



Governing the Nexus: Policy and Practice for Water-Energy-Food Security in Katsina State, Northern Nigeria

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Abstract

Original Research

The interlinkages between water, energy, and food systems collectively known as the Water-Energy-Food (WEF) Nexus represent one of the most urgent governance challenges for dryland states in sub-Saharan Africa. Katsina State in Northern Nigeria epitomises this challenge: it is simultaneously one of Nigeria's foremost agricultural states, a region chronically exposed to Sahelian drought and desertification, and a jurisdiction where energy poverty constrains irrigation and agro-processing at every turn. This paper investigates the governance structures, policy frameworks, and practical realities of WEF nexus management in Katsina State. Drawing on a structured questionnaire administered to 300 households across six Local Government Areas (LGAs), complemented by 24 Key Informant Interviews (KIIs) with government officials, civil society actors, development partners, and community leaders, the study maps the interlinkages and trade-offs among the three resource domains and assesses the coherence of existing policies. Findings reveal severe fragmentation in institutional mandates, inadequate inter-sectoral coordination, underperforming subsidy programmes, and a marked gap between federal policy ambitions and local implementation realities. The paper argues for a dedicated Katsina WEF Nexus Governance Framework anchored in participatory planning, renewable energy integration, and adaptive water allocation. Policy recommendations are offered for state and local governments, federal ministries, development banks, and international development partners.

Keywords: Water-Energy-Food Nexus, Resource Governance, Drylands, Policy Coherence, Climate Adaptation, Irrigation, Food Security.

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1. Introduction

The concept of the Water-Energy-Food (WEF) Nexus emerged prominently in the global development discourse at the 2011 Bonn Conference, catalysing recognition that water, energy, and food systems cannot be governed in isolation (Hoff, 2011). Each sector is deeply dependent on the others: irrigation agriculture is the

world's largest freshwater consumer, food systems account for roughly 30 percent of global energy consumption, and energy production from hydropower to thermal generation is itself a major water user (FAO, 2014). In the Global South, where institutional capacities are constrained and climate stress is accelerating, the governance of this nexus presents extraordinary complexity.



Nigeria, as Africa's most populous nation and largest economy, encapsulates these tensions at national scale. The country faces an estimated water deficit of 79 billion cubic metres by 2030, rural electrification rates remain below 45 percent, and over 40 percent of the population are food-insecure (World Bank, 2022; NBS, 2023). These challenges are not uniformly distributed: they are most acute in the semi-arid North, where Katsina State sits at the ecological frontier between the Sudan Savanna and the Sahel.

Katsina State is home to approximately 8.8 million people, the overwhelming majority of whom depend on rain-fed subsistence agriculture and pastoralism (NPC, 2022). The state receives between 500mm and 900mm of annual rainfall concentrated in a four-month growing season, making it acutely vulnerable to precipitation variability. Groundwater sources, while significant, are increasingly under stress from over-abstraction and sedimentation of recharge catchments. Electricity access via the national grid is intermittent and unreliable, compelling farmers to depend on costly diesel-powered water pumps, which in turn raises the cost of irrigated agriculture beyond the reach of smallholders. Soil degradation driven by desertification affects an estimated 60 percent of the state's land area (NEWMAP, 2019).

Despite this context, the governance of water, energy, and food in Katsina State remains largely siloed. The Ministry of Water Resources, the Ministry of Agriculture and Rural Development, and the Rural Electrification and Energy Ministry operate under separate budgetary frameworks, with minimal statutory mechanisms for cross-sectoral coordination. National policies including the Anchor Borrowers Programme (ABP), the National Irrigation Policy, and the Rural Electrification Strategy are implemented through vertical sectoral channels that rarely interface at the point of community-level impact.

This paper seeks to address this gap by providing an empirically grounded assessment of WEF nexus governance in Katsina State. It is guided by the following research questions: (i) What are the principal WEF nexus challenges confronting households and communities in Katsina State? (ii)

To what extent do existing policies and institutions address these challenges in a coherent and integrated manner? (iii) What governance reforms and practical interventions are required to advance WEF nexus security in the state?

