation, landscape pressures alone will not translate into deployment.

Nigeria's formal engagement with energy transition policy began with the National Renewable Energy and Energy Efficiency Policy in 2015 and the Paris Agreement in the same year. The most substantive subsequent development was the Energy Transition Plan, published in 2022, which charts a pathway to net-zero greenhouse gas emissions by 2060 and

targets 22 gigawatts of electrolyser capacity by 2050 (Federal Republic of Nigeria, 2022). The Climate Change Act of 2021 provides the legislative foundation for these commitments, establishing a national council on climate change and mandating climate action plans at federal and state levels (Federal Republic of Nigeria, 2021). The third Nationally Determined Contribution, submitted in 2025, commits Nigeria to unconditional and conditional emission reduction targets by 2030 and estimates a financing requirement of 337 billion United States dollars between 2026 and 2035 (Federal Republic of Nigeria, 2025).

Researchers who have closely examined these documents identify a consistent pattern: each establishes vision and targets without the operational instruments needed to realise them. Shari et al. (2024) observe that the Energy Transition Plan functions more as a statement of policy intention than an implementation strategy, lacking hydrogen-specific regulatory provisions, fiscal incentive structures, or procurement mechanisms. Olujobi et al. (2023) identify regulatory fragmentation across the Nigerian Electricity Regulatory Commission, the Nigerian Electricity Management Services Agency, and the Energy Commission of Nigeria as a structural obstacle to the investment certainty that energy transition projects require. Ballo et al. (2022) extend this analysis to the regional level, finding that no ECOWAS member state has enacted hydrogen-specific bylaws or market structures.

The connection between climate change and human security in Nigeria is well established in the empirical literature. Löhr et al. (2022) trace the causal chain from desertification and reduced rainfall in the Sahelian north, through shrinking grazing and farmland, to the southward movement of Fulani pastoralists and the intensification of farmer-herder conflict in the Middle Belt. Daoust and Selby (2022) connect the collapse of the Lake Chad Basin to the conditions of poverty and displacement that

have facilitated extremist recruitment in northeastern Nigeria. Barnett and Adger (2007) provide the theoretical foundation for understanding these dynamics as climate-mediated resource conflicts in which ecological scarcity, rather than ethnic or religious antagonism, functions as the structural driver.

What the climate security literature has not yet examined is whether specific energy technology deployments can actively reduce the conflict drivers it documents. This paper argues that green ammonia production from green hydrogen offers a direct pathway for doing so. Nigeria imports more than 500 million United States dollars of nitrogen fertiliser annually (Nsafon et al., 2023). When fertiliser is expensive or unavailable, farmers must cultivate more land to meet equivalent production targets, intensifying competition for grazing land already shrinking under desertification pressure (Löhr et al., 2022; Tonelli et al., 2024). Domestic green ammonia production, using solar energy in the northern zones where both irradiance and agricultural land pressure are greatest, would raise per-hectare crop yields, reduce the acreage under cultivation pressure, and directly ease the land competition underlying conflict. Kenya's geothermal-powered green ammonia programme for domestic agricultural use offers an operational demonstration that this approach is viable (Dekeyser & Medinilla, 2024).

The remainder of the paper is organised as follows. The Materials and Methods section sets out the research design and analytical framework. The Result and Discussion section presents findings on Nigeria's governance gaps, deployment barriers, and comparative regional position, and discusses their implications alongside six policy recommendations. The Conclusion closes the paper.

## Materials and Methods

This paper adopts a qualitative policy analysis approach within a single-country case study design, with Nigeria as the unit of analysis (Yin, 2018). The temporal scope covers 2015 to 2025, from the adoption of the National Renewable Energy and Energy Efficiency Policy and the Paris Agreement to the submission of the third Nationally

Determined Contribution. A comparative dimension is incorporated through the analysis of five African hydrogen cases (Morocco, South Africa, Namibia, Egypt, and Kenya), selected to represent the range of deployment strategies on the continent and used as benchmarks rather than additional primary cases.

Data are drawn from three categories of secondary source: peer-reviewed academic literature accessed through Scopus, Web of Science, and ScienceDirect; grey literature from IRENA, the International Energy Agency, the World Bank, and the African Development Bank; and Nigerian government policy documents accessed through official portals. All documentary sources are publicly available.

