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Energy Transition and Renewable Energy Adoption in the South-South Region of Nigeria: The Trajectory, Determinants, Challenges and State-Level Variations

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ABSTRACT
This research investigated the path of energy transition and the uptake of renewable energy in the South-South area of Nigeria. A descriptive survey methodology was utilized, gathering insights from 398 participants throughout the South-South states. The analysis included frequencies, percentages, weighted means, one-way analysis of variance (ANOVA), and Duncan post hoc testing. The results indicated that participants viewed the region as having significant opportunities for renewable energy advancement, yielding a weighted average of 4.18. On the other hand, governmental support for the shift from fossil fuels to renewable energy was evaluated as insufficient (WM = 2.45), while the cost-effectiveness of renewable energy technologies (WM = 2.64), involvement of the private sector (WM = 2.90), and public knowledge (WM = 3.17) were also seen as lacking. Participants pointed out insecurity and inadequate infrastructure as major barriers hindering renewable energy growth (WM = 4.25). The most widely adopted renewable energy technologies included solar home systems and rooftop photovoltaic setups (WM = 4.10), with solar street and public lighting (WM = 3.87), solar mini-grids (WM = 3.65), and solar water pumping (WM = 3.62) following. In contrast, wind energy saw very minimal adoption (WM = 1.70). The ANOVA results revealed a significant statistical difference in renewable energy adoption across the South-South states ($F = 7.63$, $p < 0.001$). Additionally, Duncan post hoc analysis showed that Rivers had the highest average adoption (3.89), whereas Bayelsa had the lowest (2.83). The study concludes that while the region possesses considerable potential for renewable energy, issues concerning policy, infrastructure, financing, technical skills, and security need addressing to promote a comprehensive and sustainable energy transition.
Keywords: Energy, Transition, Renewable, Adoption, Trajectory, Determinants**,**

1.0 INTRODUCTION

The widespread and sustained use of non-renewable energy resources has severe consequences for human health and well-being; they are inextricably linked to the environmental repercussions of non-renewable energy resources (Ali, 2022). Renewable energy sources benefit society, businesses, and governments by

reducing emissions, lowering energy prices, and promoting environmental sustainability. As a result, the beneficial effect of these sources on the ecosystem cannot be ignored. While significant progress has been achieved in bringing some renewable energy sources to reality, such as geothermal, solar, and wind energy, additional effort is required to maximize these sources' potential to generate sustainable energy on a worldwide scale (Barnes & Samad, 2018). The overall balance has a detrimental effect on health. The 2003 European heat wave demonstrated that high-income, industrialized nations are not immune to climate change. Climate change, as exemplified by the greenhouse effect and global warming, is the most serious environmental problem related with energy production and consumption (Belyakov, 2019). Energy production, mostly through the combustion of fossil fuels, is critical to resolving the issue. Greenhouse gas emissions (GHG), particularly methane and carbon dioxide, are undoubtedly the most well-known and significant consequence of the current over-reliance on non-renewable energy supplies, prompting considerable worry about their role in fuelling climate change.

Carbon dioxide emissions from energy use contribute considerably to global warming in Europe, accounting for around 75% of man-made GHG emissions in the EU, mostly from coal burning (Rada, 2017). While natural gas emits substantially less carbon dioxide than coal, this does not mean that it is an effective means of mitigating climate change, as drilling and extraction frequently result in methane leaks. Methane is five times more effective as a GHG than carbon dioxide at trapping heat. Climate change has an impact on energy demand and supply in terms of resource availability, exploitation, and transportation. In other words, climate change has an impact on energy policy across all industries. Unsurprisingly, governments are turning to renewable energy sources to mitigate climate change by reducing GHG emissions, so avoiding the health and environmental consequences associated with non-renewable energy sources such as fossil fuel combustion and nuclear energy (Bush, 2019).

Solar energy has been adjudged to be clean and without emissions, but Bush (2019) argue that there is other associated environmental impact of solar farms with implication on ecosystem stability. The prolonged coverage of land has the potency to affect soil microbial count, soil air and ground level temperature beneath with implication for soil micro-organism. Dai et al. (2020) alluded that the materials used to produce the solar panels could be toxic given the hydra headed problem of waste management in developing countries. It is on this premise that this study would sought to evaluate the renewable energy potential in the south-south part of Nigeria and the materiality of the transition from fossil fuel energy.