2. Literature Review

2.1 The Water-Energy-Food Nexus: Conceptual Foundations

The WEF Nexus framework represents a paradigm shift from single-resource management to integrated systems thinking. Nexus thinking recognises that optimising one resource often creates trade-offs or synergies in the others (Bizikova et al., 2013). Bleischwitz et al. (2018) argue that nexus governance requires a transition from sectoral silos to collaborative platforms that enable trade-off analysis, joint planning, and resource efficiency. The seminal work of Hoff (2011) for the Stockholm Environment Institute conceptualised the nexus as a means to enhance human well-being while reducing environmental risk a framing subsequently adopted by the FAO (2014) and the United Nations Economic Commission for Europe (UNECE, 2015).

More recent scholarship has extended nexus analysis to sub-national scales, recognising that the nexus manifests differently depending on agro-ecological conditions, institutional configurations, and socioeconomic dynamics (Scott et al., 2015; Leck et al., 2015). In dryland contexts specifically, Rasul (2016) demonstrates that resource scarcity amplifies nexus interdependencies and that governance failures in one sector can rapidly cascade across the others. The relevance of this insight to Sahelian Nigeria is self-evident.

2.2 WEF Nexus in Sub-Saharan Africa

Studies of the WEF Nexus in sub-Saharan Africa have concentrated on East Africa's Nile Basin (Siderius et al., 2018), the Sahel region (Venot et al., 2017), and Southern African river systems (Nhamo et al., 2020). These studies consistently identify institutional fragmentation, inadequate infrastructure

investment, and climate vulnerability as the principal barriers to nexus security. Nhamo et al. (2020) specifically call for politically mandated nexus coordination units at subnational levels as a precondition for effective governance.

In the West African context, Sani and Scholz (2021). Analysed the accessibility of Water-Energy-Food Accessibility and Tracking Progress towards Achieving Sustainable Development Goals in the Savanah Region of Katsina State, Nigeria. Adeoti et al. (2016) examined energy-water-food linkages in Nigeria's irrigated agriculture, finding that the shift from gravity-fed to pump-based irrigation has dramatically increased energy dependency in the sector, with attendant cost and reliability consequences for smallholder farmers. Okafor and Umeh (2019) studied integrated resource governance in the Lake Chad Basin, arguing that transboundary nexus pressures require both national coherence and regional coordination a point reinforced by the work of Salkida (2020) on the shrinkage of Lake Chad and its implications for the riparian communities of Borno and Yobe States in Nigeria.

2.3 Water and Energy Governance in Northern Nigeria

Northern Nigeria's water governance has been extensively studied in the context of the Hadejia-Nguru Wetlands (Goes, 2002), the Kano River Irrigation Project (Adams et al., 1996), and the Komadugu-Yobe River Basin (Abubakar et al., 2018). These studies reveal a persistent disconnect between top-down infrastructure investments such as large dams and irrigation schemes and the livelihood needs of downstream communities. Governance arrangements often privilege large-scale commercial agriculture while marginalising smallholders and pastoralists (Blench, 2004).

Energy governance in the North is equally contested. The region has historically received lower per-capita electricity investment than the South, reflecting historical neglect as well as the challenges of low-density rural populations (NERC, 2021). Solar energy is increasingly positioned as a solution, and Katsina's relatively high solar irradiation averaging 5.5–6.0 kWh/m²/day makes it particularly well-

suited for photovoltaic applications (NASENI, 2020). However, capital constraints, limited technical capacity, and inadequate financing mechanisms have impeded widespread adoption.

2.4 Food Security Dimensions

Food insecurity in Katsina is driven by a complex interaction of climatic, economic, and structural factors. Bello et al. (2021) found that 68 percent of farming households in the state are unable to meet household caloric needs from own-production alone. Crop yield variability is the primary driver, compounded by high input costs, limited access to credit, and post-harvest losses estimated at 30–40 percent of production due to inadequate storage infrastructure (IFAD, 2020). The state's dependence on irrigated wheat and tomato production in the dry season sectors strongly linked to energy availability for pump operation makes WEF nexus integration directly relevant to food security outcomes.

