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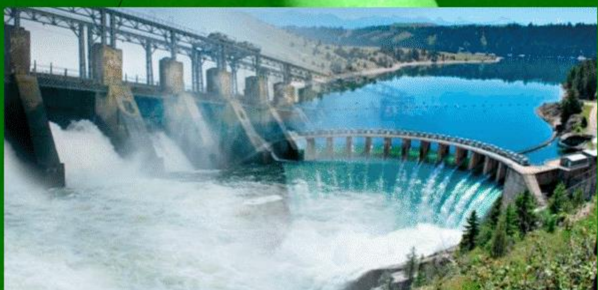

About the Journal

The Journal of Digital Food, Energy & Water Systems (JD-FEWS) is a peer-reviewed bi-annual publication that publishes recent and innovative deployment of emerging digital technologies in Food, Energy, and Water Systems. Food, energy, and water resources are interconnected scarce resources that require systems and technologies to foster sustainable management and effective utilization. The journal is also interested in articles that explore the nexus between at least two of these resources. Thejournal considers the following topics as long as they are deployed in the Food, Energy & Water space:

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- Machine Learning
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- Robotics
- System architectures
- Wireless Sensor Networks

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Editorial Team

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Household Energy Conservation Behaviour: A Socio-Economic Perspective

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Abstract- Studies on energy conservation and household behavior were predominantly based on econometrics using secondary data, with limited studies employing primary data. In addition, secondary data from developing countries are not without their inadequacies due to missing data points. However, generating data may lead to over or underestimations which led to this study deploying a structural equation model and using cross-sectional data from a developing country perspective. With 329 respondents from each household in Akure Metropolis, Nigeria, who were chosen at random to fill the structured questionnaire provided the data. The Partial Least Square Structural Equation Modeling method was used for the study. The study's findings demonstrated that socioeconomic factors such as home size, income, number of appliances, and weather substantially impact people's behavior regarding energy conservation, with income having the highest structural weight. This suggests that income is crucial to residents' electricity-saving habits since households with higher incomes use more electricity and conserve it less. Therefore, it is advisable that policies to save energy focus on limiting the purchasing power per unit at the household level, where the wealthy pay more tax than the poor. This would encourage improvements in energy conservation in the Nigerian economy's household sector.

Keywords: *Energy conservation behaviour, energy efficiency, socio-economic factors, income, weather, gender attributes*

1.0 Introduction

For a very long time, households in Nigeria have been plagued by power outages and an endless supply of electricity. All national efforts to solve the electrical supply issue have been met with difficulty. As a result, most States have come up with local solutions to this endless supply of electricity in their own communities. Being the State capital, the situation in Akure metropolis is similar. Most households in the capital city experience an inequitable allocation of power supplies. In the city, it has been noted that most families only have a meager two to three hours of electrical supply each day, while a smaller percentage have it for more than ten (10) hours. This does not exclude locations with sporadic access to energy. Residents have made multiple attempts to install alternative energy sources; however, doing so frequently results in high costs, noise, and increased carbon emissions from dirty energy sources like diesel or gasoline generating sets. As there is a clear correlation between inadequate electricity supply and subpar economic development, this issue has increased poverty and a decline in the standard of living for people [1].

In order to increase the citizens' access to electricity, Akure Metropolitan urgently needs a dependable, affordable, clean, and technology-driven source of electrical energy [2]. The behavioral preservation of the finite supply is crucial above all else. According to existing research, the situation can be improved by consuming less energy and doing it to encourage greater efficiency because this is more affordable and effective at reducing carbon emissions than increasing production [3]. A fuller knowledge of the mechanisms and driving forces behind household energy-saving goals is necessary to create energy conservation policies and promote energy-efficient behavior in households.