2.0 Literature Review

Theoretical Review

The basis of this study is rooted in the Sustainable Development Theory, Carbon Curse Theory, and Environmental Kuznets Curve (EKC) Hypothesis. The Sustainable Development Theory, linked to the 1987 report Our Common Future from the Brundtland Commission, defines development as a process that meets contemporary demands without jeopardizing the ability of future generations to fulfil their needs. This theory prioritizes the combination of economic growth, social wellbeing, and environmental stewardship. In terms of energy transition, it advocates for shifting away from detrimental fossil fuels towards cleaner and renewable energy types, all while ensuring energy remains affordable, accessible, and conducive to economic growth. This concept holds particular significance for Nigeria, which faces the challenge of tackling energy poverty alongside promoting economic growth and mitigating environmental decline. The Carbon Curse Theory offers another theoretical perspective by detailing the propensity of nations rich in fossil-fuel resources to suffer significant environmental repercussions from the extraction, processing, and utilization of those resources. Nigeria's reliance on crude oil and natural gas makes this theory especially pertinent. While fossil-fuel resources generate government income and foster economic activities, their extraction is linked to greenhouse-gas emissions, gas flaring, ecological harm, and other environmental issues. Hence, this theory serves as a framework for analyzing the economic and environmental difficulties related to Nigeria's fossil fuel dependency and the imperative to transition to cleaner energy options.

The Environmental Kuznets Curve Hypothesis provides additional insight into the possible interplay between economic growth and environmental degradation. This hypothesis suggests that environmental

damage may initially rise alongside economic growth and income levels, but beyond a certain income point, further economic development may lead to the adoption of cleaner technologies, improved environmental regulations, and increased investment in protecting the environment. This EKC is significant in the context of energy transition research as it offers a structure for evaluating whether economic growth inherently leads to greater environmental harm or if advancements in technology and the integration of renewable energy can ultimately mitigate environmental burdens.

Conceptual Review

The primary concepts involved in this discussion are energy transition, carbon neutrality, renewable energy, and environmental sustainability. Energy transition denotes the gradual shift of an energy system from reliance on traditional fossil fuels toward cleaner, low-carbon, and renewable sources of energy. In history, energy transitions have shifted from biomass to coal, and subsequently from coal to oil and gas. Today's transition is distinct, as a focus on environmental sustainability and climate change mitigation has become driving factors. Consequently, this transition seeks to enhance the role of solar, wind, hydroelectric, and other renewable sources, while also improving energy efficiency and lowering greenhouse gas emissions.

Carbon neutrality denotes reaching an equilibrium between the amount of greenhouse gases emitted into the environment and the total of those gases that are taken away or absorbed by natural processes or technological carbon sinks. It doesn't necessarily mean that emissions must drop to zero right away; it indicates that any remaining emissions must be offset by legitimate removal efforts. Key natural carbon sinks include forests, soils, and oceans, whereas reforestation, afforestation, and innovative carbon-extraction technologies can aid in carbon capture. This notion is significant for Nigeria's transition in energy since fulfilling long-term goals for emissions reduction necessitates cutting fossil fuel reliance while safeguarding and enhancing carbon sinks. Renewable energy signifies energy derived from sources that naturally replenish, including sunlight, wind, flowing water, geothermal energy, and sustainably sourced biomass. Solar and wind power play a crucial role in the current energy shift because they produce electricity with significantly lower greenhouse gas emissions during operation compared to fossil fuel-based power generation. Nigeria holds substantial potential for renewable energy, notably in solar power, and there are also prospects for diversification through wind and hydroelectric sources within the nation's energy strategy(Haugå ,2023). The idea of environmental sustainability links the generation and use of energy with the long-term preservation of natural assets. For energy development to be sustainable, it must involve energy frameworks that are financially viable, socially inclusive, and environmentally sound. Therefore, the shift towards renewable energy should aim not only at replacing fossil fuels but also at enhancing resource efficiency, fostering technological advancements, managing waste, protecting the environment, and ensuring the enduring sustainability of renewable energy systems.

