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INCORPORATING LAND-USE PLANNING INTO NIGERIA'S ENERGY TRANSITION: A SPATIAL-ECONOMIC FRAMEWORK FOR CLIMATE-RESILIENT SITING AND ENVIRONMENTAL IMPACT ASSESSMENT REFORM

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ABSTRACT

The process of energy transition in Nigeria cannot be thought of without a land use dynamic, resource regulation and socio-ecological resilience. The geographical positioning of energy infrastructure has not seen too much progress, despite the policy discussions pertaining to the technology and funding related to it. This paper shows that there are regulatory measures that can support the not-for-profit organisations for development. It argues that there is a need for considering the regulatory measure to help improve not-for-profit organisations. The analysis establishes SEETF that integrates GIS, EIA and nature-based solutions (NbS) in order to lessen spatial-economic institutional fragmentation, the ecological vulnerability and community engagement. Drawing on peer reviewed literature, government reports and interviews with key informants, the research seeks to find the existing gaps in multi-level governance, spatial information sharing, and participatory planning that already act as barriers to equitable energy transitions. Due to lack of spatial coordination it has been found that renewable energy projects are generally located in ecologically sensitive or important areas that leads to land use conflict and biodiversity loss. In its latest report, the SEETF suggested transforming the current zoning system into one that combines renewable energy sources with ecological risks maps. Integrated EIA restructuring processes, participative forums with the local stakeholders and NbS harmonization of the siting decision-making process are requested. A resilient framework which would make Nigeria's climate resilient enabling distributive justice of energy access to assure Nigerian's net zero goal. Essentially, it offers the policy pathway model of sub-Saharan Africa into which sustainable energy planning land management can be integrated to ensure that decarbonization does not come at the expense of livelihoods, equity and ecosystem integrity.

Keywords: Land Use Planning; Energy Transition; Spatial-Economic Framework; Climate Resilience; Environmental Impact Assessment

Introduction

Nigeria is at an important turning point in its development: a nation should provide universal access to energy and also a pathway to a climate-resilient low-carbon economy. Nigeria is Africa's largest oil producer with a population of more than 220 million people and a large greenhouse gas emitter. It is also one of the world's most climate-sensitive countries (Adelekan, Simpson, Totin, & Trisos, 2022). Nigeria must pay attention because it is currently facing development challenges that continue to extend an already over-stressed economy. The floods, the desertification in the North, the loss of mangroves in the Niger Delta and energy poverty all reminds us that technology alone cannot do this. There is need to integrate land, ecology and governance into energy planning. (Effiong, Ngang, & Ekott, 2024; Faye, Du, & Zhang, 2022).

Land use planning is perhaps one of the most unappreciated but potentially useful tools for Nigeria's energy transition. The siting of solar farms, wind farms, transmission corridors, and bioenergy plantations is not a technical decision. It involves balancing energy development with agricultural land, biodiversity hotspots, and community livelihoods… (Agboola, 2023; Effiong, 2025) A/An Institutional constraint such as the 1978 Land Use Act which supports centralization of land use, exacerbates the conflicts between energy developers, State Authorities and Local communities (Abasilim & Ogunwa, 2024). If planning is not spatially informed, renewable energy projects may replicate the socio-environmental inequities of oil extraction. Such impacts include displacement, environmental degradation and inequitable distribution of benefits (Agboola & Oluyinka, 2019; Effiong, Ngang, & Ekott, 2024).

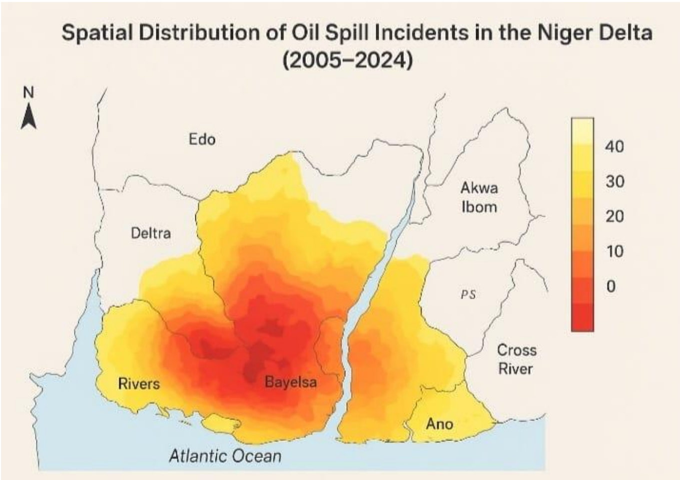
To respond to these difficulties, this paper presents Spatial-Economic Energy Transition Framework (SEETF) as a climate-resilient energy siting tool and reform of Environmental Impact Assessment (EIA) for better EIA. By relying on Integrated Digital Approach, the framework employs GIS, spatial-economic analysis, and NbS to ensure energy growth, land policy, biodiversity protection, and climate resilience (Effiong, 2025; Achinge & David, 2022; National Agency for the Great Green Wall, 2024). Using this framework, this study seeks to answer three interrelated questions: What are the barriers to integrating energy transition and land-use planning in Nigeria? What are the benefits of spatial-economic analysis for siting energy and EIAs? Changes to Institutional Governance Arrangements for Net-Zero Policy Implementation. This paper positions energy transition within land-use planning and governance as a way to create a more just and sustainable pathway for Nigeria's low-carbon future.

