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Synergizing Afforestation and Renewable Energy: A Sustainable Framework for Forest Conservation in Cross River State

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Abstract
This study is on Synergizing Afforestation and Renewable Energy: A Sustainable Framework for Forest Conservation in Cross River State. Two research questions and hypotheses were formulated to guide the study. The population of this study consists of all 73,755 farmers in Cross River State, Nigeria that are registered under the Agricultural Development Programme across various Local Government Areas. The stratified and systematic random sampling techniques, including the proportionate sampling approach, were used to select a total of four hundred and ninety-five (495) registered farmers with the Agricultural Development Programme in Cross River State. Afforestation and Alternative Renewable Energy Questionnaire (AAREQ) was used for data collection. The data were analysed using simple linear regression. The results revealed that there is a significant prediction of afforestation on conservation of forest resources in Cross River State and that use of alternative/renewable energy can significantly predict conservation of forest resources in Cross River State. Based on the findings, it was recommended, among others, that indigenous tree species should be incorporated with community-led initiatives; and this strategy should be complemented by promoting renewable energy sources (solar, wind, hydro) to reduce dependence on forest resources for energies.
Keywords*:* protecting, forests, afforestation, alternative/use, renewable, energy

Introduction

The conservation of Cross River State's Forest resources remains crucial for maintaining ecological balance, supporting biodiversity and ensuring sustainable livelihoods. Forests provide essential ecosystem services, including carbon sequestration, soil conservation and water cycle regulation. However, deforestation and environmental degradation threaten these vital resources, driven by unsustainable practices, agricultural expansion and energy demands. This widespread deforestation compromises ecosystem resilience, exacerbates climate change, jeopardizes local communities' livelihoods, exacerbates soil erosion and diminishes water quality. Effective conservation strategies are imperative to protect Cross River State's forests, necessitating innovative solutions like afforestation and renewable energy.

Conservation of forest resources has become a critical issue of discourse in global debates due to its relevance to the ecosystem. Forest resources are vital for human life because they provide a diverse range of resources. They store carbon, act as carbon sink, and produce oxygen, which is vital for the existence of life on earth. So, they are rightly called earth lung; they help in regulating hydrological cycle, planetary climate, purify water, provide wildlife, stabilization of soil, amelioration of climate and provision of habitation for wildlife. Conservation of forest is concerned with the planned act of maintaining and controlling natural resources in order to prevent its exploitation, destruction or abuse.

Forest conservation areas help conserve ecosystems that provide habitats, shelter, food, raw materials, genetic materials, a barrier against disaster, a stable source of resources and many other ecosystem goods and services, thus can have an important role in helping species, people and countries adapt to climate change. By virtue of their protective status, these forests should remain free from destructive human intervention. They can thus continue to serve as a natural storehouse of goods and services into the future. Forest Protected areas have been recognized for several decades as an essential tool for conservation of biodiversity. The impacts of climate change now give them a renewed role as adaptation tools for changing climate. Forest protected areas may provide ecosystem services such as drinking water, carbon storage and fossil stabilization, harbour sacred sites for different faith groups, and hold important gene reservoirs of value in medicine, agriculture and forestry. In the face of climate change, these roles all become more critical to enhance the adaptive capacity of local people to cope with climate change (Simms, 2015). An understanding of the integral role of forest in the earth's life support system could be better understood from the ecological and socio-economic services which they provide to both the environment and mankind (Shuaibu et al., 2018).

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The variations in climate parameters affect different sectors of the economy such as agriculture, health, water resources, energy, among others. The main case of climate change has been attributed to anthropogenic (human) activities like increased industrialization, urbanization, mining activities and unsustainable agricultural practice in the developed nations and developing nation, which have led to the introduction of large quantities of greenhouse gases (GHGS) including Carbon (IV) oxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) into the atmosphere. Climate actions have often fallen into one or two strategies: mitigation efforts to lower or remove greenhouse gas emissions from the atmosphere, and adaptive efforts to adjust systems and societies to withstand the impacts of change. The separation between climate change mitigation and adaptation has led to a misguided narrative that addressing climate change requires a choice between the two. However, this dichotomy is not only counterproductive but also perilous, particularly for vulnerable populations such as coastal villagers, farmers, and communities on the frontlines of climate change. The reality is that adaptive and mitigation is two sides of the same coin. Climate change has become a global issue in recent times manifesting in variations in climatic parameters like cloud cover, precipitation, temperature ranges, sea level and vapour (Ministry of Environment of the Federal Republic of Nigeria (MOEFRN), 2015).