3. Conceptual Framework

This study adopts an integrated nexus governance framework synthesising Hoff's (2011) WEF Nexus model, Ostrom's (1990) Institutional Analysis and Development (IAD) framework, and the Polycentric Governance approach articulated by Jordan et al. (2018).

The framework recognises three resource domains (water, energy, food) as interdependent systems whose governance is mediated by institutional arrangements, policy environments, infrastructure investments, and power dynamics operating across multiple scales from household to federal levels.

The conceptual framework identifies three analytical layers. At the resource layer, the physical interdependencies between water, energy, and food are assessed including the energy required for water pumping, the water consumed in energy generation, and the water and energy embedded in food production and processing. At the governance layer, the study examines the institutional mandates, coordination mechanisms, and policy instruments through which resource management decisions are

made. At the outcome layer, the framework evaluates the equity, efficiency, and sustainability of resource use patterns and their contribution to household and community well-being.

This framework is particularly suited to the Katsina context because it accommodates the vertical complexity of Nigerian federalism (where

constitutional authority over natural resources is distributed across federal, state, and local tiers) as well as the horizontal complexity of a multi-sectoral governance challenge. It also foregrounds the role of power and politics in shaping whose nexus priorities are addressed and whose are marginalised a critical dimension in a state characterised by significant gender and wealth disparities in resource access.