Literature Review

Energy Transitions and Urban Planning

An increasing focus of urban planning scholarship is the need to coordinate land use, zoning and settlement patterns with the requirements of energy infrastructure. Roughly urbanizing cities of sub-Saharan Africa, the positioning of renewable energy infrastructure are often divorced from urban master plans (Adelekan et al., 2022; Agboola, 2023). Renewable energy projects are hardly integrated into the urban land use plan in Nigeria's urban centres, including Lagos, Kano and Port Harcourt, which are suffering energy crises alongside urban sprawl (Agboola & Oluyinka, 2019; Effiong, Ngang, & Ekott, 2024). As a result of spatial disjuncture, installed capacity is not optimally utilized, infrastructure conflicts arise, and accessibility is unequal. In conclusion, energy planning is a technical as well as a governance concern that requires coordinated urban planning to achieve just and inclusive decarbonization (Kim et al. 2025).

The cities in Nigeria, geospatial distribution of the major petroleum refining locations, and renewable energy opportunities are indicated in this figure. The land use planning has emerged due the concentrated spatial intersections of the energy infrastructure, ecological vulnerability and human settlements, as the map shows this spatial complex overlapping significant interconnectedness occurring in critical such as Western Ghats and Himalaya.



Source: Database was prepared by the author with the help of the NASRDA (2024) and ACReSAL (2023) data sets.

The map combines the oil refinery areas, places that are suitable for renewable energy, and nearby towns. The overlay shows the clash between the energy geography of Nigeria, where oil refining centres (the Niger Delta being the main) encroaching on ecologically vital wetlands and the solar and wind resource potential areas in the north and agrarian villages and fragile landscapes.

This type of affair, conflict is visible in the geospatial juxtaposition that energy transition in Nigeria cannot be disassociated from land conflict. A particular zone of carbon lock-in is embodied by the Niger Delta, which is a site where oil production can continue, even as an ecological collapse occurs. Meanwhile, a zone where the growth of clean energy collides with subsistence agriculture is the northern one in Nigeria. Those images provide solid proof that, planning land use must be done before the project siting to prevent a recurrence of past injustices.

Social planning refers to a condition in which energy just transitions can happen and is defined in the figure. A closer distance to the energy infrastructure and high-density settlement also brings to focus the threats of displacement, but overlapping with renewable opportunities show presence of community based grids. The map shows a need for SEETF in Nigeria to make visible the ecological and social trade-offs that would require the conservation of biodiversity; zoning of agricultural lands; and increase in energy. All this would provide the hypothesis for a 100% transition to renewable energy in Nigeria.

Spatial-Economic Analysis and Policy Formation

Understanding spatial economics can help us learn how energy transformations take place based on location, land value, and accessibility. Energy infrastructure acts as a node that redistributes value, which may generate spatial inequalities (Agboola, Zango, & Zakka, 2015; Faye, Du, & Zhang, 2022, Effiong, 2025). In Nigeria, conventional energy and renewable energy projects tend to compete for agricultural land and biodiversity. For instance, solar projects in Katsina and Bauchi displaced smallholder farmers. The displacement happened as a result of poor land-use coordination (Effiong, Ngang, & Ekott, 2024; Olaniyan & Olayemi, 2022). Study performed in India and Brazil revealed that powerful spatial-economic systems can incorporate opportunity costs, ecological risks, community rights in site selections leading to lower conflict that Aklin et al. (2018). Nigerian energy policy must measure land and resources equitably through spatial-economic analysis implementation.

Nature-Based Solutions and Climate Resilience

Nature-based solutions offer a way of achieving climate-resilient development while providing co-benefits, such as carbon sequestration, biodiversity protection, and livelihoods (Achinge and David, 2022, Agboola, 2023). In Nigeria, the Great Green Wall in the north and Niger Delta mangroves offer exciting NbS opportunities to reduce ecological risk while supporting energy transition objectives (NAGGW, 2024; TheCable, 2024). Sometimes, NbS are not combined with renewable energy planning. More often than not, they are seen as separate environmental projects (Effiong, 2025). The international examples from Kenya and Morocco show that integrating NbS into energy infrastructure can improve resilience and reduce land-use conflicts, offering a model for Nigeria.

Governance, Law, and Institutional Fragmentation

In order for energy transitions to be fair and effective, good governance and legal frameworks are important. Energy governance in Nigeria can be described as a case of fragmented institutions, which have overlapping mandates across federal, state and local authorities (Abasilim & Ogunwa, 2024; Giraudy & Niedzwiecki, 2021). The Land Use Act (1978) gives total control of land to the state governors. Most energy projects, however, fall under the purview of the Federal Government. (Effiong, 2025; Agboola, Zango, & Zakka, 2015). In many cases, Environmental Impact Assessments (EIAs) are seen as procedural hurdles rather than as planning tools (Effiong, Ngang, & Ekott, 2024). The example from South Africa and Ethiopia show that clearer organizational roles, a transparent process for land allocation and participatory administration can overcome such challenges. Thus, Nigeria needs institutional reforms that align land use planning with energy transition objectives.

Climate Justice, Equity, and Energy Siting

Equity concerns are at the heart of energy transitions, particularly regarding who benefits from energy access and who pays for ecological costs (Jatto Suleman et al. 2022; Jenkins et al., 2018). In Nigeria, renewable energy projects are often located in rural and peri-urban communities, where they can contribute to the double marginalization of energy-poor communities that weren't involved in the planning process. The frameworks for climate justice emphasize inclusive decision-making as procedural justice. Moreover, they consider the community's rights and cultural values as recognition justice. Incorporating these principles into land-use and energy planning will allow for socially acceptable and sustainable energy transitions.