Empirical Review

Haugå (2023) performed a statistical examination utilizing wind speed records from various sites in Bangladesh, focusing on a decade from 1998 to 2007. Wind speed data collected hourly at heights exceeding 30 meters were sourced from the Bangladesh Meteorological Department and subsequently organized into hour, day, month, and year intervals. The data underwent analysis using the Weibull probability distribution to derive the parameters characterizing wind attributes through three distinct estimation methodologies. The research also calculated the theoretical density of wind power and the amount of energy that wind turbines could feasibly harness. The results revealed that the wind energy available in the studied areas had significant potential for energy use, particularly in water pumping and irrigation during dry periods. The research highlighted the effectiveness of statistical modeling in evaluating wind energy resources and gauging their viability for renewable energy purposes. Dai et al. (2022) investigated how the energy mix influences susceptibility to climate change. The researchers noted that rising global temperatures have led to major environmental alterations, such as the melting of glaciers and ice sheets in polar regions and the decrease of the cryosphere. Their analysis identified fossil fuel usage as a key factor in the rise of global temperatures due to the emissions of greenhouse gases, especially carbon dioxide, caused by burning coal, oil, and natural gas. The generation of electricity emerged as a significant source of greenhouse gas emissions, underscoring the need for an expanded

energy mix and greater implementation of low-carbon technologies. The research thus stressed the necessity for a well-rounded energy shift that acknowledges the advantages and drawbacks of various renewable and low-carbon energy sources. Moriarty and Honnery (2022) pointed out the tendency for over-optimism regarding solar and wind technologies as a challenge impacting the formation of a varied energy mix. The authors indicated that the fluctuations and unpredictability linked to solar and wind energy resources are often undervalued when evaluating their capability to deliver a consistent electricity supply. These assumptions may lead to an unrealistic outlook on the ability of intermittent renewable energy systems to satisfy constant electricity demands. Consequently, the research called for a more even-handed evaluation of renewable energies and other low-carbon technologies rather than an overwhelming reliance on solar and wind alone.

3. METHODOLOGY

The target population encompassed individuals from the six South-South states of Nigeria, which are Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers. According to the 2006 National Population Census, the total population of this region was 20,997,655. Utilizing the Taro Yamane formula for sample size calculation with a 5% error margin, a sample of 400 respondents was determined for the distribution of questionnaires. Additionally, 60 individuals, consisting of 10 respondents from each state, were chosen for interviews. The sample for the questionnaire was allocated across the six states proportionately based on their estimated population and household demographics. This allocation resulted in 74 respondents from Akwa Ibom, 32 from Bayelsa, 55 from Cross River, 78 from Delta, 61 from Edo, and 99 from Rivers State. A multistage sampling method was utilized. Initially, the six states forming the South-South geopolitical area were identified as research sites. Following this, the sample was proportionately distributed among the states, and respondents were chosen through random sampling. Eligible participants included adult members of households, especially heads or representatives, who were proficient in English and had access to alternative energy options, notably solar energy. Interview subjects were intentionally selected based on their understanding or engagement in energy-related policies and practices. Quantitative data analysis employed both descriptive and inferential statistical methods. Descriptive statistics, such as frequencies, percentages, means, and suitable graphical representations, summarized the socio-demographic traits of respondents and their perspectives on energy transition. Qualitative insights gained from interviews and observations were systematically coded and thematically analyzed using content analysis. This examination concentrated on repeated themes, viewpoints, experiences, and key concepts associated with the adoption of renewable energy, energy transition, and environmental consequences.

4.0 RESULTS

Objective One: To examine the socio-demographic characteristics of respondents and their implications for the assessment of energy transition in the South-South region of Nigeria.

