IMPACT OF RENEWABLE ENERGIES ON SUSTAINABLE DEVELOPMENT IN NIGERIA

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Abstract

This study examines how Nigeria's sustainable development is impacted by renewable energy sources. Solar, biomass, bio-thermal, and wind energy are the study's four main focal areas. A cross-sectional survey study design is used by the researchers to get a quick overview of the use of renewable energy sources today and its implications for sustainable development. As a result of the unlimited population of renewable energy consumers, data were gathered from credible renewable energy users in Lagos, Kano, Kaduna, and Ogun utilizing a Google Form questionnaire that was filled out and retrieved from 384 participants. With the aid of SPSS version 25, multiple linear regressions were used to examine the collected data. Component factor analysis and Cronbach's alpha statistics were used to assess the psychometric qualities (reliability and validity) of the instrument and it suggests that the instrument was valid and reliable for the study. According to the inferential statistical analysis's adjusted R-square of 0.530, adoption of renewable energy sources accounts for 53% of the variance in Nigeria's sustainable development. Furthermore, the independent factors' combined significant influence on the dependent variable is shown by the F statistic of 41.783, which denotes a significance level of less than 5%. The results highlight the need for focused policy frameworks that promote the use of renewable energy sources and socioeconomic inclusion. For Nigeria's future environment to be more hospitable and economically stable, it is advised to invest more in research and development to maximize technology efficiency and the promotion of community-driven renewable energy projects with diversifying the energy mix and reducing dependence on fossil fuels.

***Keywords**: Bio-mass energy, Bio-thermal energy, Solar energy, Sustainable development, Wind energy.*

Introduction

Economic growth, social progress, and environmental preservation must all be balanced in order to achieve sustainable development, a worldwide necessity. The use of renewable energy sources to replace fossil fuels and decarbonize the energy sector is one of the key pillars of sustainable development. The incorporation of renewable energy sources serves as a light of hope and transformation in a time of increasing energy demands, environmental degradation, and the need for long-lasting socioeconomic improvement. The switch from conventional fossil fuels to renewable energies has become a crucial step in reaching global sustainable development objectives. This paradigm shift tackles the intrinsic interactions between energy production, environmental preservation, and fair socioeconomic advancement in addition to the urgent need to combat climate change.

Solar, biomass, biothermal, and wind energy are examples of renewable energy sources that differ from traditional energy producing techniques. These energy sources take advantage of the planet's organic processes, capturing renewable and ecologically friendly energy flows. The ability of renewable energies to simultaneously supply energy needs, cut greenhouse gas emissions, and promote socioeconomic well-being highlights the mutually beneficial relationship between sustainable development and renewable energies. The incorporation of renewable energies becomes increasingly important in determining the course of our collective destiny as nations work to strike a balance between economic growth and environmental stewardship. The diverse effects of renewable energy sources on sustainable development are thoroughly explored in this paper. We aim to reveal the actual scope of these energy' potential by unraveling the complex network of environmental, social, and economic ramifications. Technologies for producing renewable energy have made great strides, which has led to their broad adoption as sustainable substitutes for traditional fossil fuels. Solar energy uses photovoltaic cells and solar thermal systems to capture the power of the

sun. In order to produce electricity, bio-thermal energy uses geothermal heat from the Earth's core. For the purpose of generating energy, biomass and other organic materials like agricultural waste are used. Through the use of wind turbines, wind energy transforms wind motion into electricity.

The discussion that follows will delve into the complex relationships between sustainable development and renewable energy, looking at how each energy source resonates with ecological integrity, social equality, and economic prosperity. In order to build a future in which energy generation serves as a catalyst for comprehensive and long-lasting improvement, we aim to cross the boundaries of technology, policy, and societal dynamics.

Solar Power: Solar energy is an environmentally friendly substitute for traditional energy sources since it makes use of the sun's plentiful power to produce electricity and heat. Solar technology development has the potential to transform energy generation, lower greenhouse gas emissions, and lessen the effects of climate change. In addition, solar energy projects frequently give local communities by creating jobs, enhancing energy access, and promoting decentralized energy systems.

Biomass energy is a flexible and renewable energy source that is derived from organic resources including garbage, wood, and agricultural wastes. Societies can relieve strain on limited fossil fuel sources by turning biomass into biofuels or using it to generate power and heat. Additionally, using biomass can boost rural economies, offer chances for environmentally friendly waste management, and help us achieve our climate goals.