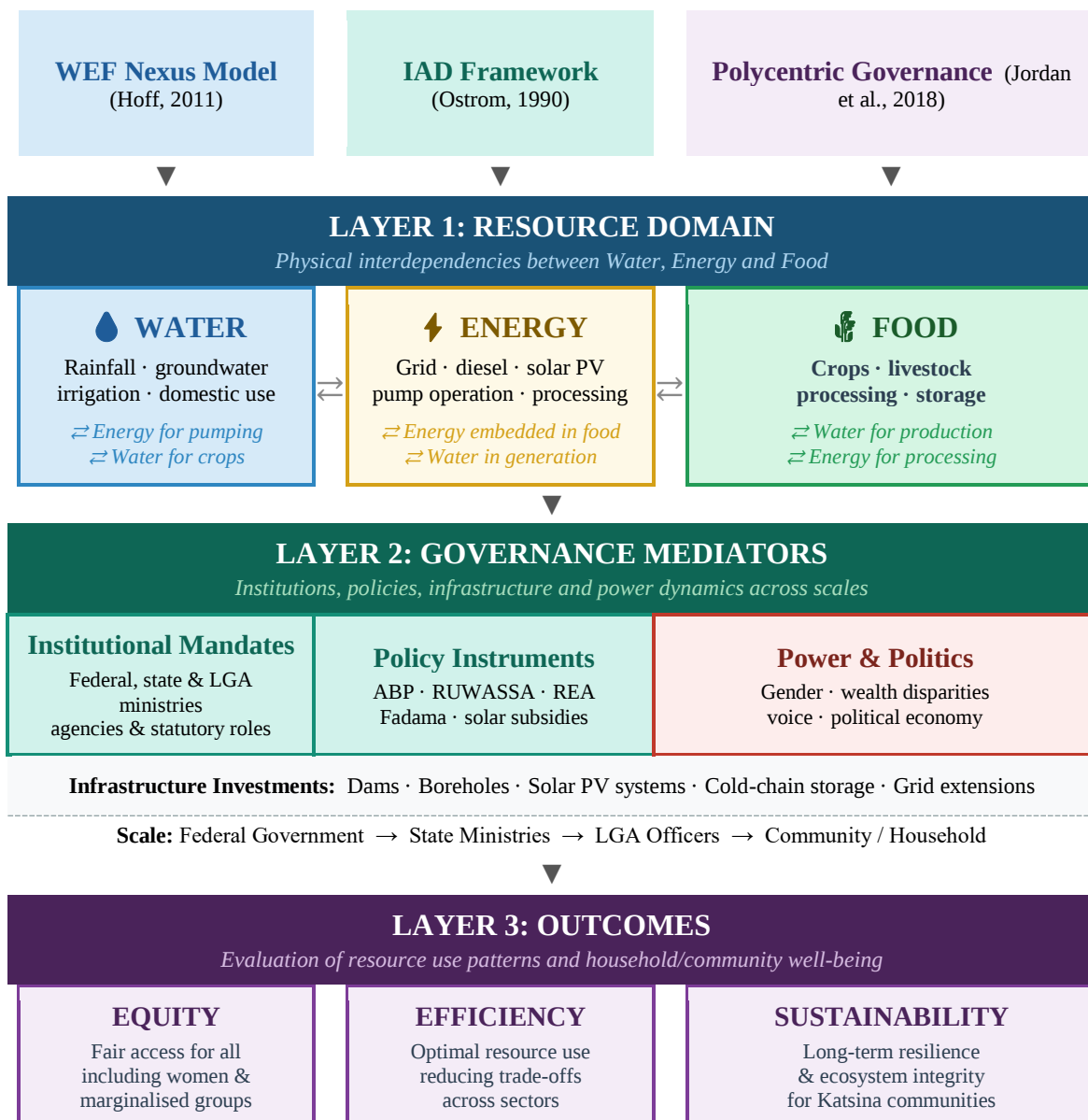


Figure 1: An Integrated WEF Nexus Conceptual Framework in Katsina State based on Hoff (2011); Ostrom (1990) and Jordan et al (2018)

4. Research Methodology

4.1 Research Design

This study employed a mixed-methods design combining quantitative household survey data with qualitative insights from Key Informant Interviews (KIIs). The mixed-methods approach was selected because the complexity of WEF nexus governance necessitates both statistical characterisation of resource challenges at scale and in-depth interpretive understanding of institutional dynamics and policy processes (Creswell and Creswell, 2018). The quantitative strand provides breadth and generalisability; the qualitative strand provides depth and contextual nuance.

4.2 Study Area and Sampling

A multi-stage stratified random sampling was used to select 400 households across four Local Government Areas (LGAs) within the three existing ecological belts in Katsina state (el-Tantawi, 2011). This captured agro-ecological, livelihood, and administrative diversity across Katsina State. The sampled communities were: Katsina (urban), Jibia (frontline, desertification), Dutsin-Ma (agrarian), and Funtua (southern southern agricultural belt). The designs of questionnaires and guides for interviews were in line with various standards covering sections on household characteristics and compositions as well as socioeconomic status.

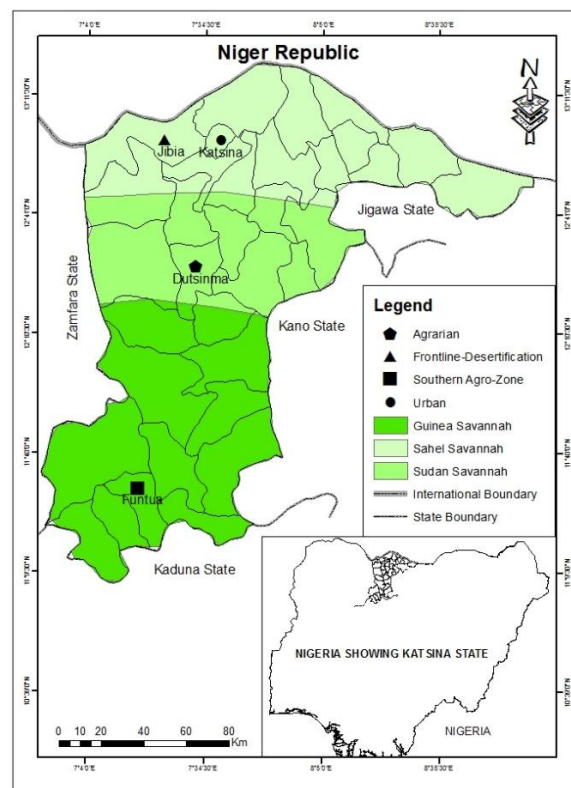


Figure 2: Map of the study area showing sampled communities

Within each community, households were randomly sampled using the systematic random sampling technique, with a sampling interval determined by the ratio of the total estimated household population to the target sample.