Table 4.1: Socio-Demographic Characteristics and Respondents' Assessment of the Trajectory of Energy Transition in the South-South Region of Nigeria (N = 398)

Variable	Category/Response	Frequency (n)	Percentage (%)
A. Socio-Demographic Characteristics			
Gender	Male	228	57.3
	Female	170	42.7
Total		**398**	**100.0**
Age	Below 20 years	32	8.0
	21–35 years	166	41.7
	36–50 years	113	28.4
	51–65 years	60	15.1
	66 years and above	27	6.8
Total		**398**	**100.0**
Marital Status	Married	207	52.0
	Single	139	34.9
	Divorced	18	4.5
	Widowed	21	5.3
	Separated	13	3.3
Total		**398**	**100.0**
Occupation	Civil servant	93	23.4
	Trader/Businessperson	86	21.6
	Student	80	20.1
	Artisan	73	18.3
	Farmer	46	11.6
	Other	20	5.0
Total		**398**	**100.0**
Educational Qualification	Primary education	20	5.0
	SSCE	80	20.1
	OND/Diploma	93	23.4
	HND	73	18.3
	BSc	93	23.4
	Postgraduate	39	9.8
Total		**398**	**100.0**
Years of Residence	1–5 years	66	16.6
	6–10 years	86	21.6
	11–15 years	100	25.1
	16–20 years	73	18.3
	Above 20 years	73	18.3
Total		**398**	**100.0**

4.1 Socio-Demographic Characteristics of Respondents

Table 4.1 outlines the socio-demographic information of the 398 individuals who participated in the study. The findings indicate that 228 (57.3%) of the respondents were male compared to 170 (42.7%) who were female, reflecting a greater male representation. In terms of age, the highest number of respondents, 166 (41.7%), fell within the 21–35 year bracket, followed by 113 (28.4%) individuals aged between 36 and 50 years. Among the respondents, 32 (8.0%) were younger than 20 years, while 60 (15.1%) were in the 51–65 age range, and 27 (6.8%) were 66 years old or older. This pattern indicates a majority of respondents were young or middle-aged adults. When considering marital status, 207 (52.0%) stated they were married, while 139 (34.9%) reported being single. Additionally, 18 (4.5%) were divorced, 21 (5.3%) were widowed, and 13 (3.3%) were separated. In terms of employment, civil servants made up the largest segment, totaling 93 (23.4%), followed by 86 (21.6%) who identified as traders or businesspeople, 80 (20.1%) as students, 73 (18.3%) as artisans, 46 (11.6%) as farmers, and 20 (5.0%) in various other occupations. The breakdown of educational qualifications reveals that respondents with an OND/Diploma and BSc each represented 93 (23.4%). Following this, 80 (20.1%) held an SSCE, and 73 (18.3%) had an HND. A smaller number, 20 (5.0%), possessed primary education, whereas 39 (9.8%) had qualifications at the postgraduate level. Overall, the respondents exhibited varied but generally moderate to high levels of education. Concerning their time residing in the area, 100 (25.1%) had lived there for 11–15 years, 86 (21.6%) for 6–10 years, while 73 (18.3%) had stayed for periods of either 16–20 years or over 20 years. This indicates that many respondents had substantial living experience in the South-South region, suggesting they were likely familiar with developments in the regional energy landscape. The study involved a diverse demographic, including variations in gender, age, marital status, occupation, education, and length of residence. The significant presence of educated individuals and long-term inhabitants enhances the importance of their views on energy transition issues within the region.

Objective Two: To assess the trajectory of energy transition from fossil-fuel-based energy systems towards renewable energy in the South-South region of Nigeria.

Table 4.2: Descriptive Statistics of Respondents Response on Trajectory of Energy Transition in the Study Area

Statement	SA (n/%)	A(n/%)	D(n/%)	SD(f/%)	U(f/%)	WM	Interpretation
The South-South region has high potential for renewable energy development.	186 (46.7)	146 (36.7)	20 (5.0)	13 (3.3)	33 (8.3)	**4.18**	Agree
Government policies strongly support energy transition from fossil fuels to renewables.	33 (8.3)	66 (16.6)	166 (41.7)	93 (23.4)	40 (10.1)	**2.45**	Disagree
There is sufficient awareness about renewable energy among residents of the region.	66 (16.6)	119 (29.9)	100 (25.1)	60 (15.1)	53 (13.3)	**3.17**	Disagree
The cost of renewable energy technologies is affordable to the general public.	40 (10.1)	80 (20.1)	133 (33.4)	85 (21.4)	60 (15.1)	**2.64**	Disagree
The private sector is actively participating in renewable energy investment.	47 (11.8)	100 (25.1)	113 (28.4)	72 (18.1)	66 (16.6)	**2.9**	Disagree
The energy transition agenda is achievable within the next decade.	80 (20.1)	119 (29.9)	86 (21.6)	53 (13.3)	60 (15.1)	**3.23**	Disagree
Renewable energy will contribute to economic	166 (41.7)	133 (33.4)	33 (8.3)	19 (4.8)	47 (11.8)	**4.04**	Agree