Policy documents were assessed using a four-dimension evaluation framework examining each instrument for hydrogen-specific regulatory provisions; climate security integration as a stated rationale for transition; concrete implementation mechanisms, including institutional responsibilities and financing arrangements; and enforcement provisions. Thematic analysis following Braun and Clarke (2006) was applied across the full evidence base using five codes: climate vulnerability patterns, green hydrogen technical potential, policy-practice gap, governance and finance barriers, and climate security co-benefits. A SWOT synthesis integrates the findings presented in the Result and Discussion section. The study does not include engineering modelling, primary data collection, or geographic information system analysis.

## Result and Discussion

### *Nigeria's Green Hydrogen Resource Endowment*

Nigeria's solar and renewable resource base for green hydrogen production is well documented and substantial. Table 1 presents the key indicators drawn from the most recent published assessments, summarising the country's physical resource potential alongside its current deployment status.

Table 1: Nigeria's green hydrogen resource base and current deployment status

| Indicator                                      | Documented Data and Source                                                                                         |
|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Solar irradiance (northern zones)              | 5.7 to 6.5 kWh/m <sup>2</sup> /day; among the highest in West Africa (Marvin & Sarkinbaka, 2024)                   |
| Estimated annual production potential          | Approximately 6,271 TWh/year, third highest in the ECOWAS region (Marvin & Sarkinbaka, 2024)                       |
| Assessed hydropower potential                  | 8,824 MW total; 2,153 MW currently harnessed (Olujobi et al., 2023)                                                |
| Wind resource (northern states)                | 4.4 to 7.0 m/s; one 10 MW operational wind farm in Katsina (Marvin & Sarkinbaka, 2024)                             |
| Annual freshwater endowment                    | 267 billion m <sup>3</sup> surface water; 52 billion m <sup>3</sup> replenishable groundwater (Shari et al., 2024) |
| Current deployed green H <sub>2</sub> capacity | Zero operational installations as of 2025 (Marvin & Sarkinbaka, 2024)                                              |
| Energy Transition Plan electrolyser targets    | 4 GW by 2040; 22 GW by 2050 (Federal Republic of Nigeria, 2022)                                                    |
| Production cost estimate                       | USD 4 to 17.4 per kilogram, varying by location and technology (Marvin & Sarkinbaka, 2024)                         |

Sources: Marvin and Sarkinbaka (2024); Shari et al. (2024); Olujobi et al. (2023); Federal Republic of Nigeria (2022).

The contrast between the scale of the documented resource endowment and the absence of any deployed capacity is the central empirical fact motivating this analysis. Nigeria's position within the African context deserves note: although Niger and Mali hold higher raw modelled production potential, Nigeria's combination of solar resources, existing industrial infrastructure, port access for export, and a domestic market for hydrogen derivatives such as green ammonia gives it advantages that raw irradiance figures alone do

not capture (Marvin & Sarkinbaka, 2024; Dekeyser & Medinilla, 2024).

**Governance and Policy Analysis**

The analysis of Nigeria's key energy transition documents against the four-dimension evaluation framework reveals a consistent pattern of vision without operationalisation. Table 2 summarises this assessment across the five principal documents examined, contrasting what each instrument states with respect to hydrogen against the implementation mechanisms it actually puts in place.

**Table 2: Assessment of Nigeria's key policy documents against the governance framework**

| Policy Document                                               | Hydrogen-Specific Provisions                                                                                            | Implementation Mechanisms                                                                                                 |
|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Energy Transition Plan (2022)                                 | Targets 22 GW electrolyser capacity by 2050; identifies hydrogen's role in decarbonising transport, industry, and power | No regulatory instruments, fiscal incentives, procurement frameworks, or market structures specified (Shari et al., 2024) |
| Climate Change Act (2021)                                     | No direct hydrogen reference; establishes Climate Change Fund and carbon pricing architecture                           | Mandates climate action plans; enforcement through national council on climate change (Federal Republic of Nigeria, 2021) |
| Nationally Determined Contribution 3.0 (2025)                 | No hydrogen-specific targets; broad renewable energy ambition; USD 337 billion financing requirement stated             | No hydrogen implementation pathway; concessional finance conditions not specified (Federal Republic of Nigeria, 2025)     |
| National Renewable Energy and Energy Efficiency Policy (2015) | No hydrogen reference; framework predates commercial green hydrogen viability                                           | Renewable energy targets established but largely unmet as of 2025 (Olujobi et al., 2023)                                  |
| National Integrated Electricity Policy (2024)                 | No hydrogen-specific provisions; focuses on electricity grid reliability and off-grid access                            | Grid investment mandates; no hydrogen integration pathway specified                                                       |

Sources: Federal Republic of Nigeria (2021, 2022, 2025); Shari et al. (2024); Olujobi et al. (2023).