For the key informant interview (KII) component, 24 interviews were conducted with purposively selected informants spanning: state ministry officials (n=6), LGA-level officers (n=4), traditional and community leaders (n=4), development partner representatives (n=4), civil society and NGO actors (n=3), and private sector actors including solar energy entrepreneurs (n=3).

4.3 Data Collection Instruments

The household questionnaire comprised four sections: (i) respondent socioeconomic profile; (ii) water access, use, and challenges; (iii) energy access, use, and challenges; (iv) food production, sufficiency, and policy awareness. A five-point Likert scale was used to measure the severity of specific nexus challenges, with 1 indicating "not a challenge" and 5 indicating "an extremely severe challenge." Descriptive statistics means and percentages were computed for all scale items.

The key informant interview guide was semi-structured, covering institutional mandates and coordination experiences, policy design and implementation perceptions, stakeholder **relationships**, financing arrangements, and recommendations for reform. Interviews were conducted in English and Hausa (with professional interpretation where required), audio-recorded with informed consent, and transcribed verbatim. Thematic analysis following Braun and Clarke (2006) was applied to the KII transcripts, with themes deductively anchored to the conceptual framework and inductively generated from the data.

5. Study Area

Katsina State is located in the north-western geopolitical zone of Nigeria, between latitudes 11°08' and 13°22' North and longitudes 6°52' and 9°20'

East. It shares international boundaries with the Republic of Niger to the north. The state has a total land area of approximately 24,192 km², with an estimated population of 8.8 million people (NPC, 2022). It is administratively divided into 34 LGAs and comprises three senatorial districts: Katsina Central, Katsina North, and Katsina South.

The state's climate is semi-arid, characterised by two distinct seasons: a rainy season (June–September) with highly variable annual rainfall ranging from 500mm in the north to 900mm in the south, and an extended dry season (October–May). Harmattan winds, originating from the Sahara, intensify moisture loss and accelerate desertification during the dry months. The Sahara Desert is advancing southward at an estimated rate of 0.48 km per year in the state, threatening cultivable land and groundwater recharge zones (FMENV, 2021).

Agriculture accounts for approximately 70 percent of the state's GDP and employs over 80 percent of the working population. Major crops include groundnut, cotton, cowpea, sorghum, millet, and irrigated wheat and tomatoes. Livestock keeping; cattle, sheep, and goats is widespread and forms the primary livelihood of a significant Fulani pastoralist population. The state is home to several fadama (floodplain) areas, particularly along the Katsina River and its tributaries, which support dry-season irrigation using shallow groundwater.

Electricity supply to the state is provided through the Kano Electricity Distribution Company (KEDCO), which serves approximately 22 percent of households with formal grid connections. Load shedding is frequent averaging 16–18 hours per day in rural areas making diesel generators and solar systems important supplementary energy sources (REA, 2023). The Zobe Dam, located in Dutsin-Ma LGA, is the state's principal surface water infrastructure, meant to supply water to surrounding communities including Katsina city and supporting downstream irrigation. However, the dam's storage capacity has declined due to sedimentation, and its distribution infrastructure is substantially in disrepair.

6. Results

6.1 Socioeconomic Profile of Respondents

Table 1 presents the socioeconomic characteristics of the 300 household survey respondents. The sample was predominantly male (81.7%), reflecting the predominantly male-headed household structure in the study communities, though women were specifically targeted in communities where female

focus groups were organised to supplement the survey. Respondents in the 31–45 age bracket constituted the largest group (39.3%), consistent with the age profile of the active agricultural workforce. Almost 30 percent of respondents had no formal education, underlining the importance of oral and community-based communication in policy dissemination.