growth in the South-South region.							
The region lacks adequate technical expertise for renewable energy development.	146 (36.7)	133 (33.4)	47 (11.8)	19 (4.8)	53 (13.3)	**3.99**	Agree
Environmental and public health impacts of renewable energy are minimal.	100 (25.1)	166 (41.7)	40 (10.1)	26 (6.5)	66 (16.6)	**3.77**	Agree
Insecurity and poor infrastructure hinder renewable energy projects in the South-South.	199 (50.0)	119 (29.9)	33 (8.3)	21 (5.3)	26 (6.5)	**4.25**	Strongly Agree

4.2 Descriptive Statistics of Trajectory of Energy Transition in the South-South Region

Table 4.2 investigates the views of participants regarding the direction of energy transition in the South-South area. The findings indicate that the respondents significantly acknowledged the region's capacity for renewable energy, as evidenced by a weighted mean of 4.18 for the assertion that the South-South region has a high potential for renewable energy advancements, which was interpreted as Agree. This suggests that participants believe the region is well-suited for renewable energy initiatives.

Conversely, respondents showed disagreement concerning the extent to which government policies facilitate the shift from fossil fuels to renewable energy, as reflected by a weighted mean of 2.45. In a similar vein, respondents disagreed with the notion that there is a sufficient level of awareness regarding renewable energy among residents, which earned a weighted mean of 3.17 and was interpreted as Disagree. The opinion on the affordability of renewable energy technologies was also unfavorable, receiving a weighted mean of 2.64.

The findings further reveal that participants did not view the private sector as sufficiently engaged in renewable energy funding, evidenced by a weighted average of 2.90. They also disagreed with the notion that the energy transition plan is feasible within the upcoming decade, which resulted in a weighted average of 3.23. These results imply that, despite having substantial renewable energy potential, challenges related to institutions, financing, awareness, and investments might be hindering the transition's speed. On a more encouraging note, participants acknowledged that renewable energy could drive economic development in the South-South region, reflected in a weighted average of 4.04. They also concurred that the region lacks sufficient technical skills for the advancement of renewable energy, indicated by a weighted average of 3.99. Additionally, the claim that the environmental and public health effects of renewable energy are minimal achieved a weighted average of 3.77 and was interpreted as Agree. The statement with the highest weighted average of 4.25 indicated that insecurity and insufficient infrastructure obstruct renewable energy initiatives in the South-South region. This was interpreted as Strongly Agree, highlighting that insecurity and infrastructural inadequacies serve as significant obstacles to the regional energy transition. This reflects a complex path for energy transition. The South-South region is regarded as having significant renewable energy prospects and there is optimism that renewable energy will foster economic advancement. However, insufficient policy backing, lack of awareness, affordability issues, limited involvement from the private sector, insufficient technical capabilities, insecurity, and poor infrastructure pose considerable challenges to a swift energy transition.

Objective Three: To identify and assess the major types of renewable energy adopted and utilized in the South-South region of Nigeria.