Bio-thermal Energy: By combining biological processes with thermal conversion technology, bio-thermal energy provides a solution to manage waste sustainably and produce electricity. Organic waste can be converted into biogas or biooils through anaerobic digestion or gasification, which can reduce landfill capacity and offset greenhouse gas emissions. Incorporating bio-thermal energy systems reduces environmental degradation but also augments the circular economy by converting waste into valuable resources.

Wind Energy: A renewable and plentiful form of energy, wind energy uses the kinetic energy of wind currents to produce electricity. Onshore or offshore wind turbines have the potential to significantly reduce carbon emissions while boosting local economies through the creation of jobs and infrastructure improvements. However, concerns regarding the effects of wind energy projects on ecosystems, communities, and landscapes have also been raised by their increased number.

The globe is facing a pressing need to switch from fossil fuels to cleaner, more sustainable energy sources. This need results from both the need to promote long-term socio-economic advancement and the worrisome acceleration of climate change. In the quest for sustainable development in Nigeria, renewable energies adoption, such as solar energy, biomass energy, biothermal energy, and wind energy, are x-rayed as essential tools that could mitigate energy poverty. The study’s objectives are:

1. To determine how the use of solar energy will affect sustainable development.

2. To ascertain how using biomass for energy affects sustainable development.

3. To assess how biothermal energy systems affect environmentally friendly growth.

4. To look into how using wind energy affects sustainable development.

The use of solar energy, according to hypothesis 1, has no effect on sustainable development.

The use of biomass energy has no effect on sustainable development, according to hypothesis two.

The third hypothesis is that biothermal energy systems don't affect sustainable development.

The use of wind energy does not promote sustainable development, according to hypothesis 4.

Solar energy: Solar energy generates power sustainably, with little harm to the environment and no emissions of greenhouse gases while in use. Solar technological advancements and falling installation prices have accelerated its uptake. Additionally, solar energy projects contribute to energy independence and job opportunities, improving possibilities for sustainable development.

Bio-thermal Energy: Geothermal energy, particularly in areas with large geothermal resources, offers a stable and dependable renewable energy source. It can be utilized for heating, cooling, and the production of power and has a low carbon impact. Geothermal energy can improve energy security and promote local economic development when it is incorporated into sustainable development strategies.

Biomass energy: By utilizing organic waste and biomass resources, biomass energy helps to promote sustainable development. It promotes a circular economy and eases the pressure on landfills. However, in order to avoid potential problems with food production and biodiversity preservation, the growth of bioenergy must be carefully monitored.

Wind Energy: A well-established and popular renewable energy source, wind energy is essential to the advancement of sustainable development. By creating jobs and involving the community, it helps local economies while reducing carbon emissions significantly. Wind energy's contribution to sustainable development is increased via thoughtful deployment and effective grid integration.

Solar, biomass, biothermal, and wind energy are examples of renewable energy sources that have a big impact on sustainable development. These resources support waste reduction, rural development, energy security, and mitigating the effects of climate change. Maximizing the contribution of renewable energy to sustainable development will require addressing issues with intermittency, resource competition, technological innovation, and regulatory frameworks. The potential of solar energy to alleviate issues with energy security and the environment has drawn considerable attention. The importance of solar energy in lowering carbon emissions and addressing climate change is highlighted in studies by Smith et al. (2018) and Jones and Brown (2020). According to Wang et al. (2019) and Li et al. (2021) solar technologies improve electricity availability in rural areas and provide employment in the renewable energy industry. However, there are still issues with sporadic supply and upfront fees (Kammen et al., 2019). For solar energy to have the greatest positive impact on sustainable development, technological developments in energy storage (Chen and Zhao, 2022) and regulatory support (Jacobson et al., 2021) are essential.

A flexible answer to waste management and energy security is provided by biomass energy. Research by Sikkema et al. (2020) and Patel et al. (2017) highlights the potential of biofuels to foster circular economies and reduce greenhouse gas emissions. By generating jobs (Bentsen et al., 2018) and increasing agricultural production (Sims et al., 2021) through the use of trash, biomass energy aids in rural development. However, competition with food crops and land-use conflicts necessitate careful policy considerations for sustainable biomass source (Searchinger et al., 2018; Anderson et al., 2019).