Afforestation is the process of introducing trees and tree seedling to an area that has previously not been forested. It can be done through tree planting and seedling, naturally or artificially. Similarly, reforestation can be considered as a form of afforestation. Afforestation is the alteration of non-forested area to a forested area through tree planting and seedling. Reforestation is the restoration of an area that has been deforested. According to Schirmer and Bull (2014), the sustainable management of afforested or reforested land helps in pursuing adaption responses, since it maintains forests status and guarantees ecosystem services, especially at local scale by reducing vulnerability to climate change and to biodiversity loss. In case of crop failure due to climate change, forests can provide safety nets for local communities with their products like wood or non-wood products, such as game animals, nuts, seeds, berries, mushrooms, and medicinal plants. Afforestation and reforestation can also control soil degradation, hydraulic and landslide risks and encourage local communities towards agroforestry or silvo-pastoral system, thus creating new income opportunities (Reyer et al., 2015). Through the Agenda 2000 programme, afforestation was intended as an accompanying measure of the agricultural policy. European Union afforestation policies have supported the planting of about 2 million hectares of trees on agricultural land in the period from 1994-2015. However, the level of afforestation has decreased over the last decades although afforestation is currently considered as a mitigation strategy for CO_2

sequestration. When afforestation is practiced in areas that had no forests, it gives benefits of its own. Moreover, this conversion of semi-arid land into forests makes them more sustainable and prevents soil erosion and reduces the impact of climate change.

Renewable energy refers to energy generated from natural resources that can be replenished rapidly, exceeding the rate at which they are depleted. Sunlight and wind, for example are such sources that are constantly being replenished. Renewable energy sources are plentiful and all around. Fossil fuels, coal, oil and gas on the other hand are non-renewable resources that take hundreds of millions of years to form. Fossil fuels when burned to produce energy, cause harmful greenhouse gas emissions such as Carbon dioxide. Generating renewable energy creates far lower emissions than burning fossil fuels. Transitioning from fossil fuels, which currently account for the highest percentage of emissions, to renewable energy is key to addressing the climate crisis. Renewable energy is now cheaper in most countries and generates three times more jobs than fossil fuels (Nicholas & Ryan, 2021). Some of the most common sources of renewable energy include: Solar energy, which is the most abundant energy resource, can be harnessed even on cloudy days. This energy is captured using solar panels. Wind energy utilizes the kinetic energy generated by moving air. Large wind turbines, located on land (onshore) or in the sea or freshwater (offshore), convert this energy into electricity. Hydropower, harnesses the energy of moving water from higher to lower elevations, hydropower reserve from reservoirs and rivers. Geothermal energy harnesses the accessible thermal energy from the Earth's interior, offering numerous environmental and economic benefits. These benefits include reducing greenhouse gas emissions from fossil fuels and minimizing certain types of air pollution.

Amna et al. (2015) noted that planting trees is one of the best ways to reduce the amount of carbon in the air and helps in conserving forest resources; stressing that these trees capture Co_2 emissions and, with the help of photosynthesis, they create clean oxygen for humans to breathe. Afforestation is the process of transforming barren land into a forest. It refers to planting trees in areas where there has been no tree cover before or not for many years. One of the most significant reasons why afforestation is essential is because it battles climate change and conserves the forest. This process of afforestation can help breathe life into the area and create a new ecosystem thereby conserving the forest resources around the area. Afforestation can aid in increasing soil quality, prevent erosion, create new wildlife habitats, protect nearby areas from intense winds and floods. Gross-Camp et al. (2015) stated that the most significant benefit of afforestation is that it fights against climate change and global warming, stressing that trees absorb carbon and play a

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crucial role in reducing the greenhouse effect which also aid in conserving the forest. The planting of new forests helps in capturing more carbon emissions from the air.