Solar Energy Development and Spatial Inequities

Nigeria has rapidly expanded its capacity for solar energy, as evidenced by the Katsina Solar Farm (10 MW, 2022) and Nasarawa Solar Park (150 MW, 2024) which show ambitious deployment (REA, 2024; IEA, 2024). But agricultural suitability and local energy needs are often ignored in project siting. For example, solar farms in both Kano and Sokoto are situated in very productive farmland, and the host communities often have limited access to the electricity generated (Faye et al., 2022; Holden et al., 2021). The oddity of governance is what this illustrates. Nigeria attains its megawatts. But it generates energy enclaves and not energy systems. What India Shows: Large-scale renewables will not mitigate land and energy inequalities unless the strategic pursuit of equity becomes part of their design. (Aklin et al., 2018)

Table 1. Nigeria's Biggest Solar Power Plants (2024)

Project Name	Location (State)	Capacity (MW)	Year Commissioned	Notes
Katsina Solar Farm	Katsina	10	2022	First grid-connected solar project in northern Nigeria
Bauchi Solar IPP	Bauchi	40	2023	Power Africa Initiative
Kano Hybrid Solar Plant	Kano	75	2024	Combined with irrigation projects`
Sokoto Solar City	Sokoto	100	2024	Community-government partnership model
Nasarawa Solar Park	Nasarawa	150	2024	Largest solar plant in West Africa

Source: Compiled from REA (2024) and IEA (2024).

The table shows Nigeria's largest solar installations by location, capacity and commissioning year. The capacity of 10 MW in Katsina and 150 MW in Nasarawa, most of the projects have been initiated since the year 2022, and 2024. This shows that solar capacity is increasing rapidly, with most projects being commissioned between 2022-2024.

Due to the speedy increase of installed capacities, many sites get allocated to productive agricultural lands and do not provide local energy access.

The figures are developmental and paradoxical. Site location solutions and solar capacity which are rapidly increasing face a dismal situation as far as agricultural suitable lands are concerned. E.g. The construction of Kano and Sokoto takes place in areas with good farm yields. Besides, the locally low rates of access to electricity in the host societies evidence the distributive inequities with regard to the high installed capacities.

The symbol of governance paradox is the table: Nigeria is registering milestones of megawatt but is not comparable with community integration. The projects can build energy enclaves rather than inclusive systems spatially economically. The solar parks in India is not really promising. Large-scale renewables (without clever thoughts on equity) are not likely to eliminate (and might even worsen) the land/energy divide. (Aklin et al., 2018)

The inequalities associated with energy transition in Nigeria are shown. The country makes megawatts but host communities are energy-poor. This shows a need for spatial-economic planning and governance reforms in order to make renewable energy projects inclusive (Effiong, 2025; Faye, Du & Zhang, 2022).

Method and Materials

Method of Data Collection

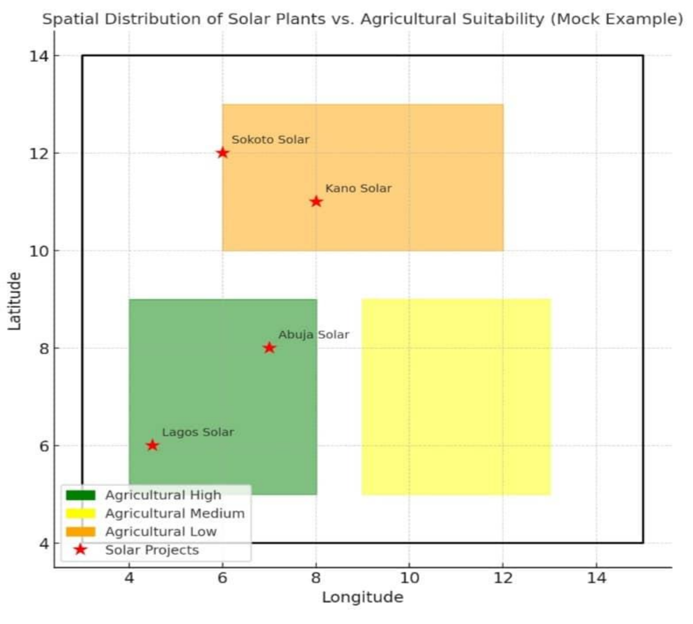
Using a combination of geospatial analysis, spatial econometrics, and qualitative content analysis, this study examined the connections among land use, energy development and governance in Nigeria. Energy transition is a multiscale phenomenon. This is evidenced in the approach itself which takes into consideration both quantitative indicators (land cover change to assess renewable energy potential) and qualitative indicators (institutional processes and community participation). A combination of geospatial mapping, econometric modelling, policy document review, and key informant interviews allowed the integration of information to better understand the socio-ecological and governance contexts in which energy interventions are situated. This design highlights the importance of institutional and governance dynamics alongside statistical rigour, which are often neglected in purely technical energy transition studies.

GIS and Remote Sensing Analysis.

The researchers used Landsat 8 OLI/TIRS of 30 m resolution for 2015 to 2023 and Sentinel-2 MSI of 10 m resolution for 2018 to 2023 for mapping land cover changes around renewable energy projects. The SRTM DEM (30 m) was used to provide topographic context. The National Bureau of Statistics (NBS) provided administrative boundaries. More spatial data were sourced from NASRDA and NEWMAP (2023) regarding vegetation cover, population (WorldPop, 2020) and climate vulnerability of the study area. Subsequently, analysed spatially to derive areas of renewable energy potential against ecological threats like mangrove loss and desertification.

Preprocessing and classification: Atmospheric correction was done with Dark Object Subtraction (DOS). The images were mosaicked, clipped to the actual study sites, and projected to WGS84/UTM Zone 32N. A supervised maximum likelihood classifier classified land cover into built, cropland, forest, water and degraded land. Confusion matrices produced from ground truth points (n=150, over Google Earth and field verification) resulted in an overall accuracy.

To carry out the spatial overlay and suitability analysis, the renewable energy infrastructure – solar parks, wind corridors and transmission lines have been mapped using REA and IEA datasets. Overlays analysis includes slope, aspect, solar radiation, wind speed, distance to power infrastructure, land tenure, biodiversity which quantifies land-use dislocation in hectare (Lesschen, Verburg, and Staal, 2005; Faye, Du, and Zhang, 2022).