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Earlier studies have employed the theory of planned behavior (TPB) to forecast or clarify family energy-saving behavior [4] [5] [6]. The TPB framework states that the intention to engage in a particular behavior (perceived behavioral control) is determined by three psychological predictors: a positive evaluation of the action (attitude), social pressure to engage in the behavior (subjective norm), and perceived ease of engaging in the behavior. However, according to some researchers [7] [8], while few studies have examined the effects of socio-economic factors on household energy-saving intention or behaviors, the TPB framework pays less attention to the interactions between behavioral intention and energy conservation practices. Most empirical studies have also concentrated on Asian, European, and American households' energy-saving behaviors. For instance, Jiang et al. [9] investigated the residential building sector's energy conservation and emission reduction approach in Jiangsu Province, China. Based on an econometric analysis of data from Danish smart meters, Andersen et al. [10] evaluated residential power usage and household characteristics. A study entitled "Saving from Home! How Income, Efficiency, and Curtailment Behaviors Shape Energy Consumption Dynamics in US Households" was conducted by Kumar et al. [11]. In Malaysia, Ali, [12], investigated the key variables influencing home electricity use. However, there are few empirical research on this topic in the context of Sub-Saharan Africa.

Studies on energy efficiency and household behavior were also primarily focused on econometrics utilizing secondary data, with just a small number of studies using primary data. Additionally, secondary data from developing nations is limited due to missing data points. To assess the impact of socioeconomic factors on energy conservation behavior, and to analyze the socioeconomic constructs and indicators affecting Household energy conservation behavior in Akure Metropolis, this study employed a structural equation model and used cross-sectional data from a developing country perspective. This study, therefore, sought to fill the knowledge gap. By identifying the socio-economic drivers of energy conservation behavior and how they affect electricity usage, this study adds to our body of knowledge. This is crucial for boosting electricity conservation and end-use effectiveness in Nigeria's domestic economy. The results of this study explain energy-saving behavior that supports activities that advance national development.

The introduction is the first section of the study's structure, followed by a discussion of a review of pertinent literature. Thereafter, the presentation of the tools and techniques used to accomplish the objectives, results were provided and discussion ensued. The conclusion and recommendation were then given.

2.0 Literature Review

2.1 Energy conservation

Energy conservation, also known as energy saving, is often referred to as the "Fifth Fuel," with the other four fuels being main or "fossil" fuels like coal (solid), oil (liquid), gas, and nuclear/hydroelectricity [40]. This idea supports the need to reduce energy use nationally and internationally. According to the rate of usage, it is a basic reality that the world's fossil fuel reserves will eventually deplete; as a result, if the consumption of these energy sources is decreased, the reserves will last longer [13]. Research might offer ways to increase the currently accessible reserves, thereby extending the time before these non-renewable energy sources inevitably run out.

Electrical energy conservation refers to reducing or eliminating the usage and wastage of superfluous energy [14]. Making scarce resources last as long as possible is not the goal of power conservation; doing so would amount to nothing more than extending a crisis until all available energy sources have been exhausted. According to Parag et al. [15], conservation is lowering demand on a finite supply and allowing that supply to start rebuilding. Reducing demand, protecting, and replenishing supplies, and repairing any harm left behind from previous energy operations are the three main objectives of energy conservation measures.

International policies addressing pollution, global warming, and the depletion of fossil fuels all include energy conservation as a crucial element. The housing market is crucial to these efforts since the residential sector accounts for nearly one-fifth of the world's energy demand [15]. Policymakers, the real estate business, and academics are all interested in finding novel strategies to cut residential energy use [16].

Energy conservation behaviors are those that help people use less energy (electricity) overall, according to the definition used in this study. One example of such behavior is curtailment, which saves energy by reducing use [7]; efficiency, which saves energy by purchasing more energy-efficient electrical appliances; or maintenance,

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which saves energy by performing maintenance on appliances to increase their overall performance and efficiency. Efficiency practices can be divided into two categories: low investment in intensive measures (such as switching from incandescent to compact fluorescent lighting) and high investment in intensive practices [11].