Table 1: Socioeconomic Profile of Survey Respondents (n=300)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	245	81.7
	Female	55	18.3
Age Group	18–30	72	24.0
	31–45	118	39.3
	46–60	87	29.0
	60+	23	7.7
Education	No Formal	89	29.7
	Primary	76	25.3
	Secondary	91	30.3
	Tertiary	44	14.7
Primary Livelihood	Farming	196	65.3
	Pastoralism	54	18.0
	Trade/Commerce	32	10.7
	Civil Service	18	6.0

Source: Field Survey, 2026

6.2 WEF Nexus Challenges: Scale and Severity

Respondents were asked to rate the severity of eight WEF nexus challenges on a five-point scale. Table 2 presents these findings ranked by mean severity score. Erratic and inadequate rainfall emerged as the most severe challenge (mean = 4.51; 91.3% of

respondents rated it as severe or extremely severe), consistent with the state's documented trend of declining and increasingly unpredictable precipitation (NIMET, 2023). Limited irrigation infrastructure ranked second, reflecting the pervasive inability of smallholders to transition from purely rain-fed to supplemental irrigation.

Table 2: Severity of WEF Nexus Challenges (n=300)

Nexus Challenge	Severity (Mean)	% Severely Affected	Rank
Erratic/Inadequate Rainfall	4.51	91.3	1
Limited Irrigation Infrastructure	4.43	88.7	2
Grid Electricity Unreliability	4.38	87.6	3
Desertification/Land Degradation	4.29	85.7	4
High Cost of Diesel for Pumps	4.21	82.3	5
Post-Harvest Losses	4.17	79.0	6
Conflicts over Water Access	4.06	76.3	7
Weak Policy Coordination	3.98	74.7	8

Source: Field Survey, 2026; Scale: 1 = Not a challenge; 5 = Extremely severe

The high severity rating for grid electricity unreliability (4.38) directly links energy insecurity to water and food insecurity in the nexus chain: without reliable electricity, electric pumps cannot lift groundwater for irrigation, forcing dependence on diesel pumps whose operating cost renders irrigation uneconomical for the majority of smallholders. KII respondents corroborated this finding emphatically. As one official from the Ministry of Agriculture noted:

"The farmer who has a borehole but cannot afford diesel is effectively the same as a farmer who has no borehole at all. We keep building infrastructure but we do not solve the energy problem, and so the irrigation infrastructure sits idle."

Desertification and land degradation (4.29) also featured prominently, underscoring the ecological dimension of the nexus. Soil erosion reduces water retention capacity, increasing runoff and decreasing moisture availability for crops, a process that

simultaneously depletes aquifer recharge. Post-harvest losses at 4.17 driven by inadequate cold-chain infrastructure (itself energy-dependent), represent a final-mile failure in the food system that nullifies upstream agricultural investments.

6.3 Policy Awareness and Programme Performance

Despite the severity of WEF nexus challenges, awareness of relevant government programmes was uneven, and reported benefit levels were consistently modest (Table 3). The Rural Water Supply and Sanitation Agency of Katsina (RUWASSA) had the highest awareness rate (82.7%) reflecting its direct community-level presence, and also the highest benefit rate at 44.3 percent. However, KII informants noted that RUWASSA's mandate is primarily focused on domestic water supply, with minimal integration into agricultural water management.

Table 3: Awareness, Benefit, and Effectiveness of WEF-Related Policies and Programmes (n=300)

Policy/Programme	% Aware	% Benefitted	Effectiveness Rating
Anchor Borrowers Programme	74.3	31.7	Moderate
Rural Electrification Agency	61.0	18.3	Low
Katsina RUWASSA	82.7	44.3	Moderate
Green Wall Sahara Initiative	39.3	9.0	Very Low
Solar Pump Subsidy (State)	55.3	22.0	Moderate
National Fadama Project	68.0	29.3	Moderate

Source: Field Survey, 2026

The Anchor Borrowers Programme (ABP), the federal government's flagship smallholder credit scheme was known to 74.3 percent of respondents but had benefitted only 31.7 percent. Focus group discussions revealed that loan documentation requirements, collateral demands, and the requirement to operate through registered cooperatives effectively excluded the poorest and most food-insecure households. A civil society informant described this as "the paradox of pro-poor programmes that cannot reach the poor."