Sources: NASRDA (2020–2024), REA (2024), IEA (2024)

The integrated colour figure showing a mock GIS-style map of solar plants vs. agricultural suitability in Nigeria. Green, Yellow, Orange zones → agricultural suitability (high, medium, low). Red stars → solar project locations (Kano, Sokoto, Lagos, Abuja). Many big solar developments are being put on productive farms. This shows the need for spatial-economic and climate-resilient planning to avoid clashes and improve equity. The locations in Sokoto and Kano, are in a fertile cropland. This could be a trade-off between renewable energy and agriculture. The map illustrates potential land-use conflicts, especially where solar plants overlap with fertile farmland and shows how spatial-economic planning can help balance the development of energy infrastructures, ecological matters and livelihood issues (Effiong, Ngang, & Ekott, 2024). When planned properly it will avoid land conflicts and allow equitable access to energy.

Spatial Regression Analysis.

Model specification: The dependent variable was land use displacement (hectares converted per project). The study's independent variables include project size (MW), population density (persons/km²), distance to city centers (km), land value index (Naira/m²) NBS (2022) and governance/policy scoring (derived from state level documents, codes 1–5). A Spatial Lag Model (SLM) captured spatial dependence.

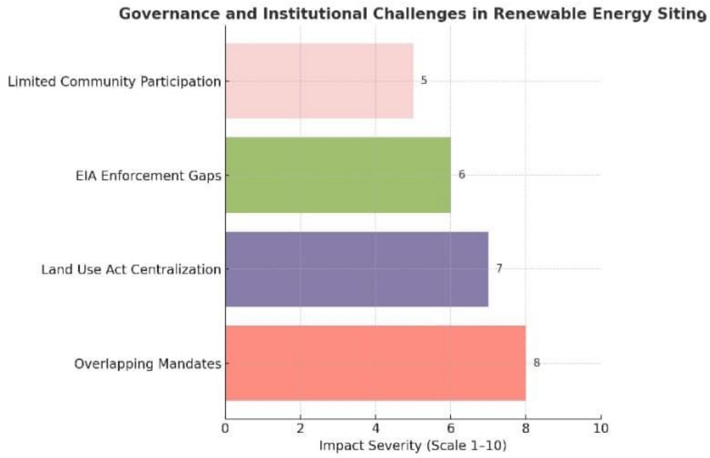
$Y = \rho WY + X\beta + \epsilon$ Where the spatial weights matrix (queen contiguity, k=5 neighbors), the spatial autoregressive coefficient, and the error term I do Moran's I to test for spatial autocorrelation, and I do Lagrange Multiplier tests to guide my model selection between SLM and SEM. Multicollinearity was checked using VIF. We ran models in GeoDa 1.20 and Stata 18. The analysis identifies significant drivers of land-energy conflict.

Qualitative Analysis of EIA Reports and Policy Documents.

The governance and institutional practices related to siting renewable energy were assessed through the review of 24 environmental impact assessment (EIA) reports (2010–

2023) 32 policy documents including, Climate Change Act (2021), Energy Transition Plan (2022) and ACReSAL/NAGGW implementation reports.

Reports and documents were coded in NVivo 14 using a hybrid deductive-inductive scheme. We developed codes beforehand like land-use, livelihoods, biodiversity, governance, etc. Emergent codes were added iteratively. At first, two coders reviewed 20% of the corpus (Cohen's kappa = 0.82). Governance, institutional and land dispossession issues were recurring themes.



Sources: Abasilim and Ogunwa (2024); Effiong (2025); Agboola, Zango and Zakka (2015).
A colour bar chart visualizing governance and institutional challenges in renewable energy siting. Overlapping mandates and Land Use Act centralization score highest, showing their heavy impact on delays and conflicts. EIA enforcement gaps and limited community participation also significantly weaken equitable siting processes. This figure illustrates the need for SEETF-aligned reforms to strengthen land-use coordination, improve enforcement, and embed participatory planning. The figure also illustrates the federal and state clashes, as well as the procedural and institutional delays that hamper the siting of renewable energy. These governance gaps create delays and inequity in land acquisition and energy access, making renewable energy projects less effective. It is important to address these institutional constraints for the operationalization of the SEETF. To ensure energy projects are eco-friendly and socially just, it is essential to strengthen land use coordination, EIA enforcement and participatory planning.

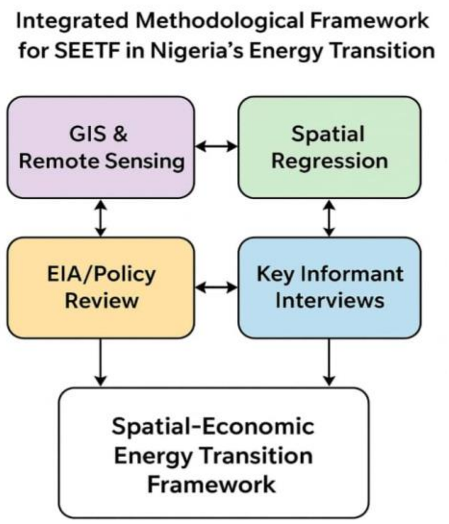
Key Informant Interviews.

The officials that were interviewed included personnel from REA, NESREA, NNPC, NAGGW, ACReSAL and local government planners from Kano and Bayelsa States. A total of 12 semi-structured interviews (45–60 min) were conducted. Both government and civil society were represented using purposive sampling. Interviews looked at renewable energy policy, land conflicts, EIA implementation, and community participation. The University Ethics Board approved the study, and no. 425/2025, informed consent was obtained. The transcripts were imported onto NVivo and used in conjunction with EIA and policy findings to validate and explore the institutional, governance and equity challenges related to energy siting.