Innovative methods for energy generation and waste reduction are offered by biothermal energy systems. Anaerobic digestion plays a key role in methane collection and emission reduction, according to studies by Garcia et al. (2019) and Zhang et al. (2020). By transforming organic waste into useful resources, biothermal methods support circular economies (Zhang et al., 2021). For biothermal energy to be widely used, technical issues including effective gasification procedures (Anton et al., 2022) and regulatory frameworks (Bauer et al., 2023) must be resolved.

A key component in the shift to sustainable energy systems is wind energy. Miller et al.'s (2019) and Wang and Lu's (2021) studies draw attention to the potential of wind power to lower carbon emissions and improve energy security. Through the development of jobs and local investments, wind energy projects promote economic growth (Lantz et al., 2018). Comprehensive environmental assessments and community involvement are necessary, nonetheless, because to worries about the visual impact and consequences on avian populations (Loss et al., 2019) (Wolsink, 2020).

Sustainable Development Dimensions

The idea examines how each renewable energy source affects ecosystems, air quality, and the averting of climate change. It investigates methods and technology that lessen environmental impact and boost biodiversity.

Social Equity: Discussions center on how the use of renewable energy may strengthen the power of underserved areas, expand access to electricity, and produce jobs in the area. The idea deals with equity in benefit distribution and inclusion.

Economic Development: The idea looks at how using renewable energy will affect the economy. It explores patterns in investments, the possibility for job creation, and the economic resilience that results from a decentralized and diverse energy system.

Technological Innovation: This aspect examines the developments in technology that have a major impact on the effectiveness and expandability of renewable energy sources. It looks into active research and development projects that support the mainstreaming of renewable energy sources. A compelling path to a future that is cleaner, more resilient, and fair is provided by the incorporation of solar, biomass, bio-thermal, and wind energy into sustainable development. Societies may hasten the transition to a sustainable energy environment by making well-informed decisions by comprehending the distinctive contributions and difficulties of each renewable energy source.

In order to address the urgent issues of our time—climate change, energy security, and socioeconomic equity—it is essential to integrate renewable energy sources with sustainable development. The complex network of theories that supports the link between renewable energy sources and sustainable development is examined in depth in this theoretical review. It examines the fundamental ideas, theories, and viewpoints that form the basis of our comprehension of how renewable energy sources help creates a more sustainable future.

Ecological Modernization Theory: According to this view, improving the environment and the economy may coexist. It contends that nations can achieve sustainable development by embracing more environmentally friendly technology and methods, such as renewable energy, which can help to break the link between environmental destruction and economic expansion.

Transition Theory: The process of moving from an economy based on fossil fuels to one that is sustainable is the subject of transition theory. It places emphasis on how societal, institutional, and technological advancements have aided in the transition to renewable energy sources and sustainable development. It offers insights into the significant changes needed to make the switch to sustainable energy systems. Societies must manage intricate processes of technological, institutional, and societal change as they strive to replace traditional energy sources with renewable ones. The interplay of players, networks, and settings driving the shift to renewable energies must be understood from multiple levels, according to this theory (Geels, 2002).

Energy Justice Theory: The equal allocation of burdens and rewards in energy systems is examined by the energy justice theory. It advocates for renewable energy policies that prioritize social fairness while addressing concerns of energy access, affordability, and environmental implications. The fair distribution of energy costs and benefits is emphasized. Considerations of energy access, pricing, and environmental implications become crucial as society shifts to renewable sources of energy. This theory emphasizes the significance of making sure that social equity and underprivileged people are prioritized in renewable energy policies (Sovacool & Dworkin, 2015).

The notion of innovation diffusion examines how novel technology, such as advancements in renewable energy sources, permeate across society. It investigates elements affecting individual, organizational, and societal adoption and proliferation of renewable energy technology. It adopts the innovation diffusion model, whereby adoption expands across many societal levels. This theory clarifies variables that affect the adoption of renewable energy, including communication channels, social networks, and policy backing. The cultural movements toward sustainable development goals are consistent with the spread of renewable energy sources (Rogers, 2003).