Table 2 evaluates all five of Nigeria's principal energy transition documents (the Energy Transition Plan, the Climate Change Act, the third Nationally Determined Contribution, the National Renewable Energy and Energy Efficiency Policy, and the National Integrated Electricity Policy) against the four governance functions identified in the Introduction as essential to enabling deployment: regulatory certainty, fiscal incentives, financing architecture, and institutional coordination. Taken together, the five documents confirm a single conclusion: not one of them, individually, performs all four functions at once. None provides a hydrogen-specific regulatory framework, a fiscal incentive structure for investors, a dedicated procurement mechanism, or an enforceable domestic supply obligation.

Among the five, the Energy Transition Plan comes closest to a strategic foundation, since it at least sets a quantified electrolyser capacity target, but it still operates at the level of vision rather than operational policy, since it lacks the other three functions entirely.

The regulatory fragmentation problem identified by Olujobi et al. (2023) is confirmed by this document analysis. Energy licensing responsibilities are distributed across the Nigerian Electricity Regulatory Commission, which governs the electricity sector; the Nigerian Electricity Management Services Agency, which handles technical standards and safety; and the Energy Commission of Nigeria, which coordinates national energy policy. None of these agencies carries a hydrogen-specific

mandate, and the three operate without a statutory coordinating mechanism. An inter-ministerial committee was established in 2023 to develop a national hydrogen policy, but no published strategy had emerged from this process at the time of this analysis (Marvin & Sarkinbaka, 2024).

**Barriers to Deployment**

The governance void identified above produces a cascade of downstream barriers. Table 3 classifies these barriers across five categories and assigns a severity assessment to each, indicating which obstacles function as primary constraints and which are secondary or context-dependent.

**Table 3: Barriers to green hydrogen development in Nigeria, by category and severity**

| Barrier Category             | Specific Barriers Identified                                                                                                                                                                                         | Severity                                    |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| Governance and policy        | No national hydrogen strategy; no ECOWAS regulatory framework; no fiscal incentives; regulatory fragmentation across three agencies without a coordinating mandate                                                   | Critical: primary binding constraint        |
| Financial                    | Production cost gap of USD 4 to 17.4/kg versus USD 2.8 to 3.5/kg for blue hydrogen; commercial lending rates of 20 to 30 percent; circular dependency between governance credibility and concessional finance access | Critical: compounds governance barrier      |
| Technical and infrastructure | No hydrogen storage, transport, or distribution infrastructure; grid instability preventing efficient continuous electrolysis; limited domestic workforce with hydrogen system expertise                             | High: requires greenfield development       |
| Environmental                | Electrolysis water demand of 9 litres per kilogram of hydrogen conflicts with freshwater scarcity in northern zones of highest solar potential; land-use competition between solar farms and smallholder agriculture | High: requires spatial planning             |
| Social                       | Risk of green extractivism: export-oriented development without domestic supply obligations or community benefit-sharing could reproduce oil-economy dynamics in clean-energy form (Nsafon et al., 2023)             | Medium to high: governance design dependent |

Sources: Ballo et al. (2022); Marvin and Sarkinbaka (2024); Isah et al. (2023); Löhr et al. (2022); Nsafon et al. (2023).

A structural feature of the barrier landscape deserves particular attention: the circular dependency between governance and finance. Concessional financing from development banks such as the African Development Bank and the World Bank is available in principle for green

hydrogen projects in Nigeria. However, these institutions require a credible national policy framework and a demonstrated regulatory environment before committing capital at scale. The absence of the governance framework thus prevents the financing that could make projects

viable from being mobilised, while the lack of viable projects reduces the political pressure to develop the governance framework. This circular dependency is the mechanism through which the governance void reproduces itself.

scale of the governance gap and identifies transferable lessons. Table 4 sets out the governance approach adopted by each comparator country and the corresponding lesson it offers for Nigeria's policy design.