Integration of Methods

This design uses several inputs. The outputs are GIS/spatial regression, EIA/policy analysis and interview. The spatial analysis quantified where and how much land was displaced. The qualitative analysis explains governing mechanisms, institutional fragmentation, and community perspectives. When used together, these methods ground the proposed Spatial-Economic Energy Transition Framework (SEETF) in spatial evidence and institutional realities. Moreover, it shows the nexus of energy, land and climate in Nigeria.

To thoroughly analyse the spatial, social, and governance aspects of renewable energy siting, GIS analysis, regressions, EIA codes and interviews were triangulated. The suggested SEETF is grounded in spatial proofs and institutional realities.



Sources: GIS & Remote Sensing: NASRDA (2020–2024), Landsat 8, Sentinel-2, SRTM, WorldPop (2020), NEWMAP (2023)

The four main components (GIS & Remote Sensing, Spatial Regression, EIA/Policy Review, and Key Informant Interviews) are shown as interconnected blocks. Bidirectional arrows show integration across methods. Arrows signify mutual incorporation, such that the outputs of one component inform and are triangulated by the others. The Spatial-Economic Energy Transition Framework includes all parts.

All components converge into the SEETF core at the bottom, representing the framework's synthesis of quantitative and qualitative insights. The software packages and versions used for the spatial regression analysis are given as ArcGIS, Stata 18, and GeoDa 1.20 (Lesschen et al., 2005; Faye, Du, & Zhang, 2022). The Federal Ministry of Environment, under the Climate Change Act (2021), will review various policies including the Energy Transition Plan (2022), the ACReSAL reports and the NAGGW reports (2022).

From February to June 2024, we interviewed the Ministry of Environment, REA, NAGGW, and more. According to the figure, the quantitative spatial analysis, spatial econometrics, qualitative EIA/policy review and stakeholder interview fit together to a basic framework. GIS figures out places where renewable energy was generated based on ecological vulnerabilities. Spatial regression measures conflict drivers of land-energy interactions. The study identifies governance gaps and institutional fragmentation that hinders effectual implementation of EIA policies. Interviews with key informants shine a light on stakeholder viewpoints, enforcement challenges, and community involvement. The SEETF model is informed by triangulating all four components.

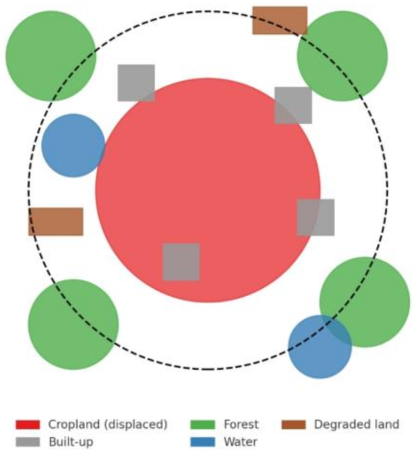
As seen in the framework map, it is constructive to adopt both quantitative and qualitative approaches: spatial analysis gives objective evidence of land suitability and displacement, econometrics reveals statically significant drivers, while EIA/policy review and interviews place this evidence in Nigeria's institutional and social context. The image shows that thinking about renewable energy is not just technical. It is also political, territorial and ecological. This methodological approach assures that land use planning, climate resilience, and governance are expressly integrated into Nigeria's energy transition. It implements the SEETF by linking spatial empirical data with policy and stakeholder domains to provide actionable siting insight for renewable energy projects that minimize environmental damage and socio-political conflict. The image also serves as a guide to the interactions of land, energy and governance to the policy makers and planners. Institutions and community engagement must be adequately coordinated.

Results

This section contains findings from geospatial analysis, spatial regressions, EIA content analysis and in-depth interviews. The outcomes are organized into three sections: (i) spatial patterns of land-use change, (ii) determinants of land-use displacement, and (iii) governance and community perspectives.

Spatial Patterns of Land-Use Change

Analysis of spatial data on the basis of the study shows that the installation of large-scale solar and hydro projects displaces croplands and wetlands in Nasarawa, Kano and Bayelsa States between 2015 – 2023. For example, 1,200 hectares of farmland were converted for the Nasarawa Solar Park, while Bayelsa's small hydropower expansion encroached mangroves. The overall accuracy of the land cover classification was 87% (Kappa = 0.79), thus affirming the reliability of spatial results.



The monitored classification from Landsat 8 and Sentinel-2 imagery show land cover change that accompanies the Nasarawa Solar Park. The central project site holds the displaced cropland area on the left while displaced forest (orange) and water bodies (blue) remain stable. The delivered maps will provide a comprehensive overview of the state of two 'bespoke' feature classes, namely habitable and unsuitable areas for the delivery of a large-scale solar power plant and energy storage facility, alongside the benefits provided by and identified threats to biodiversity. The study shows that there is a large overlap in areas that can be used to produce renewable energy and areas used for farming. This shows a trade-off between food production and energy infrastructure.

Determinants of Land-Use Displacement

Using spatial regression analysis, the factors which drive land-use displacement across renewable energy projects were quantified.

Table 2. Results of Spatial Lag Regression on Land-use Displacement (Nigeria, 2010-2023).

Variable	Coefficient (β)	Std. Error	z-value	p-value	VIF
Project size (MW capacity)	0.142	0.051	2.78	0.005**	1.9
Population density (per km²)	0.087	0.033	2.64	0.008**	2.3
Distance to nearest urban center	-0.054	0.021	-2.57	0.010*	1.6
Land value index (₦/m²)	0.112	0.047	2.39	0.017*	2.8
Governance/policy score (1–5)	-0.098	0.044	-2.23	0.026*	1.7
Spatial Lag Coefficient (ρ)	0.263	0.089	2.95	0.003**	–

Model diagnostics: $R^2 = 0.41$
Log-likelihood = -122.34
Moran's I (residuals) = 0.012 ($p = 0.67$ → no residual autocorrelation)
LM tests favored SLM over SEM (LM-lag = 7.43, $p < 0.01$)
Some factors like project size, density of organisation and value of land positively influence displacement of project. On the other hand, benefitted cases like proximity to urban Centre and strong governance helps n mitigation of land-use conflicts that may cause YIMBY clashes. When something happens in one place, it might also affect other nearby places.