Table 4.3: Descriptive Statistics of Respondents Response on The Types of Renewable Energy Adopted in the Study Area

Statement	SA (n/%)	A(n/%)	D(n/%)	SD(f/%)	U(f/%)	WM	Interpretation
Solar home systems and rooftop PV	199 (50.0)	119 (29.9)	32 (8.0)	24 (6.0)	24 (6.0)	**4.1**	Agree
Solar mini-grids for communities	139 (34.9)	119 (29.9)	60 (15.1)	40 (10.1)	40 (10.1)	**3.65**	Agree
Biomass cookstoves for households	100 (25.1)	139 (34.9)	80 (20.1)	40 (10.1)	39 (9.8)	**3.5**	Agree
Biogas digesters for farms and homes	80 (20.1)	100 (25.1)	100 (25.1)	60 (15.1)	58 (14.6)	**3.09**	Disagree
Small hydropower along rivers	72 (18.1)	88 (22.1)	119 (29.9)	72 (18.1)	47 (11.8)	**2.84**	Disagree
Solar water pumping for irrigation	119 (29.9)	135 (33.9)	72 (18.1)	40 (10.1)	32 (8.0)	**3.62**	Agree
Solar street and public lighting	159 (40.0)	139 (34.9)	48 (12.1)	32 (8.0)	20 (5.0)	**3.87**	Agree
Waste-to-energy initiatives	48 (12.1)	80 (20.1)	119 (29.9)	80 (20.1)	71 (17.8)	**2.74**	Disagree
Wind energy (small turbines)	4 (1.0)	8 (2.0)	80 (20.1)	239 (60.1)	67 (16.8)	**1.7**	Strongly Disagree
Industrial biomass and cogeneration	88 (22.1)	111 (27.9)	100 (25.1)	60 (15.1)	39 (9.8)	**3.17**	Disagree

4.3 Descriptive statistics of Types of Renewable Energy Adopted in the Study Area

Table 4.3 displays the evaluation of different renewable energy technologies by the respondents in the study area. Among the technologies examined, solar home systems and rooftop photovoltaic installations achieved the highest weighted mean of 4.10, reflecting an Agree stance. This indicates that these solar technologies play a significant role in renewable energy usage in the region. Solar street and public lighting secured a comparatively substantial weighted mean of 3.87, whereas solar mini-grids achieved a mean of 3.65. Solar water pumps for agricultural use recorded a mean of 3.62. All three were interpreted as Agree, suggesting a noticeable implementation of solar technologies. Biomass cookstoves for households also garnered a positive response, earning a weighted mean of 3.50. However, biogas digesters utilized on farms and in residences had a weighted mean of 3.09 and were interpreted as Disagree, indicating minimal use. Small river hydropower also presented a low weighted mean of 2.84, resulting in a Disagree interpretation. Waste-to-energy projects yielded a weighted mean of 2.74, pointing to limited usage. Wind energy, specifically small turbines, had the lowest weighted mean of 1.70, interpreted as Strongly Disagree. This suggests that there is very little wind energy utilization in the study area. Industrial biomass and cogeneration attracted a weighted mean of 3.17 and were interpreted as Disagree, showing that this technology is not yet widely embraced. The results reveal that, in the South-South region, the uptake of renewable energy is primarily characterized by solar technologies, particularly solar home systems, rooftop PV, solar street lighting, mini-grids, and solar water pumping. Other

technologies, including biogas, small hydropower, waste-to-energy, wind energy, and industrial biomass, are still largely underdeveloped.

H_{01}: There is no significant variation in the adoption and use of renewable energy among the six states of the South-South geopolitical zone of Nigeria.

Table 4.4: ANOVA Summary Testing the Hypothesis 'There is no Variation in the Adoption and Use of Renewable Energy in the South-South Geopolitical Zone of Nigeria'

Source of Variation	Sum of Squares (SS)	df	Mean Square (MS)	F-Calculated	F-Critical (0.05)	Sig. Level (p)	Decision
Between Groups	48.72	5	9.74	7.63	2.25	.000	**Significant**
Within Groups	500.41	392	1.28				
Total	**549.13**	**397**					

4.4 ANOVA Test of Variation in Renewable Energy Adoption

Table 4.4 outlines the results from a one-way Analysis of Variance (ANOVA), aimed at assessing variations in the adoption and application of renewable energy across the six states in the South-South region. The analysis yielded an F-calculated value of 7.63 when compared to an F-critical value of 2.25 at the 0.05 significance threshold. Because the calculated F-value of 7.63 surpasses the critical value of 2.25, and the corresponding probability value is 0.000—which is below 0.05—the null hypothesis is deemed invalid. This means there is a statistically meaningful difference in the levels of renewable energy adoption and utilization in the South-South states of Nigeria. Consequently, renewable energy implementation is not consistent across these six states. The ANOVA findings confirm that significant disparities exist in renewable energy adoption rates among the South-South states. This supports the necessity for a post hoc Duncan test to identify which specific states exhibit differences from one another.