2.2 Socio-economic determinants of energy conservation behaviour

Based on prior research, the current study has identified nine (9) socioeconomic characteristics frequently discussed in earlier research and linked to energy-saving behavior in households. It has been discovered that these factors directly affect people's propensity to conserve energy. The socioeconomic factors include: the cost of electricity, income, the household size, the age and gender of the head of the household, the number of rooms in the home, the number of appliances, and the weather. These socioeconomic characteristics are used in this study, as will be discussed in the following paragraphs.

a. Electricity Price

According to Parag et al. [15], energy prices significantly impact both short- and long-term household energy use. Increased energy prices also lead to changes in the type of energy consumed and reduced energy use [9]. The paper also contends that "slight variations in energy prices do not usually impact residential energy use. It is only possible to observe a decrease in energy demand if the price exceeds a specific threshold.

b. Income

Energy usage in a nation is significantly impacted by economic growth [1]. A strong economy is necessary to meet people's demands and ensure efficient resource allocation. The economic system, particularly the householder's income, now determines the use of technology and, in turn, impacts the consumption of energy [17]; [18]; [19]. This is due to the increasing engagement of technology in our day-to-day lives.

c. Household Size

The term "household size" simply refers to the population of each household. According to researchers, occupancy has the biggest impact on changes in energy consumption. Large household sizes were associated with a higher likelihood of using unclean sources of fuel for cooking, according to Ahmad et al., [19] Urban households and those with higher wealth levels were more likely to cook with clean fuel sources. According to Ali et al., [12], socio-demographic factors like income and household size that affect energy use incentives and restraints tend to be strongly linked to household energy usage.

d. Householders' Age

In this study, the term "households' age" refers to the age of the household head. According to Chen et al., [20], householder age is one of the key determinants of the household cooking energy transition in mountainous locations.

e. Gender Attributes

Issa [21] found that gender diversity on a board positively impacted a company's use of clean energy, drawing on the gender socialization theory and diversity theory. According to research by Kyaw et al. [22], women are more likely to favor using clean energy because they are more concerned with societal and ecological issues. This increases the reduction of carbon emissions and enhances environmental performance.

f. Dwelling Size (Number of Rooms)

According to Wassie et al. [23], the size of a home is a significant predictor of how much is spent on energy. The overall amount of energy a house uses depends on how many rooms it has. It goes without saying that more energy is needed for space heating, cooling, and lighting the larger the floor size of a house [12].

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g. Energy Efficient Appliances

Energy consumption in the residential sector can be parsed into five major end uses: space heating, water heating, cooking, lighting, and electric appliances. Appliances can be further broken down into refrigerators, clothes washers, dryers, dishwashers, and even TV. However, the magnitude of each end use differs from country to country. Appliance affordability and the number of a household is one of the leading causes of increases in residential energy demand [24].

h. Weather Condition

Climate and weather zone Numerous studies have demonstrated the impact of weather variables on energy consumption, specifically on electricity demand, and the numerous human factors affecting domestic energy use [25]. When determining the effect of outdoor temperature on energy use in buildings, energy analysts utilize three quantitative indices: heating degree-days, cooling degree-days, and degree-days. Every building has a minimal energy use temperature, also known as the "balance point" for that particular building, when no heating or cooling occurs. The building is heated or cooled by each degree that it deviates from the balancing point [26].

2.3 Studies on Socio-economic Factors influencing Energy Conservation Behaviour

To establish a successful energy policy and forecast future power consumption, it is necessary to understand the factors that influence electricity consumption. As a result, a large body of research employing various techniques on data from various nations and groups of nations is trying to pinpoint and explain the factors that influence energy usage. Piao and Managi [7] looked into life satisfaction, energy consumption, and home energy-saving behavior. The study determined if purchasing energy-saving products at the household level can reduce greenhouse gas emissions and whether an increase in household income can encourage energy-saving behavior. A large-scale survey was carried out in 37 countries using online and in-person methods, gathering 100,956 observations. It was discovered that the wealth effect on household energy expenditure was positive across all countries, demonstrating that energy consumption rises as household wealth increases. There was a positive correlation between home energy use and life satisfaction in 27 out of 37 households, including those in China, India, the US, and Germany. Additionally, it is confirmed that energy-saving behaviors in households have positive impacts. Compared to behavior that reduces energy use, purchasing household energy-saving products minimized energy consumption expenses.

Based on data from the Pakistan Demographic and Health Survey (PDHS) 2017–18, Ahmad et al. [19] did a study on "Dirty versus clean fuel for cooking." An estimating method used was binary logistic regression. The findings indicated that households with agricultural land and livestock, as well as those with large household sizes, were more likely to use dirty sources of fuel for cooking than households with better wealth status and those living in urban areas. Additionally, households with male household heads and higher educational status were also more likely to use clean sources of fuel for cooking.