### **Comparative Position Within Africa**

Benchmarking Nigeria against five comparable African countries provides perspective on the

**Table 4: African green hydrogen governance approaches and lessons for Nigeria**

| Country      | Governance Approach                                                                                                                                                    | Key Lesson for Nigeria                                                                                                                                                                        |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Morocco      | Export corridor to Europe through the OCP Group; policy certainty attracted substantial international investment before projects became operational                    | Policy certainty precedes investment; geographic proximity to European markets can be partly substituted by certification credibility (Dekeyser & Medinilla, 2024)                            |
| South Africa | Just Energy Transition Partnership: USD 8.5 billion financing architecture with legally structured governance provisions; most advanced regulatory framework in Africa | A legally binding financing and governance architecture is what converts political commitment into bankable projects (Dekeyser & Medinilla, 2024)                                             |
| Namibia      | Hyphen Hydrogen Energy project valued at USD 9.4 billion; export-oriented; social licence and water-use governance remain unresolved                                   | Export-first models face growing social legitimacy challenges; domestic benefit provisions are becoming a prerequisite for project approval (Dekeyser & Medinilla, 2024)                      |
| Kenya        | Geothermal-powered green ammonia for domestic agricultural use; reduces fertiliser imports; smallholder focus                                                          | Most directly transferable model for Nigeria: domestically oriented, agricultural-sector focus, addresses import dependency and land productivity simultaneously (Dekeyser & Medinilla, 2024) |
| Egypt        | USD 40 billion in investment agreements for the Suez hydrogen export corridor; state-led; geopolitical advantage from Suez Canal location                              | State-led investment at scale is possible where governance certainty exists; geopolitical positioning matters for export routes (Dekeyser & Medinilla, 2024)                                  |

Source: Dekeyser and Medinilla (2024).

As noted in the Introduction, the global literature shows that countries making real progress on green hydrogen have consistently built their governance architecture (regulations, incentives, financing, and coordinating institutions) before attracting major investment, rather than waiting for investment to arrive first. Table 4 tests whether this same order of events holds among Nigeria's African peers, and it does: in every one of the five comparator countries where meaningful deployment progress has occurred, governance design came first and investment followed. Nigeria is the outlier against this pattern: it holds the largest solar resource endowment of any ECOWAS country and the strongest industrial base, yet it has the weakest governance architecture of the group. This disparity is not explained by technological factors, since electrolysis technology is commercially available and improving globally. It is explained by institutional inaction.

Kenya's model is the most directly transferable to Nigeria's circumstances. Its focus on

domestic green ammonia for agricultural use addresses the specific intersection of energy transition and climate security that is most urgent in Nigeria's northern zones. It does not require the export infrastructure or international finance architecture that larger-scale export-oriented projects depend on, making it viable at an earlier stage of governance development.

### **SWOT Synthesis**

Table 5 consolidates the resource assessment, the policy document review, the barriers analysis, and the country comparison into a single SWOT framework. It makes the central finding of the paper visible at a glance: Nigeria's strengths are concentrated in the biophysical domain (solar resources, water endowment, existing infrastructure) and exist independently of any policy action, while its weaknesses and threats are concentrated in the governance domain, where policy intervention can make a decisive difference.

**Table 5: SWOT synthesis of Nigeria's green hydrogen transition**

| Category          | Factors Identified                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Strengths</b>  | <ul style="list-style-type: none"> <li>• Solar irradiance of 5.7 to 6.5 kWh/m<sup>2</sup>/day in the north; production potential of 6,271 TWh/year (Marvin &amp; Sarkinbaka, 2024)</li> <li>• National water endowment of 267 billion m<sup>3</sup> surface water (Shari et al., 2024)</li> <li>• Energy Transition Plan (2022) targets 22 GW of electrolyser capacity; political commitment signal exists</li> <li>• Existing gas infrastructure partially repurposable for hydrogen transport</li> <li>• Atlantic coastline provides export route access; German-Nigerian Hydrogen Office provides technical support</li> </ul> |
| <b>Weaknesses</b> | <ul style="list-style-type: none"> <li>• Zero operational green hydrogen capacity as of 2025 (Marvin &amp; Sarkinbaka, 2024)</li> <li>• No national hydrogen strategy; no ECOWAS regulatory framework (Ballo et al., 2022)</li> <li>• Production costs of USD 4 to 17.4/kg; commercial lending rates of 20 to 30 percent (Isah et al., 2023)</li> <li>• No hydrogen storage, transport, or distribution infrastructure (Shari et al., 2024)</li> </ul>                                                                                                                                                                            |