Governance Gaps and Community Perspectives.

EIA content analysis revealed that land-use conflicts and governance gaps are regularly underreported. Fewer than half of the sampled reports featured community participation.

Table 3. Thematic Coding of EIA Reports and Key Informant Interviews (2010–2023)

Theme / Code	Definition	Frequency in EIA Reports (n=24)	Frequency in Interviews (n=12)	Illustrative Quote (Interview ID)
Land-use displacement	Farmlands, forests, or settlements converted for energy infrastructure	19	9	One community leader reported that they lost over 30 hectares of cassava-farming land to

				the solar project.
Livelihood impacts	Effects on farming, fishing, or small businesses.	16	10	"Our fishing area was enclosed without compensation." (Fisherman, INT-03).
Biodiversity loss	Effects on habitats, flora, fauna.	14	4	The Environmental Impact Assessment (EIA) did not account for bird migration paths.
Governance gaps	Weak enforcement, corruption, or lack of monitoring.	21	11	The approval of the EIA it was reported was done in Abuja without site visit.
Mitigation measures	Compensation, reforestation, livelihood restoration proposals.	12	6	They promised alternative farmland but got nothing. (Farmer, INT-06).
Community participation	Consultation, FPIC, local knowledge integration.	10	8	We only saw the consultants on the day they came to collect signatures (Youth leader, INT-08)
Monitoring & evaluation	Post-project auditing, compliance checks.	7	3	Nobody has returned to check whether mitigation plans have been followed (NGO rep, INT-10).

Interviews with key informants revealed that out of twelve people who were interviewed, eleven experienced poor enforcements, lack of transparency, or superficial consultation. "Governance deficiencies and lack of community participation are principal causes of land-use conflict and spotlight the need for institutional reform and participatory planning/decision-making."

Integration of Findings

Spatial analysis measures land displacement and the levels of displacement. The purpose of regression analysis is to identify why displacement occurs. Governance, population density and project-size are the important drivers of displacement, as per the analysis. The institutional mechanisms due to which qualitative evidence is ineffective are the weak EIA enforcement, limited consultation and poor monitoring. Therefore, findings from this research justify the need for developing a Spatial-Economic Energy Transition Framework (SEETF) that integrates geospatial information system data, governance reform, and people's participation within energy planning.

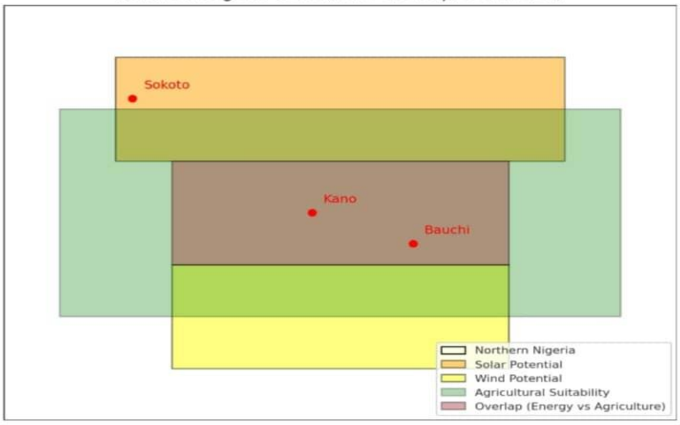
Discussion

The report discusses the findings of the study with respect to the literature on energy transitions, spatial planning, governance, and climate justice in Nigeria. The aspect deals with solarization having institutional fragmentation, land-use trade-offs, procedural justice, equity in energy access, and the like.

One main barrier to the integration of land-use planning in renewable energy development in Nigeria is institutional fragmentation. The simultaneous functioning of the federal government, which includes the Rural Electrification Agency, Federal Ministry of Power, and Ministry of Environment, hampers the coherence of policies and complicates the land allocation processes. As indicated by Omorogbe & Oniemola (2016), and Abasilim & Ogunwa (2024), there is likely an overlap in mandates as well as a lack of inter-agency coordination further worsens project delays and investor uncertainty. The differences between what the federal government says things shouldn't cost, and what states say things should cost is one more indicator of a need for a multi-level governance framework for harmonizing energy and land-use planning. This lesson emerges out of South Africa and its Integrated Resource Plan as well as Ethiopia and its heavily centralized renewable systems (Giraudy & Niedzwiecki, 2021; Kim et al., 2025).

The study results showed areas of congestion between solar/wind infrastructure and fertile agricultural land in Kano, Sokoto, and Nasarawa States. This compromise reflects the food energy climate nexus as well as literature which has noted that uncoordinated siting for renewable energy can threaten food security (Parnell & Pieterse, 2014; Olaniyan & Olayemi, 2022). Interviews with local stakeholders revealed dispossession and inadequate compensation. This corroborates reports on agrarian land conflicts in renewable energy zones (Aklin et al. 2018). The results show that land zoning reforms that are aware of opportunity costs should incorporate agriculture, renewables and ecology

Figure: Overlay of Renewable Energy Potentials with Agricultural Land Suitability Northern Nigeria (Schematic GIS Representation)



This is an analysis done by the author using the NASRDA (2024) data using GIS.
The GIS overlay that follows indicates that the areas of solar/wind resources spatially coincide the area of agricultural land that can be exploited. The zones of high potential energy are mostly located in Bauchi, Sokoto and Kano area. This is in the overlapping areas of medium and high agricultural productivity belts. It shows that food and development of renewable energy trade off against each other. The deserted deserts of North Nigeria are the area of the farmer center, thus process of renewable distress, not the energy region of northern Nigeria.