Ali et al. [12] conducted research on the key factors influencing home power use in a metropolis that is quickly expanding. By investigating relationships and their impacts on energy usage among 620 urban families in Seremban, Malaysia, this study sought to examine the important factors influencing household electricity consumption. According to the findings, the average urban household uses 648.31 kWh of power per month, and when quality of life rises, this figure rises along with monthly household income ($r = 0.360$; $p<0.01$) and the number of rooms ($r = 0.376$; $p<0.01$). Home and kitchen use took up a significant amount of the electricity, followed by cooling and lighting. According to results from multiple linear regressions, married households with high monthly incomes and large household size of three to five individuals are significant predictors of power use in Seremban. According to the study's empirical findings, the number of rooms plays the most important role in determining how much electricity is consumed. Strategies to improve energy efficiency, ensure resource sustainability, and lessen greenhouse gases' damage to the urban ecosystem are essential. To achieve the largest

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potential decrease in energy consumption in metropolitan areas, low carbon initiatives for energy conservation and technology advancement and the implementation of domestic sector laws are crucial.

Similarly, Huang [27] demonstrated that quantiles and variations over time can be used to discern the effects of demographic, socioeconomic, and housing variables on household electricity consumption in Taiwan. According to this study, higher income levels, more household members, and the presence of older individuals in the home are the primary features of those households that are larger energy consumers. Price, income, and weather conditions were identified as the three main determinants of electricity use in Spain by Blazquez et al. [28] using aggregate panel data, with weather variables having the greatest influence on consumption.

According to Ackah et al. [29], households tend to migrate from energy-intensive cooking appliances to energy-efficient ones when their income increases. In developing nations like South Africa, Ye et al. [30] showed that household income and power costs significantly determine the amount of electricity consumed. Additionally, their research revealed that households in metropolitan locations with a high appliance density consume more electricity, particularly if there are more household members and they reside in larger homes. According to [31] analysis of the factors influencing electricity use in Jordan, the GDP, urbanization, economic structure, and total water consumption are all significant and positively correlated with electricity use, while electricity prices are significant and negatively correlated with it. Ownership of an air conditioner, freezer, fan, refrigerator, and television, as well as changes in socioeconomic and building factors like income, household size, and floor space, have been shown to have a high statistical significance in Ghana and collectively account for 57% of the variance in total electricity consumption in households, according to Sakah et al. [32].

Finally, it can be said that every nation, regardless of its degree of development, has its unique set of elements that affect energy consumption. However, the assessment of earlier studies shows that there are still few studies on the socio-economic factors of energy conservation in Nigeria, making the present study crucial.

3.0 Methodology

The research area is the Nigerian Ondo State metropolis of Akure. It is one of the 18 local government areas in Ondo State, with its headquarters in Akure, which serves as both the state capital and the area with the highest population in the state. It is one of the six local government areas that make up the Ondo Central Senatorial District. It can be found between latitudes 7’21" and 7’50" north and longitudes 5’50" and 7’25". It has a land mass that is 331 square kilometers in size, 250 meters above sea level. The study used a structured questionnaire as part of its survey research strategy. The survey was meant to gather data on the socioeconomic aspects impacting households in certain neighborhoods in the Akure metropolis’s energy conservation behaviors. According to the Ondo State Ministry of Lands and Housing directory, there are 1,538 households in total, making up the total population. With 329 respondents representing an individual from each household in Akure Metropolis, who were chosen at random to fill the structured questionnaire provided the data on socioeconomic determinants and energy-saving behavior components. A 7-point Likert scale was used as the rating for each indicator in a construct. The Smart-PLS procedure found in [33] was used to execute the objective of the study as expressed in the equation below:

The effect of socio-economic factors on energy conservation behaviour

$$dECB = \alpha_0 + \alpha_1 bSEFEP + \alpha_2 bSEFI + \alpha_3 bSEFHS + \alpha_4 bSEFAH + \alpha_5 bSEFGA + \alpha_6 bSEFHO$$

$$+ \alpha_7 bSEFNR + \alpha_8 bSEFNA + \alpha_9 bSEFW + e$$

Where;

dECB is energy conservation behaviour, α_0 is constant term, α_1 to α_9 are parameter coefficients, e is error term, bSEFEP is price of electricity, bSEFI is household income, bSEFHS is household size bSEFGA is gender

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attributes, bSEFAH is age of household head, bSEFHO is home ownership, bSEFNR is number of rooms, bSEFNA is number of appliances, and bSEFW is weather condition.