| Category             | Factors Identified                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      | <ul style="list-style-type: none"> <li>Regulatory fragmentation across the Nigerian Electricity Regulatory Commission, the Nigerian Electricity Management Services Agency, and the Energy Commission of Nigeria (Olujobi et al., 2023)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Opportunities</b> | <ul style="list-style-type: none"> <li>European Union import target of ten million tonnes of green hydrogen by 2030 (Ballo et al., 2022)</li> <li>Green hydrogen projected to reach cost parity in high-irradiance locations by the early 2030s (Gómez &amp; Castro, 2024)</li> <li>Green ammonia could displace USD 500 million in annual fertiliser imports (Nsafon et al., 2023)</li> <li>World Bank Distributed Access through Renewable Energy Scale-up (DARES) project, valued at USD 750 million, supports distributed renewable energy (Shari et al., 2024)</li> <li>First-mover advantage: no ECOWAS member state currently has a hydrogen governance framework (Ballo et al., 2022)</li> </ul> |
| <b>Threats</b>       | <ul style="list-style-type: none"> <li>Planned gas expansion from 4 to 14 GW risks crowding out hydrogen investment (Shari et al., 2024)</li> <li>Fossil fuel incumbency suppresses renewable niche development (Isah et al., 2023)</li> <li>Water scarcity in northern zones conflicts with electrolysis demand (Löhr et al., 2022)</li> <li>Risk of green extractivism in the absence of domestic supply obligations (Nsafon et al., 2023)</li> <li>European Union hydrogen certification standards may exclude early-stage Nigerian projects (Marvin &amp; Sarkinbaka, 2024)</li> </ul>                                                                                                               |

Sources: As cited within the table entries.

### **Governance as the Binding Constraint**

The findings of this study support a clear and specific conclusion: Nigeria's green hydrogen deployment gap is not explained by insufficient solar resources, immature technology, or absent international demand. It is explained by a structural governance void that prevents the conversion of natural endowment into investment-ready projects. This finding is consistent with the theoretical proposition derived from the Multi-Level Perspective that, in resource-dependent states with entrenched fossil fuel regimes, governance functions as a structural prerequisite for niche breakthrough rather than merely as an accelerator of it. No amount of landscape pressure (falling

electrolyser costs, European import demand, or domestic energy poverty) produces deployment in the absence of the regulatory and financial architecture that investor decision-making requires.

The circular dependency between governance credibility and concessional finance access is particularly significant for Nigeria's low-carbon transition. It establishes that the governance gap is self-reinforcing: without a strategy, there is no financing; without financing, there are no projects; without projects, there is reduced pressure to develop a strategy. Breaking this cycle requires a deliberate political intervention that establishes governance credibility as a precondition for

investment mobilisation, rather than an outcome of it. This is precisely what South Africa achieved through its Just Energy Transition Partnership and what Morocco achieved through bilateral export corridor agreements. Nigeria has not yet made that intervention.

### ***Green Ammonia as the Priority Near-Term Application***

The analysis consistently points to green ammonia production as the highest-value near-term application for Nigeria, for three reasons. First, it addresses an existing economic pain point: Nigeria spends over 500 million United States dollars annually on fertiliser imports, and smallholder farmers face cost and availability volatility that limits their capacity to invest in land productivity (Nsafon et al., 2023). Second, it connects the energy transition directly to the climate security challenge: improved per-hectare yields reduce the acreage under cultivation pressure, easing the land competition

that drives farmer-herder conflict in the Middle Belt (Löhr et al., 2022). Third, it does not require the large-scale export infrastructure or sophisticated international certification that positions such as Morocco's depend on, making it viable at an earlier stage of governance development. Kenya's geothermal-powered green ammonia programme offers a directly transferable operational model (Dekeyser & Medinilla, 2024).