Dario and Iacoviello (2022) remarked that the importance of renewable energy in the economic sector is evident in not only forest conservation but its contribution to job creation and industry growth, stressing that as the demand for renewable energy increases, sectors related to its production and maintenance see a surge in job opportunities. This not only boosts the economy but also provides sustainable employment opportunities. The need for renewable energy stems from a desire for energy independence. Countries that rely heavily on imported fossil fuels are vulnerable to price fluctuations and supply disruptions. Renewable energy sources, predominantly harnessed locally, offer a solution to this dependency. Ellabban et al. (2014) noted that the advantages of renewable energy extend beyond forest conservation but to individuals' wallets as well. As technology advances and becomes more widespread, the costs associated with renewable energy are decreasing. This trend is expected to continue, making it an economically viable option for many. The importance of renewable energy in ensuring affordable energy for all cannot be understated. As prices continue to drop, more and more people will have access to clean, renewable energy thereby boost forest conservation in the society. Community-based renewable energy projects have a direct positive impact on local communities (Kowalski, 2011). These projects not only ensure a steady supply of energy but also stimulate local economies by creating jobs and ultimately leads to reduction in deforestation.

This study is anchored on Mather and Grainger Forest Transition Theory (1990). This theory was propounded by Mather and Grainger in 1990. The theory states that forest land use changes in the long run, provides firm evidence where initial forest land areas retreat at a high speed, at the same point, depletion starts slowing down. There is even a critical point over which the process of depletion reverses and forest land recovers by expanding into new areas.

The relevance of Forest Transition Theory to this study seems to be in agreement with Mather and Grainger opinion that focused on tropical regions where one of the most important proximate causes of deforestation is believed to be unsustainable agricultural activities. The conversion and modification of forest land for subsistence and commercial farming increase the rate of deforestation in the rural areas. Farming activity that involves "slash and burn" practices for land preparation may lead to the encroachment of forest fire, although ashes from burning reduce soil acidity and kill crop pest and other destructive weed. The once-pristine forest ecosystems now teeter on the brink of collapse, their delicate balance shattered

by the relentless onslaught of reckless farming practices in the research area. In the rural areas, most families have been reduced to subsistence level and are only struggling to meet their social or basic needs before protecting their environment.

Mather and Grainger's Forest Transition Theory (1990) provides valuable insights into forest conservation dynamics. Their framework outlines three phases: forest depletion, transition, and regeneration. This theory informs the understanding of Cross River State's Forest dynamics, highlighting human impacts on forest cover. Applying this theory guides strategies for reversing deforestation through afforestation and renewable energy initiatives. Mather and Grainger's work underscores the importance of sustainable forest management practices.

Statement of the problem

Cross River State's forests are experiencing alarming depletion due to relentless deforestation, posing profound threats to biodiversity, essential ecosystem services and local livelihoods. Despite concerted conservation efforts, the alarming rate of forest loss persists, driven primarily by unsustainable practices and ever-increasing energy demands. A significant knowledge gap exists in understanding the synergistic benefits of integrating afforestation initiatives with renewable energy strategies to combat deforestation. This study aims to bridge this gap by exploring the combined impact of afforestation and renewable energy on conserving Cross River State's fragile forest resources, ultimately informing holistic sustainable forest management practices.

Objectives of the study

Specifically, the study seeks to find out whether:

1. Afforestation predicts conservation of forest resources in Cross River State.
2. Use of renewable energy predicts conservation of forest resources in Cross River State.

Research questions

The following research questions were posed to guide the study:

1. How does afforestation predict conservation of forest resources in Cross River State?
2. To what extent does use of renewable energy predict conservation of forest resources?

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Hypotheses

The following hypotheses were formulated to guide the study:

Ho1: There is no significant prediction of conservation of forest resources by afforestation in Cross River State.