3.1 Partial least squares methods

This study used the partial least square structural equation modeling (PLS-SEM) approach to obtain adequate information from the model developed for the objective. Due to the procedure's ability to handle reflectively and formatively measured entities. To analyze the model, the study used SmartPLS version 3.3.3. The measurement model evaluation of the outer and inner models for the structural routes is part of the PLS-SEM methodology. Before any relevant conclusions about the correlations could be made, these two sequences were carried out to demonstrate that each construct's indicators are genuine and trustworthy. As a result, the study provides a report on the measurement model for each of the employed indicators and constructs.

All the categories and variables assessing socioeconomic factors and households were used in the original model. The model contained 13 constructs and 37 items or indicators but, because of low outside loadings, four items (bSEFHO5, dECBPS3, dECBSCC1 and dECBSCC2) were eliminated due to a composite reliability issue. Although, the construct dECBSCC's Cronbach Alpha (0.505) was below the cutoff point (0.7), the construct was retained since the average value extracted (AVE) was higher (0.502) than the threshold value (0.500). The factors were subsequently reduced from 37 items to 33 items and 13 constructs. The AVE evaluates convergent validity, whereas the Cronbach Alpha and composite reliability measure the internal consistency and reliability of the constructs and indicators. Each item was modeled as an indicator representing the relevant construct (Figure 1).

As a result, the study adhered to the standards set forth for the evaluation of the reflective model. These comprise of the convergent validity, discriminant validity, and internal consistency reliability. Based on the approaches suggested by Hair et al. [33] and Cronbach's alpha (CA) and Composite reliability (CR), the internal consistency of the constructs was assessed. Both CA and CR have a threshold of 0.700, according to Herath and Rao [34], with higher values denoting a higher degree of reliability. While the other validity coefficient was anticipated to be satisfactory, certain fields of study agreed that a suitable reliability range between 0.600 and 0.700 is appropriate [33].

Table 1: Construct Reliability and Validity

	Cronbach's Alpha	Composite Reliability	AVE
bSEFAH	0.842	0.894	0.678
bSEFEP	0.683	0.806	0.513
bSEFGA	0.741	0.838	0.569
bSEFHO	0.759	0.849	0.589
bSEFHS	0.876	0.915	0.728
Bsefi	0.762	0.847	0.581
bSEFNA	0.698	0.815	0.524
bSEFNR	0.770	0.850	0.587

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bSEFW	0.724	0.83	0.551
dECBPS	0.662	0.816	0.600
dECBSCC	0.505	0.751	0.502
dECBSCM	0.719	0.826	0.544
dECBSCU	0.703	0.818	0.531