### ***Policy Recommendations***

The following recommendations are derived from the evidence and analysis presented above. Table 6 sets out each recommendation alongside its underlying rationale and the body best placed to lead its implementation; the recommendations are sequenced in order of logical priority, since later measures depend on the institutional foundations created by earlier ones.

**Table 6: Policy recommendations, underlying rationale, and responsible implementing bodies**

| <b>Recommendation</b>                                                                                                                                                                                                                                                         | <b>Rationale</b>                                                                                                                                                                                                                | <b>Responsible Body</b>                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| R1: Enact a legally binding National Green Hydrogen Strategy with green ammonia as the priority near-term application, domestic supply obligations, and European Union-aligned certification provisions                                                                       | Provides the governance credibility required to unlock concessional development finance and creates the regulatory certainty investors need. Without this, all other recommendations operate without an institutional anchor.   | Energy Transition Office; Federal Ministry of Power                                                    |
| R2: Establish a statutory Inter-Agency Coordination Body for green hydrogen with executive authority to resolve fragmentation among the Nigerian Electricity Regulatory Commission, the Nigerian Electricity Management Services Agency, and the Energy Commission of Nigeria | Regulatory fragmentation is the most immediate operational governance problem. An independent coordinating body with statutory authority removes the jurisdictional ambiguity that currently deters pioneer project applicants. | Office of the Vice President; Nigerian Electricity Regulatory Commission; Energy Commission of Nigeria |

| Recommendation                                                                                                                                                                                        | Rationale                                                                                                                                                                                                                                                                                  | Responsible Body                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| R3: Establish a Blended Finance Facility combining sovereign green bonds, concessional lending from the African Development Bank and World Bank, and carbon revenues from the Climate Change Act Fund | Breaks the circular dependency between governance credibility and finance access. Concessional capital at 5 to 7 percent reduces the effective project cost significantly relative to commercial lending rates of 20 to 30 percent.                                                        | Nigeria Sovereign Investment Authority; African Development Bank; World Bank                              |
| R4: Initiate Green Ammonia Pilot Projects in Sokoto, Kano, and Katsina states, linked to smallholder fertiliser subsidy programmes                                                                    | These three states combine the highest solar irradiance with the most acute agricultural land pressure and farmer-herder conflict incidence. Piloting here generates the domestic evidence base, demonstrates viability to investors, and delivers immediate climate security co-benefits. | Federal Ministry of Agriculture; State Governments; Energy Transition Office                              |
| R5: Mandate Environmental and Social Impact Assessments as a condition of all hydrogen project licences, including water demand mapping and community benefit-sharing agreements                      | Water scarcity in northern zones and the risk of green extractivism require proactive governance design rather than reactive problem management. Social licence in conflict-affected ecological zones is a prerequisite for project viability.                                             | Federal Ministry of Environment; Nigerian Electricity Regulatory Commission; State Environmental Agencies |
| R6: Commission a National Green Hydrogen Resource Atlas integrating solar irradiance, wind, water availability, land use, and climate vulnerability data at state level                               | A high-resolution national resource assessment resolves the data gap that currently prevents informed prioritisation of deployment zones and that deters international investors requiring credible site-level evidence before committing capital.                                         | Energy Commission of Nigeria; Research Institutions                                                       |

Source: Derived from the findings presented above.

## Conclusion

This paper has investigated why Nigeria, despite possessing one of West Africa's largest green hydrogen resource endowments, had deployed no green hydrogen capacity as of 2025, and what this means for the country's wider low-carbon energy transition. The analysis confirms that the deployment gap is not attributable to insufficient resources or immature technology. It is attributable to a structural governance void: the absence of a standalone national

hydrogen strategy, hydrogen-specific regulatory instruments, fiscal incentives, and a financing architecture capable of mobilising private investment. A circular dependency between governance credibility and development finance access is identified as the self-reinforcing mechanism through which this void perpetuates itself.

Comparative benchmarking against Morocco, South Africa, Namibia, Egypt, and Kenya confirms that governance design precedes and

enables investment in every African case where meaningful progress has been made. Nigeria's combination of solar resources, industrial infrastructure, and domestic market size positions it well to replicate and exceed these examples, but institutional action is required before market forces will operate in its favour.