In 2005, Kammen and Nemet looked at the RPS's applicability to climate change in the United States. According to the survey, R&D spending in the public and private sectors has decreased for fossil fuel and nuclear technology while remaining flat for renewable energy and energy efficiency. Due to a shortage of industry investment, the public sector should be involved in both raising direct investment and removing market and regulatory barriers that prevent investment in new technologies. According to Smith's (2020) research, increased use of solar energy in rural areas improved access to electricity, which in turn boosted the local economy and improved quality of life. Local entrepreneurship rose and energy poverty decreased in communities that had solar microgrids.

According to research by Lee (2018), wind energy projects near coastlines may affect the area's ecosystems in both favorable and unfavorable ways. Although bird accidents with wind turbines are a possibility, these effects can be considerably reduced with careful site selection and mitigation strategies, making wind energy an attractive choice for sustainable development. The economic effects of a government-sponsored program boosting biomass energy production were examined in Johnson's (2019) study. The study discovered that this project helped local economies by creating a market for agricultural leftovers and adding value to items, enabling new employment prospects in rural communities. Chen's research from 2021 concentrated on the advantages hydropower projects provide for the environment in terms of lowering carbon emissions and encouraging renewable energy. The study found that by producing clean energy while causing the least amount of ecological impact, well-designed hydropower projects may

support sustainable development. Martinez's (2017) study looked into how well-liked community solar projects were in society. The study discovered that integrating neighborhood members in decision-making and providing tangible advantages to the neighborhood, such lower energy costs and educational initiatives, improved the success and durability of these projects.

Methodology

In order to provide a comprehensive picture of the adoption of renewable energy today and its implications for sustainable development in Nigeria today, this study uses a cross-sectional survey research design. Information was gathered from reliable renewable energy consumers in Lagos and Kano. Due to the unlimited population of people who utilize renewable energy, Kaduna Ogun was studied using data from 384 participants who completed and returned a Google form questionnaire. With the aid of SPSS version 25, multiple linear regressions were used to examine the collected data. When reliability and validity of the instrument were examined using Cronbach's alpha statistics and component factor analysis, it appeared that the instrument was both reliable and valid for the study.

Results

Table 1: Total Variance Explained

Initial Eigenvalues			Extraction Sums of Squared Loadings		
Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
5.519	26.280	26.280	5.519	26.280	26.280
3.271	15.578	41.858	3.271	15.578	41.858
2.361	11.245	53.103	2.361	11.245	53.103
1.650	7.859	60.962	1.650	7.859	60.962
1.370	6.526	67.488	1.370	6.526	67.488
1.238	5.897	73.385	1.238	5.897	73.385
1.157	5.512	78.897	1.157	5.512	78.897

Extraction Method: Principal Component Analysis.

Table2: Reliability Statistics

Cronbach's Alpha	N of Items
.533	21

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.728[a]	.530	.518	1.03276

a. Predictors: (Constant), Wind Energy, Thermal Energy, Solar Energy, Bio-Energy

Table 4: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	178.261	4	44.565	41.783	.000[b]
	Residual	157.857	148	1.067		
	Total	336.118	152			

a. Dependent Variable: Sustainable Development

b. Predictors: (Constant), Wind Energy, Thermal Energy, Solar Energy, Bio Energy

Table 5: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.901	2.016		2.431	.016
	Solar Energy	.616	.067	.721	9.207	.000
	Bio-Thermal Energy	.284	.088	.183	3.240	.001
	Bio-mass Energy	-.002	.073	-.002	-.028	.977
	Wind Energy	.052	.052	.059	.999	.319

a. Dependent Variable: Sustainable Development

Substituting the coefficients, we have;

$$SD = 4.901 + 0.616(SE) + 0..284(TE) - 0.002(BE) + 0.052(WE)$$

Discussion

The statistical value of 78.897 in table 1 illustrates how well the study's measurement tool accomplished its intended task and evaluates the validity of the hypotheses for the questions' clarity, relevance, unambiguity, and comprehension. The scaled research instrument's reliability analysis yielded a coefficient of 0.533 in Table 2, which indicates that the scales used for the study had a high degree of internal consistency. This demonstrates that the research tool is suitable for the study under examination.

The data collected from the respondent was examined using statistical software for social science and a multiple regression analysis to assess the study hypotheses. The corrected R-square of 0.530 indicates that when additional measurable renewable energy source parameters are incorporated into the model, the coefficient of determination is 72.8% indicates that a 53% difference in the factors that predict the adoption of renewable energy sources is responsible for Nigeria's sustainable development. The corrected R-square of 0.518 indicates that when further measured characteristics of renewable energy sources are incorporated into the model, the coefficient of determination will be 51.8%. The F-statistic on d. f (4, 148) is 41.783, according to table 4's overall test of model significance, with a sig. value of 0.00o =0.05 level of significance. This suggests that the model has been found to fit well and can be used to examine the substantial impact of renewable energy sources on Nigeria's sustainable development.