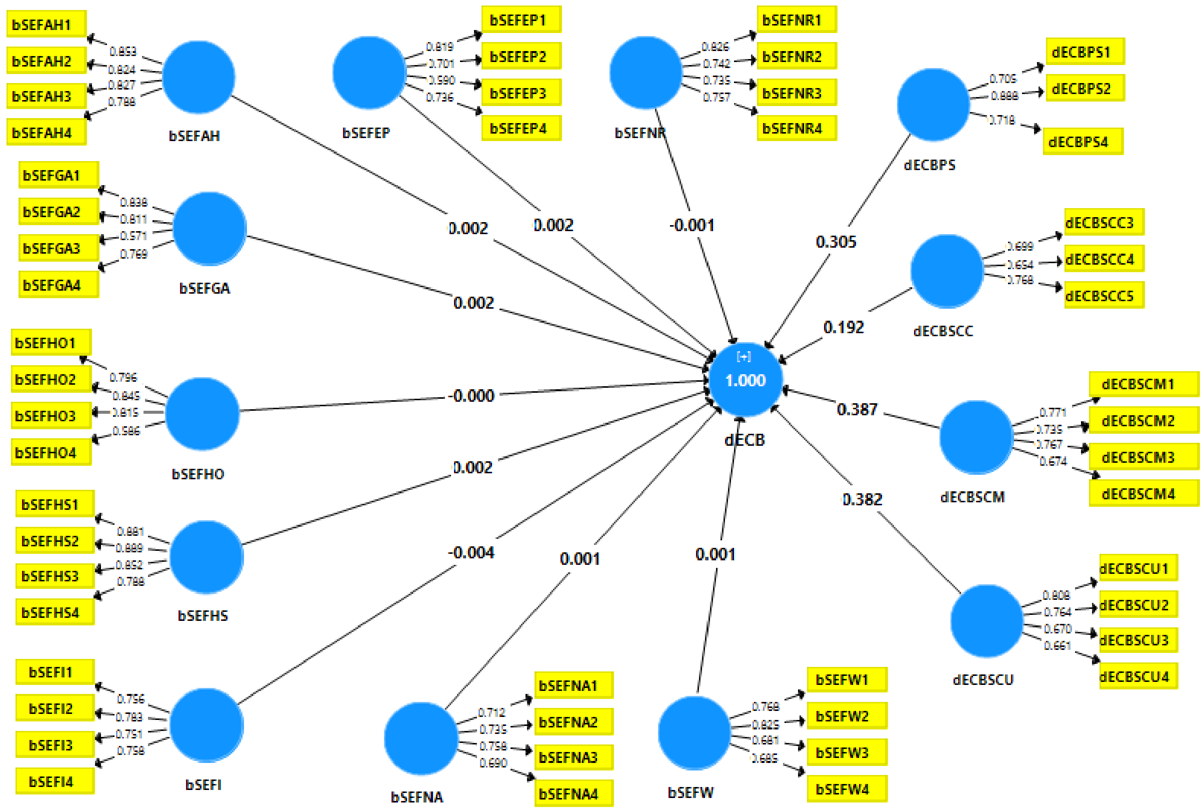

Figure 1: Measurement Model for Socio-Economic Factors and Energy Conservation Behaviour (Algorithm)

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Table 1 clearly shows that the CR values range from 0.751 to 0.915 and the CA values range from 0.505 to 0.876. The fact that these findings are above the suggested thresholds for both tests show that the constructs have no issues of reliabilities [33]. The results of the average variance extracted (AVE), a measure of convergent validity, were also provided in Table 1. The value ranged from 0.513 to 0.728, which is higher than the suggested value of 0.5 [33].

According to Hair et al. [33], discriminant validity assesses a construct's uniqueness by determining if the phenomenon it captures is distinct from other constructs in the model. This work used the Fornell-Larcker criterion and cross-loadings to evaluate discriminant validity. This was accomplished by contrasting the latent variable correlations with the square root of the AVE values. The diagonal of the correlation matrix displays the square roots of the AVE coefficients. To demonstrate discriminant validity, the squared root of each concept's AVE should be larger than its highest correlation with any other construct [33]. The study assessed the discriminant validity of the constructs based on their cross-loadings, Fornell-Larcker criterion, and the assessment of the correlation that is Heterotrait-Monotrait ratio (HTMT), which is presented in the measurement model in more detail. According to the cross-loading results, an indicator's outer loading on its latent construct (as indicated in Appendix I) needs to be more important than its cross-loadings on the other constructs in the model. There is no issue of cross-loading when the outer loadings of each indicator are larger on their respective constructs as compared to their cross-loadings on any other construct, with a minimum difference of 0.10, as indicated by Gefen and Straub [35] and Adepoju and Adeniji [34]. The Fornell-Lacker criterion is an additional method for proving the discriminant validity. It was suggested that the squared inter-construct correlation between each construct's AVE and any other reflectively assessed constructs within the structural model should be used to compare each construct's AVEs [33]. In essence, the shared variance for every model construct shouldn't be higher than their AVEs. The findings in Table 2 have shown that the AVE recommendation has been met for all constructs.