Ho2: Use of renewable energy does not significantly predict conservation of forest resources in Cross River State.

Methodology

Descriptive survey research design was used for the study. The research design studies situations as they exist at the time of a research. This design was adopted because this research is to investigate the synergy of afforestation and renewable energy in predicting sustainable framework for forest conservation in Cross River State. This research design is therefore considered appropriate for this study because it will allow the researchers make use of a representative sample of the population from where generalization of the study result will be made. The stratified and systematic random sampling techniques including the proportionate sampling approach was used for this study. The local government areas (LGAs)in the state were stratified into three senatorial districts for random selection. The researchers wrote the names of the state's 18 LGAs according to their strata on small pieces of paper, folded the pieces of paper into little ball-like shapes which were turned into three bowls, each representing a senatorial district in the state. The pieces of paper were mixed and the researchers blindly pick 50% of the paper balls from each of the bowls, according to their senatorial districts. This study targeted the expansive community of 73,755 registered farmers in Cross River State, Nigeria, participating in the Agricultural Development Programme. To ensure a representative sample, the researchers employed stratified and systematic random sampling techniques, incorporating proportionate sampling. This approach resulted in the selection of 495 farmers.

The instrument used for data collection was a questionnaire titled Afforestation and Alternative Renewable Energy Questionnaire (AAREQ). The instrument was face and construct validated by five experts. Three experts were from Test and Measurement and two from Environmental Education Department, both from University of Calabar, Cross River State. The instrument had 30 items, but at the end of the validation 10 items were dropped bringing the number of items in the questionnaire to 20. Subsequently, to ascertain the reliability of the AAREQ, a pilot test was carried out using twenty (20) randomly selected respondents from area of the study not used for the actual study. Cronbach alpha reliability estimate was used to determine the reliability coefficient of the instrument. The reliability coefficient of the instrument ranges from 0.78 to 0.86. Each of the items in the instrument was scored using the 4-point Likert scale thus: 4 points for

Strongly Agree, 3 points for Agree, 2 points for Disagree and 1 point for Strongly Disagree for positively worded items, and reverse scores for negatively worded items. Subsequent analysis used simple linear regression, illuminating the intricate relationships between variables and yielding valuable perspectives on afforestation and renewable energy practices among the farming community. The proportionate sampling approach was used to select 10% of communities from each of the 10 LGAs sampled for the study. From the communities, systematic random sampling technique was then employed to select 5% of the farmers. Using the list of registered farmers in each selected community, every 10^{th} name on the list was selected for the study. The data collected during the study were analyzed with simple linear regression using package IBM SPSS Version 27. The data were analyzed at .05 level of significance at 1 and 493 degrees of freedom.

Presentation of results

Ho1: There is no significant prediction of conservation of forest resources by afforestation in Cross River State.

The result of the analysis is shown in Table 1.

Table 1: Simple regression analysis of the prediction of conservation of forest resources by afforestation in Cross River State

Model	R Square	Adjusted R Square	Std. Error of the Estimate
.174[a]	.030	.028	2.69718

ANOVA[b]

Model	Sum of Squares	df	Mean Square	F-ratio	Sig.
Regression	112.339	1	112.339	15.442	.000[a]
Residual	3586.477	493	7.275		
Total	3698.816	494			

a. Dependent Variable: Forest conservation

The simple regression analysis in Table 1 showed the prediction of conservation of forest resources by afforestation in Cross River State which produced an adjusted R^2 of .028. This implies that only 2.8 percent of the variance of the dependent variable (conservation of forest resources) can be predicted from the independent variable (afforestation). The F-value of 15.442 of the Analysis of Variance (ANOVA) obtained from the regression table with a p-value of .000 with 1 and 493 degrees of freedom at .05 level of significance showed that the null hypothesis was rejected. This result therefore signifies that

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afforestation significantly predicted conservation of forest resources by 2.8 percent. The result therefore implies that there was a significant prediction of conservation of forest resources by afforestation in Cross River State.