Table 4.5: Duncan Post Hoc Test for Variation in the Adoption and Use of Renewable Energy among South-South States of Nigeria

State	N	Mean	Subset for α = 0.05	Homogeneous Groups
Bayelsa	32	2.83	A	
Cross River	55	2.95	A	
Akwa Ibom	72	3.22	A	B
Edo	61	3.46		B
Delta	78	3.71		B
Rivers	99	3.89		B

4.5 Duncan Post Hoc Test

Table 4.5 displays the comparison from the Duncan post hoc analysis concerning the integration of renewable energy within the six states in the South-South region. Rivers State achieved the highest average adoption score at 3.89, followed by Delta State with 3.71 and Edo State at 3.46. Akwa Ibom has an average score of 3.22, while Cross River and Bayelsa posted the lowest average scores of 2.95 and 2.83, respectively. The homogeneous subsets indicate that Bayelsa and Cross River are categorized within Group A, contrasting with Rivers, Delta, and Edo, which are mostly categorized in Group B. Akwa Ibom is positioned at the border of Groups A and B, indicating its level of renewable energy adoption does not significantly differ from the other states within either category. Consequently, the results suggest that the pronounced differences identified in the overall ANOVA results are primarily linked to the elevated adoption levels in Rivers, Delta, and Edo when compared to the notably lower levels found especially in Bayelsa and Cross River. The Duncan analysis highlights significant variations in renewable energy

adoption among states. Rivers State leads with the highest average, while Bayelsa records the least. These results indicate that the progress of renewable energy is inconsistent throughout the South-South area, potentially reflecting disparities in factors such as infrastructure, funding, policy execution, public awareness, economic activities, and institutional capability.

5.0 DISCUSSION OF FINDINGS

Table 4.1 illustrates that the male participants made up the larger portion of the sample at 57.3%, while female participants represented 42.7%. The majority of the respondents fell within the age range of 21 to 35 years, comprising 41.7%, with 52.0% being married and possessing at least a secondary or tertiary education level. The largest segment of the workforce consisted of civil servants at 23.4%, and 25.1% reported living in the area for a period of 11 to 15 years. In summary, the surveyed individuals were primarily young to middle-aged, well-educated, and relatively long-term inhabitants, making them adept to evaluate energy-transition matters within the region. This observation aligns with findings in energy-transition studies conducted in Nigeria, where educated and economically active individuals are frequently acknowledged as key players in the processes surrounding the adoption of renewable energy and the execution of related policies. Research on renewable energy initiatives in Nigeria has highlighted the significance of public awareness, technical proficiency, and stakeholder involvement throughout the transition journey.

Table 4.2 reveals that participants acknowledged the considerable renewable-energy prospects in the South-South region (WM = 4.18) and held the opinion that renewable energy could foster economic development (WM = 4.04). Nonetheless, respondents expressed disagreement regarding the significant support for the transition offered by government policies (WM = 2.45), the affordability of renewable technologies (WM = 2.64), and the sufficiency of private-sector involvement (WM = 2.90). The primary challenges identified were insecurity and inadequate infrastructure (WM = 4.25). These results closely mirror the findings of Nwozor et al. (2021), who determined that Nigeria possesses substantial prospects for clean-energy advancement but grapples with policy inconsistencies, weak institutional resolve, an unfavorable investment environment, and low private investment. Similarly, they align with Abdullahi et al. (2022), who pinpointed technological, financial, political, and social hurdles as key challenges to solar-energy implementation in Nigeria. More recently, Adewuyi et al. (2024) similarly noted that institutional, infrastructural, and economic challenges hinder the growth of renewable energy in Nigeria. Consequently, the current findings validate that while Nigeria's transition to renewable energy has significant possibilities, it is still hampered by systemic and institutional obstacles.