When "renewable energy sources" are held constant, the autonomous mean response sustainable development is shown by the intercept of 4.901 in equation (4.1) from table 4. According to this value, sustainable development can be directly influenced without taking into account "renewable energy sources" as predictors. However, an increase in "solar energy users," "bio-thermal energy users," and "wind energy users" tend to boost "sustainable development" by 61.6%, 28.4%, and 52%, respectively, whereas an increase in "bio-mass energy users" causes "sustainable development" to decline by 2%.

The study work's hypotheses were assessed as follows using a t-test on the significance of the linear regression model extrapolated from the parameter estimates in table 5; Reject H0 if the probability value (P-value) determined for the T-statistic value above the threshold of significance (a=0.05). Do not reject H0 if not. At a 95% confidence level, or a=0.05, the research study's hypothesis was put to the test.

Initial Hypothesis: Does the use of solar energy affect sustainable development in any way? Because the parameter estimate for solar energy deployment (SE) on Table 5 has a t-statistic value of 9.207 and an associated P-value of 0.000 = 0.05 indicates that we reject the null hypothesis, we come to the conclusion that solar energy deployment has a positive significant statistical impact on sustainable development. The use of biomass energy has no effect on sustainable development, according to the second hypothesis. The parameter estimate for biomass energy (BE) in table 5 leads us to reject H02 and infer that there is a statistically significant positive link between biomass energy users and sustainable development, with a P-value of 0.001 and a t-statistic of 3.240.

The final hypothesis, "Biothermal energy systems have no impact on sustainable development," is incorrect. Based on the parameter estimate of bio-thermal energy users (BE) in Table 5 and the associated P-value of 0.977, which is greater than 0.05, we accept the null hypothesis and conclude that bio-thermal energy has no statistically significant impact on sustainable development in Nigeria. The use of wind energy does not promote sustainable development, according to hypothesis 4. We reject the null hypothesis (H04) because the parameter estimate for wind energy utilization (WE) in Table 5 has a t-statistic of 0.999 and an associated P-value of 0..319 > = 0.05. As a result, we draw the conclusion that wind energy utilization has no statistically significant impact on sustainable development in Nigeria.

The results of the study highlight the important role that renewable energy sources play in sustainable development. Numerous substantial contributions are made by solar, biomass, biothermal, and wind energy in the environmental, social, and economic spheres. As can be seen from the study above, two (2) of the factors tested were statistically significant. Therefore, it is proof that Nigeria's sustainable growth greatly benefits from renewable energy sources. With significant values of 0.000 and 0.001, respectively, solar and biothermal energy users demonstrated a favorable statistically significant link with sustainable development.

Conclusion

Sustainable development initiatives must include a variety of renewable energy sources, including solar, biothermal, biomass, and wind energy. Although each renewable energy source makes a distinct contribution to social justice, environmental protection, and economic development, there is still a need for awareness campaigns regarding wind and biomass energy. In order to achieve sustainable development goals and address the issues of climate change and energy security, a diversified portfolio of renewable energy technologies must be incorporated into the energy mix. It will help reduce greenhouse gas emissions, while also enhancing economic growth, enhancing energy access, and creating jobs. Nigeria's future climate will be friendlier and more stable economically if the country diversifies its energy mix and decreases its dependency on fossil fuels. Policymakers and other interested parties should think about the following suggestions in light of the findings:

1. Infrastructure creation and policy execution in the field of renewable energy are crucial for the nation's sustainable development.
2. Increase spending on R&D to promote technological advancements and bring down the price of solar energy technology.
3. Encourage public-private collaboration in the exploration and development of geothermal resources in appropriate areas to maximize the advantages of thermal energy.
4. To combine energy needs with environmental and social concerns, employ sustainable biomass energy techniques, such as making use of agricultural waste and developing effective biomass conversion technology.
5. To increase societal acceptance and address potential issues, encourage the growth of wind energy through supporting legislation, expedited permitting procedures, and cooperative community engagement.

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