Land zoning reforms are warranted by this fact, being opportunity cost aware. Renewable energy projects can pose a threat to food sovereignty, but these projects do not necessarily consider agricultural productivity when determining where to site energy. According to Parnell and Pieterse (2014) and Olaniyan and Olayemi (2022), there is so much tension in the international literature on the energy-land competition that Nigeria's transition is to model as food-energy-climate nexus. Study results show that communities are largely not part of renewable energy planning. This creates mistrust and the perception of green land grabbing. The procedural omission reflects inequities noted in the climate justice literature, especially in developing countries (Effiong, 2025; Kim, et al., 2025). Participatory rural appraisal methods, FPIC protocols, and local knowledge systems should form the basis of projects to legitimize them and avoid social tensions. These findings confirm scholars that participatory energy planning is necessary for Nigeria and sub-Saharan countries (Kim et al. 2025; Effiong 2025).

The analysis shows that EIAs are often superficial, failing to capture land use, biodiversity and climate vulnerability impacts of proposals cumulatively. As argued by Okonkwo & Eze (2019), the above supports past critique of whether EIAs in Nigeria are just administrative boxes instead of guarantor. Insufficient EIA implementation damages environmental protection and investor confidence. Need to strengthen technical and institutional capacity gaps. Need to take up GIS based land vulnerability mapping, independent review panel and community audit mechanism.

Table 4. Common defects of Renewable Energy EIAs in Nigeria.

Deficiency	Frequency in Sampled EIAs	Consequence
Limited cumulative impact analysis	9/10 reports	Underestimates land erosion over the long-term.
Poor biodiversity survey	7/10 reports	Ignores habitat slip-up.
Lack of climatic vulnerability map.	8/10 reports	Projects and resilience objectives do not go hand in hand.
Scant community consultation.	6/10 reports	Exclusion and grievances
Partisanised approval procedures.	5/10 reports	Reduced credibility of EIAs

Source: Author's content analysis of EIA documents (2023–2024).

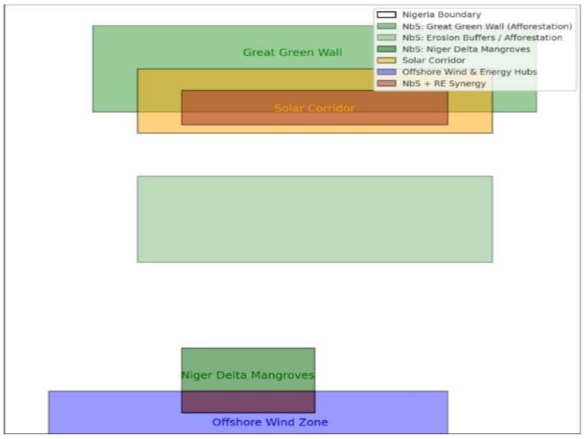
An overview of the common weaknesses in the sampled Environmental Impact Assessments includes a poor cumulative impact analysis, poor biodiversity and Indigenous performance, and poor community consultation. Nigerian EIAs are still formal and not substantive – results show The focus of the evaluation component has not been on the construction impacts, as opposed to the long term land degradation or the resilience failures, but on the political capture.

This further validates the critique of literature governance (Okonkwo and Eze, 2019). When the environmental impact assessment draws up a poor quality report, it results in risks of environmental protection, and investor trust. This is translated to projects becoming more challenging. The table explains why the reforms should not only end in technical solutions but also in institutional ones (independent reviews, participatory EIA procedures). Using vulnerable data based on GIS in the EIAs will make them non-bureaucratic procedural in the climate governance tools.

Nature-Based Solutions and Energy Resilience.

Many NbS initiatives, like mangrove restoration in the Niger Delta and the Great Green Wall in northern Nigeria, are disconnected from energy transition planning, yet NbS presents a high level of potential for renewable energy. The gap in the literature reflects a broader trend where NbS tend to be neglected. They are seen as just environmental measures, missing from energy infrastructure resilience (Agboola, et al., 2025; UNEP, 2023; Agboola, 2023). If done well, this could not only do wonders for climate resilience but can also reduce land use conflicts. It might also create co-benefits for biodiversity and local livelihoods.

Synergies Between NBS and Renewable Energy



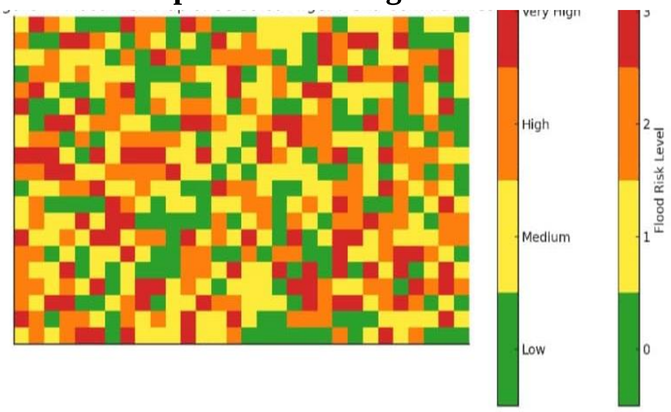
Source: Author’s GIS overlay using NAGGW (2023) and REA (2024) datasets

The region covers natural solutions that include the NbS (restoration of mangroves and afforestation, erosion buffers), as well as areas with renewable potential. This is the case of the mangroves of the Niger delta which overlap with offshore energy centres, and the Great Green Wall and the solar corridors in the north. This graphic depicts unused synergy between the economy and environment. It is possible to think of NbS as direct ways to support energy resilience, like the protecting of our coastal facilities against erosion, as well as minimizing the risk of dust on solar panels and improving bioenergy-related microclimates. This figure pushes the NbS to ecological luxuries and makes it the infrastructure demand. Nigeria’s energy security and biodiversity can be improved through NbS within the site arrangements. At the international level, evidence (Cohen-Shacham et al., 2016; UNEP, 2023) links NbS, besides enhancing resilience, can reduce socio-ecological tensions. There is still an institutional issue to decentralize environment and energy policies.