The Green Wall Sahara Initiative, Nigeria's flagship anti-desertification programme, had the lowest awareness and benefit rates. Community members in northern LGAs the most directly affected by desert encroachment demonstrated little knowledge of the programme's existence, let alone access to its interventions. This finding raises serious concerns about the territorial reach and communication strategy of what is arguably the most directly relevant ecological programme for northern Katsina.

6.4 Institutional Fragmentation and Governance Gaps

Qualitative findings from KIIs revealed a landscape of institutional fragmentation that undermines coherent WEF nexus governance. At the state level, responsibility for water resources, irrigation, agriculture, and energy is divided among at least five different ministries and agencies, each with independent budget lines, planning cycles, and performance metrics. Informants consistently reported that inter-ministerial coordination was ad hoc at best and entirely absent at worst.

One informant from the Katsina State Ministry of Water Resources stated: "We plan our dam rehabilitation without knowing what energy supply the Ministry of Power has planned for the pump stations, and the Ministry of Agriculture does not always know when water will be available." This pattern of bilateral ignorance across sectors was corroborated by multiple informants across different ministries, suggesting it reflects systemic

governance architecture rather than individual negligence.

At the federal level, the absence of a functional WEF Nexus inter-ministerial committee despite its recommendation in Nigeria's National Water Resources Master Plan (FMWR, 2013) was noted by development partner informants as a significant governance gap. The Federal Ministry of Water Resources, the Federal Ministry of Agriculture and Rural Development, and the Ministry of Power maintain separate technical assistance relationships with international development partners, with limited joint programming.

Community-level governance institutions including water users' associations (WUAs), fadama community associations, and irrigators' cooperatives exist in several study communities but suffer from weak legal standing, unreliable technical support, and limited financial resources. These bodies could serve as critical nexus governance nodes at the local level, but require deliberate capacity development and statutory recognition.

6.5 Gender and Social Inclusion Dimensions

Female respondents (18.3% of the sample) and qualitative participants consistently reported lower awareness of and benefit from WEF programmes, and greater vulnerability to nexus-related shocks. Women in the study communities are disproportionately responsible for domestic water collection an average of 2.3 hours per day was reported and for processing and preserving food, tasks that are directly constrained by energy insecurity. Yet women's participation in formal water users' associations and cooperative governance structures was found to be minimal, averaging less than 12 percent of membership.

These findings align with the broader literature on gender and natural resource governance in Northern Nigeria (Nwosu and Alabi, 2021) and underscore the need for explicit gender mainstreaming in WEF nexus governance reforms.

7. Discussion: Towards Integrated WEF Nexus Governance

7.1 The Governance Deficit

The findings presented in this paper confirm and extend the broader literature on governance deficits in WEF nexus management in dryland Africa (Leck et al., 2015; Nhamo et al., 2020). Katsina State faces an acute governance paradox: the physical interdependencies of water, energy, and food are stark and daily experienced at the community level, yet the institutional architecture through which these resources are managed remains fragmented, siloed, and uncoordinated. This paradox is not primarily a technical problem the knowledge base for WEF nexus integration is well established, but a political economy problem rooted in bureaucratic incentive structures, competing ministerial interests, and limited political prioritisation of integrated resource management.

The low benefit rates of flagship programmes like the ABP and the Green Wall Initiative suggest that programme design failures in targeting, access conditions, and communication are as significant as implementation failures. Programmes that are well-designed on paper can nonetheless fail the most vulnerable because they are mediated through institutional channels that systematically exclude them.

7.2 Renewable Energy as a Nexus Lever

The findings strongly support the potential of renewable energy particularly solar photovoltaic (PV) as a transformative lever for WEF nexus improvement in Katsina State. Solar-powered irrigation systems (SPIS) can simultaneously address energy access constraints and water access constraints for smallholders, reducing the cost of pump operation from approximately ₦220,000 per season (diesel) to near-zero marginal cost once installed (IRENA, 2021). Katsina's high solar irradiation profile makes this technically and economically viable at scale.