Table 4.3 indicates that the adoption of renewable energy in the South-South region is largely led by solar technologies. Solar home systems and rooftop photovoltaic systems achieved the highest average score (4.10), followed by solar street and public lighting (3.87), solar mini-grids (3.65), and solar water pumping systems (3.62). In comparison, wind energy reported the lowest average score (1.70), while waste-to-energy (2.74), small hydropower (2.84), and biogas (3.09) exhibited relatively low usage rates. The prevalence of solar energy aligns with the findings from Abdullahi et al. (2022), who asserted that solar photovoltaic systems are a critical renewable-energy option in Nigeria, although their development is hindered by financial, technical, political, and societal challenges. Furthermore, it corresponds with the observations of Ozoegwu and Akpan (2021), who emphasized solar energy as a vital element of Nigeria's renewable-energy agenda and underscored the urgency for more robust policy-driven business frameworks and enhanced public awareness to promote its broader acceptance. The comparatively low uptake of wind energy observed in this study is consistent with recent studies from Nigeria, which consistently reveal that solar has more feasible deployment opportunities than wind within the current context of the nation’s renewable-energy framework.

Table 4.4 presents a statistically significant disparity in the uptake of renewable energy among the six South-South states ($F = 7.63$, $p < 0.001$). Given that the calculated F-value is higher than the critical threshold ($7.63 > 2.25$), the hypothesis suggesting no differences is dismissed. This indicates that the adoption of renewable energy is not consistent across the South-South states. This observation aligns with the general discussion in Nigerian energy-transition research, asserting that the advancement of renewable

energy is influenced by variances in infrastructure, institutional effectiveness, investment climates, and the enforcement of policies. Nwozor et al. (2021) similarly noted that structural and institutional variances hinder Nigeria's shift towards renewable energy, while Adelaja (2020) highlighted obstacles in policy adoption that affect the progression of renewable energy in Nigeria.

Table 4.5 indicates that Rivers State exhibited the highest average level of renewable energy adoption (3.89), succeeding Delta (3.71) and Edo (3.46), while Bayelsa displayed the lowest average (2.83), followed closely by Cross River (2.95). Akwa Ibom came in with an average of 3.22. The Duncan grouping further reveals that Bayelsa and Cross River were primarily linked to the lower-adoption category, whereas Rivers, Delta, and Edo belonged to the higher-adoption category. This outcome underscores the unequal progress of renewable energy initiatives within the South-South region. This finding aligns with contemporary literature on Nigeria's energy transition, indicating that the deployment of renewable energy is shaped by differences in infrastructure, investment potential, institutional frameworks, and technical expertise. Adewuyi et al. (2024) specifically noted that infrastructural, institutional, and economic obstacles continue to influence the uneven growth of renewable energy in Nigeria.

CONCLUSION

The research indicates that Nigeria's South-South region has significant possibilities for the advancement of renewable energy, especially in solar power, which is the most prevalently utilized renewable source. Nonetheless, the progress toward energy transformation continues to be hampered by insufficient governmental policy backing, low levels of public awareness, expensive renewable energy technologies, lack of technical skills, insecurity, and underdeveloped infrastructure. Participants in the study also noted that renewable energy could play a major role in boosting economic development as well as enhancing both environmental quality and public health outcomes. The notable ANOVA finding ($F = 7.63$, $p < 0.001$) demonstrates that the adoption of renewable energy significantly differs among the South-South states, with Rivers achieving the highest average adoption rate and Bayelsa the lowest. In summary, the results indicate that despite the region's strong potential for renewable energy, realizing a successful energy transition will necessitate enhanced institutional support, improved infrastructure, increased funding, and expanded capacity building.

RECOMMENDATIONS

i. Government should enhance policies and investment incentives for renewable energy by establishing more explicit regulatory structures, providing financial incentives, subsidies, and tax breaks that can motivate households, communities, and private investors to adopt renewable energy solutions.

ii. There should be an increase in awareness and technical skills related to renewable energy through ongoing public education, vocational training, and community-driven initiatives.

iii. Improvements to infrastructure and security measures are necessary throughout the region to support renewable energy initiatives.

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