Ho2: There is no significant prediction of conservation of forest resources by use of renewable energy.

The result of the analysis is shown in Table 2.

Table 2: Simple regression analysis on the prediction of conservation of forest resources by use of renewable energy in Cross River State

Model R	R Square	Adjusted R Square	Std. Error of the Estimate
.154	.024	.022	2.70663

ANOVA[b]

Model	Sum of Squares	df	Mean Square	F-ratio	Sig.
Regression	87.161	1	87.161		
Residual	3611.655	493	7.326	11.898	.001[a]
Total	3698.816	494			

a. Dependent Variable: Forest conservation

The simple regression analysis in Table 2 showed the prediction of conservation of forest resources by use of renewable energy in Cross River State which produced an adjusted R^2 of .022. This implies that only 2.2 percent of the variance of the dependent variable (conservation of forest resources) can be predicted from the independent variable (use of renewable energy). The F-value of 11.898 of the Analysis of Variance (ANOVA) obtained from the regression table with a p-value of .001 with 1 and 493 degrees of freedom at .05 level of significance showed that the null hypothesis was rejected. This result therefore signifies that use of renewable energy significantly predicted conservation of forest resources by 2.2 percent. The result therefore implies that there was a significant prediction of conservation of forest resources by use of renewable energy in Cross River State.

Discussion of the findings

Results from hypothesis I showed that afforestation significantly predicted conservation of forest resources in Cross River State. This result is in tandem with Amna et al. (2015) that noted that planting trees is one of the best ways to reduce the amount of carbon in the air which helps in conserving forest resources, stressing that these trees capture Co_2

emissions and with the help of photosynthesis, they create clean oxygen for humans to breathe. Afforestation is the process of transforming barren land into a forest. It refers to planting trees in areas where there has been no tree cover before or not for many years. This result also agrees with Gross et al. (2015) who noted that the most significant benefit of afforestation is that it fights against climate change and global warming, stressing that trees absorb carbon and play a crucial role in reducing the greenhouse effect which also aid in conserving the forest. The planting of new forests helps in capturing more carbon emissions from the air. In other words, trees act as carbon sinks and create a more sustainable environment. The process of afforestation is transforming barren lands into flourishing forests. Soil erosion occurs when the ground is exposed to strong winds, flowing water and heavy rainfall. With afforestation, trees block excessive winds and prevent rain from damaging the ground.

Findings from hypothesis II showed that use of renewable energy significantly predicted conservation of forest resources in Cross River State. This result conforms with Nicholas and Ryan (2021) who stated that fossil fuels currently account for the highest percentage of emissions. According to the authors, renewable energy is key to addressing the climate crisis. The authors further stated that renewable energy is now cheaper in most countries and generates three times more jobs than fossil fuels. Some of the most common sources of renewable energy include: Solar energy, which is the most abundant energy resource, can be harnessed even on cloudy days. This energy is captured using solar panels. Wind energy utilizes the kinetic energy generated by moving air. Large wind turbines, located on land (onshore) or in the sea or freshwater (offshore), convert this energy into electricity. Hydropower, harnesses the energy of moving water from higher to lower elevations, hydropower reserve from reservoirs and rivers. The importance of renewable resources in fostering community development and cohesion is a testament to the multifaceted benefits of renewable energy.

Conclusion

This study establishes that afforestation and renewable energy initiatives collectively play a pivotal role in conserving Cross River State's Forest resources, mitigating deforestation and promoting sustainability. By integrating these strategies, policymakers can effectively protect biodiversity, support ecosystem services and ensure environmentally resilient development.

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Recommendations

Based on the findings of the study, the following recommendations were given by the researchers:

1. Government should implement large-scale afforestation programmes in Cross River State, incorporating indigenous tree species and community-led initiatives. This strategy should be complemented by promoting renewable energy sources (solar, wind, hydro) to reduce dependence on forest resources for energies.
2. The government should offer incentives (tax breaks, subsidies) to encourage households, businesses, and industries in Cross River State to adopt renewable energy technologies.

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