However, the capital cost barrier is substantial, and

without targeted financing mechanisms such as the concessional credit facilities and results-based financing models used in Kenya and Ethiopia (Closas and Rap, 2017) adoption will remain confined to wealthier farmers. Development partners including the World Bank's TROPIC programme and IFAD's Rural Agro-Industrial Development Programme offer potential financing vehicles that the Katsina State Government should proactively engage.

7.3 Towards a Katsina WEF Nexus Governance Framework

Based on the analytical findings of this study, the paper proposes a Katsina WEF Nexus Governance Framework built around three strategic pillars. The first is Institutional Integration: the establishment of a Katsina State WEF Nexus Coordination Unit, hosted within the Governor's Office or the State Planning Commission, with statutory authority to convene inter-ministerial working groups, develop joint WEF nexus plans, and monitor nexus-relevant performance indicators. This unit should have a dedicated budget line and be staffed by specialists in water resources, energy systems, and agricultural economics.

The second pillar is Resource Infrastructure Investment, prioritising: the rehabilitation and sedimentation management of the Zobe Dam and its distribution network; the deployment of solar-powered irrigation pumps through a state-managed subsidy and revolving fund scheme; and the construction of small-scale water harvesting structures sand dams, stone bunds, and check dams in the northern LGAs most affected by rainfall variability.

The third pillar is Participatory and Inclusive Governance, including: the legal recognition and capacity development of community WUAs and fadama associations as primary local nexus governance bodies; mandatory gender quotas (at least 30 percent female membership) in all state-funded water and agriculture cooperatives; and community-level monitoring through participatory WEF nexus scorecards adapted from the

methodologies of the International Water Management Institute (IWMI, 2019).

8. Conclusion and Recommendations

This paper has examined the governance of the Water-Energy-Food Nexus in Katsina State, Northern Nigeria, using a mixed-methods empirical approach. It finds that the physical nexus in Katsina the interdependence of rainfall, irrigation, energy for pumping, and food production is severe, structurally embedded, and deepening under the pressure of climate change and population growth. The governance response to this challenge is characterised by institutional fragmentation, policy incoherence, and persistent exclusion of the most vulnerable households and communities from programme benefits.

The paper makes the following concrete recommendations:

- i. State Government: Establish a WEF Nexus Coordination Unit within the State Planning Commission with cross-sectoral mandate, dedicated budget, and performance accountability. Develop a ten-year Katsina State Integrated Water-Energy-Food Security Plan through a consultative process involving communities, civil society, and technical agencies.
- ii. Federal Government: Activate the inter-ministerial WEF Nexus Committee recommended in the National Water Resources Master Plan. Reform the Anchor Borrowers Programme eligibility criteria to remove barriers excluding the poorest households, and establish a dedicated Solar Irrigation Trust Fund capitalised at the federal level with state-level disbursement mechanisms.
- iii. Development Partners: Fund a Katsina WEF Nexus Baseline Study and Monitoring System to establish quantitative baselines for water availability, energy access, and food security, enabling evidence-based adaptive management. Prioritise gender-

transformative programme design in WEF nexus investments.

- iv. Community Institutions: Strengthen water users' associations and fadama community associations through capacity development programmes, legal recognition, and linkage to state extension services. Promote community-based solar energy cooperatives as a mechanism for distributing the capital cost of solar irrigation systems.
- v. Research and Academia: Invest in multi-year, longitudinal nexus research in Katsina and analogous dryland states in the Lake Chad Basin, to build the evidence base for adaptive governance. Establish university-government-community research partnerships that translate scientific knowledge into actionable policy guidance.

Ultimately, governing the WEF Nexus in Katsina State requires not merely technical solutions but a political commitment to integrated, inclusive, and adaptive resource governance. The resources are finite; the interdependencies are real; and the window for proactive governance action is narrowing. The analytical and policy framework advanced in this paper offers a pathway grounded in community realities and institutional pragmatism towards a more secure and sustainable future for the people of Katsina State.

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