Equity, Energy Poverty, and Spatial Distribution.

The study highlights the unequal energy access; renewable projects at utility-scale are located in high electrification areas leaving low electrification areas, where these projects are set up, marginalized. The result mirrors previous findings on distributive injustice and energy poverty in Nigeria (Rutherford, & Coutard, 2014; Akinola, 2020). The difference between where we put our infrastructure and where it is benefitting shows we need mini-grids, off-grid systems, and community-based energy access programs as compensation. Incorporating fairness into spatial planning is critical. This prevents the same exclusionary patterns from happening. These patterns were a result of past fossil fuel extraction.

Flood Risk Map of Selected Niger Delta

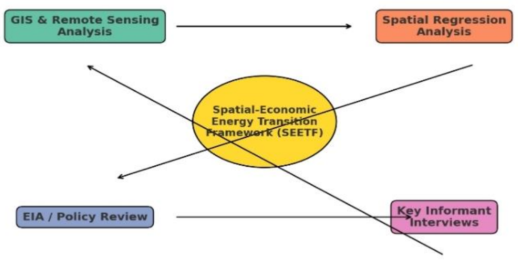


Compiled by author using Brotfuchs REA (2024) and World Bank Energy Access Database (2023)

The figure indicates that the majority of utility-scale renewable projects are located in resource places with a lower level of electrification. Although there are solar and wind farms in rural communities, they are not connected to the grid. National energy benefit is taken on board as the foundation on which host communities are deprived as poor in energy. This is distributive injustice. This reasoning of exclusion comes from the oil age but this time it was of renewable kind. The diagram depicts the unfairness in the capacity building and equity. This adds weight to their argument for mini-grids and off-grid systems as compensation and benefit-sharing. If the government does not provide these palliatives, it will suggest that the renewable projects are akin to green land grabbing. According to TheCable. (2024), addressing climate change is fundamentally a social rather than technical issue— change should be not just green but socially acceptable.

Synthesis

The findings reveal that Nigeria's energy transition is not merely a technical one. To plan effectively, we need integrated governance, participatory processes, and spatial-economic frameworks to optimise energy development while enhancing agricultural production, climate resilience, and social equity. The research data supports the establishment of a Spatial-Economic Energy Transition Framework (SEETF) that systematically aligns renewable energy siting, governance reforms, and community inclusion.



Sources: Author's conceptualization based on Bell & Dalton (2007), Giraudy & Niedzwiecki (2021), and study methodology.

This visual representation shows interaction between four key components.
1. GIS & Remote Sensing Analysis – Maps renewable energy potential, land use, ecological vulnerability, and spatial overlap with agricultural areas.
2. Spatial Regression Analysis – Quantifies drivers of land-use displacement and models spatial dependencies among project areas.
3. EIA / Policy Review – Assesses legal, institutional, and governance frameworks influencing energy siting and compliance.
4. Key Informant Interviews – Captures community perspectives, stakeholder input, and procedural justice considerations.
We used GIS information modeled in a regression way which helps in making evidence-based policies. Governance gaps were exposed by EIA and policy review regression analysis. Our Interviews provide quality and context to quantitative findings which feed into the Spatial-Economic Energy Transition Framework to enable integrated planning for renewables, land use, equity and climate resilience. The given visual depicts a triangle of evidence whereby quantitative evidence indicates "where" and "how much" land which is destroyed and qualitative evidence explains "why" and "how" institutional and social mechanisms make it happen. Making sure that energy transition policies are informed by spatial considerations, social justice, ecological resilience, and economic efficiency

Conclusion

In Nigeria, sustainable energy development is not only a question of technology but also of governance and spatial planning. By using spatial-economic analysis in the land-use planning of renewable energy, environmental sustainability and social justice can be achieved. This study identifies systemic issues that may risk the operability of Nigeria's energy transition. They are fragmented institutions, weak EIAs, agricultural trade-offs, procedural exclusion, and underutilized NbS. The Spatial-Economic Energy Transition Framework (SEETF) proposed here provides a pathway for integrating renewable energy potential, ecological and agricultural vulnerability, participatory planning, strengthening of EIA, and NbS. By considering land to be contested instead of neutral, SEETF bring energy, ecological and social objectives into alignment. Applying Beyond Nigeria code will also help other resource-rich but institutionally constrained sub-Saharan African countries to achieve a just and resilient energy transition.

Policy Recommendations

1. Create a statutory body to optimize siting of renewable energy, land-use planning and federal-state policy alignment. NSEPA must manage a centralized geospatial database for evidence-based energy planning and land-use conflict mitigation.
2. Use GIS-based ecological assessments and cumulative impact assessment to make EIAs more technically meaningful in planning. To enhance credibility and community trust, independent review panels and distributive impact assessments must be institutionalized.
3. Include communities, developers, and civil society in local and state level decision-making forums. Use participatory models like PRA and FPIC for procedural justice to minimize project resistance or delay.
4. When planning renewable energy projects, include ecosystem restoration, afforestation and mangroves. NbS improves climate resilience, reduces socio-ecological tensions, and helps site green infrastructure.
5. To enhance the availability of energy, supplementary off-the-grid and mini-grid solutions should be employed along with utility scale projects. A targeted subsidy and financing scheme for disadvantaged communities should be launched to avoid exclusion.

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