Green ammonia production in the northern zones is identified as the priority near-term application. It addresses an existing economic vulnerability in Nigeria's fertiliser import dependency, connects the energy transition directly to the climate security challenge of farmer-herder conflict in the Middle Belt, and is viable at an earlier stage of governance development than export-oriented hydrogen production.

This paper contributes to the literature on low-carbon energy transition governance by establishing that, in resource-dependent developing states with entrenched fossil fuel regimes, governance functions as a structural prerequisite for deployment rather than merely an accelerator of it. This finding carries implications beyond Nigeria for other sub-Saharan African countries that combine abundant renewable resources with institutionally weak energy sectors. Future research should examine the community-level dimensions of green hydrogen governance in conflict-affected ecological zones, and the conditions under which blended finance instruments successfully break the circular dependency between governance credibility and investment mobilisation.

## References

- Ballo, I. F., Diallo, M., & Moussa, R. (2022). Green hydrogen in West Africa: Governance frameworks and regulatory landscape for ECOWAS member states. *Energy Policy*, 165, Article 112931. <https://doi.org/10.1016/j.enpol.2022.112931>
- Barnett, J., & Adger, W. N. (2007). Climate change, human security and violent conflict. *Political Geography*, 26(6), 639-655. <https://doi.org/10.1016/j.polgeo.2007.03.003>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp0630a>
- Daoust, G., & Selby, J. (2022). Understanding the climate-conflict nexus from a multiscale perspective: A case study of the Lake Chad Basin. *WIREs Climate Change*, 13(1), Article e738. <https://doi.org/10.1002/wcc.738>
- Dekeyser, L., & Medinilla, A. (2024). *Africa's green hydrogen ambitions: Export corridors, governance, and justice dimensions* (Discussion Paper No. 340). European Centre for Development Policy Management.
- Federal Republic of Nigeria. (2021). *Climate Change Act 2021*. Federal Government of Nigeria.
- Federal Republic of Nigeria. (2022). *Nigeria Energy Transition Plan*. Energy Transition Office, Office of the Vice President.
- Federal Republic of Nigeria. (2025). *Nigeria Nationally Determined Contribution 3.0*. Federal Ministry of Environment.
- Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case study. *Research Policy*, 31(8-9), 1257-1274. [https://doi.org/10.1016/S0048-7333\(02\)00062-8](https://doi.org/10.1016/S0048-7333(02)00062-8)
- Gómez, J. R., & Castro, M. T. (2024). The economics of green hydrogen: Cost trajectories and deployment pathways to 2050. *Renewable Energy*, 220, Article 119634.

<https://doi.org/10.1016/j.renene.2023.119634>

- International Renewable Energy Agency. (2022). *Green hydrogen: A guide to policy making*. IRENA.
- Isah, A. D., Adamu, S., & Yusuf, B. (2023). Institutional fragmentation and energy regulatory governance in Nigeria's electricity sector. *Utilities Policy*, 84, Article 101635.
- Löhr, K., Bonatti, M., Ségla, K. A. C., & Sieber, S. (2022). Climate change adaptation and farmer-herder conflict in the West African Sahel: A scoping review of mediating mechanisms. *Climate and Development*, 14(4), 311-324.
- Marvin, U. E., & Sarkinbaka, Z. (2024). Green hydrogen potential and deployment readiness in Nigeria: A technical and policy assessment. *Energy Reports*, 11, 4502-4518.
- Nsafon, B. E. K., Owolabi, A. B., Suh, D., Huh, J. S., & Sarkinbaka, Z. (2023). Fertiliser import dependence and the case for domestic green ammonia production in Nigeria. *Journal of Cleaner Production*, 405, Article 137034.
- Olujobi, O. J., Olarinde, E. S., & Yebisi, T. E. (2023). Regulatory fragmentation in Nigeria's electricity sector and its implications for energy transition investment. *Energy Policy*, 178, Article 113584.
- Shari, R. B., Ibrahim, A. M., & Nwosu, C. (2024). Operationalising Nigeria's Energy Transition Plan: A gap analysis of hydrogen-specific policy instruments. *Energy Research & Social Science*, 108, Article 103392.
- Tonelli, B., Ouedraogo, I., Diallo, M., & Sissoko, F. (2024). Desertification, land scarcity, and pastoral mobility in the Sahel: Implications for resource-based conflict. *Land Use Policy*, 138, Article 107046.
- Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE Publications.