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Table 2 Fornell-Larcker Criterion

	bSEFAH	bSEFEP	bSEFGA	bSEFHO	bSEFHS	bSEFI	bSEFNA	bSEFNR	bSEFW	dECBPS	dECBSCC	dECBSCM	dECBSCU
bSEFAH	0.823												
bSEFEP	0.461	0.716											
bSEFGA	0.618	0.493	0.755										
bSEFHO	0.190	0.302	0.276	0.767									
bSEFHS	0.662	0.567	0.612	0.245	0.853								
bSEFI	0.248	0.375	0.224	0.301	0.229	0.762							
bSEFNA	0.375	0.410	0.399	0.397	0.490	0.447	0.724						
bSEFNR	0.172	0.206	0.139	0.324	0.169	0.517	0.384	0.766					
bSEFW	0.422	0.376	0.446	0.417	0.507	0.396	0.655	0.372	0.742				
dECBPS	0.436	0.614	0.453	0.265	0.565	0.338	0.438	0.206	0.447	0.775			
dECBSCC	0.338	0.255	0.268	0.238	0.249	0.371	0.321	0.270	0.398	0.365	0.709		
dECBSCM	0.425	0.409	0.478	0.330	0.527	0.388	0.539	0.285	0.583	0.481	0.342	0.738	

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dECBSCU	0.425	0.394	0.402	0.352	0.491	0.465	0.610	0.336	0.572	0.541	0.406	0.593	0.729

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In light of the limitations of the AVE approach, the study then evaluated the Heterotrait-Monotrait ratio (HTMT) to ascertain the discriminant validity of the components. [36]. It was suggested that a value greater than 0.90 indicated a lack of discriminant validity. Additionally, the value 1 should not be included in the HTMT confidence interval. Table 3 demonstrates that the results has met the HTMT requirements. The assessment of the measurement model, which determines the caliber of the indicators in relation to their constructions, is the final section of the HTMT report. The study looked at the structural models, which revealed information on the study's goals. Results and discussion contained the evaluation of the structural model.

4.0 Results and Discussion

Only 329 of the 400 copies of the questionnaire issued as part of the study were correctly filled out and used, representing 82% completion rate. According to the respondents' demographic breakdown, men made up 55.3% of the sample, while the remaining respondents were all women. Additionally, households between the ages of 20 and 30 made up the majority of respondents (42.6%). About 28.0% of the population is between the ages of 30 and 40. Whereas, about 6.6% of respondents are over 65, and lastly, 22.8% are between the ages of 40 and 60. Accordingly, the study's representatives were more middle-aged, making them a good study sample.

In addition, the findings of respondents' family structures show that 16.7% of single respondents have no dependents, 17.0% of single respondents have dependents, 21.3% of married respondents have no dependents, and 45.0% of married respondents have dependents. This means that about 62% of the respondents require control and monitoring of their households' electricity consumption due to the associated dependents. The study comprised of 4.0% of respondents with Ph.D. degrees, followed by 16.7% Master's degree holders, 44.1% First Degree holders, 18.2% Higher National Diploma holders, 10.3% Ordinary National Diploma holders, 5.8% Senior School Leaving Certificate holders, and 0.9% Primary School Leaving Certificate holders. As a result, it can be inferred from the respondents' educational backgrounds that at least 93.3% of them held degrees from postsecondary institutions, making them appropriately educated to understand the content and context.

The results also show that 8.5% of respondents have one person living with them, 11.9% have two people living with them, 18.8% have three people living with them, 23.7% have four people living with them, 16.4% have five people living with them, 13.4% have six people living with them, 4.0% have seven people living with them, 2.7% have eight people living with them, 0.3% have nine people living with them, and 0.3% have ten people living with them. With all of these statistics, we would not be surprised to have positive relationships between socio-economic indicators and energy conservation. The results of the monthly income survey indicate that 45.6% of the respondents earn less than ₦100,000 (or $130) per month. In addition, 39.5% of respondents have monthly incomes between ₦100,000 and ₦250,000, 10.6% have incomes between ₦250,000 and ₦500,000, 3.6% have incomes between ₦500,000 and ₦1,000,000, and 0.6% have incomes over ₦1,000,000 each month. According to the Consumer News and Business Channel (CNBC) research from 2019, the monthly income findings indicate that most of the respondents are middle-income earners. The results of the respondents' monthly electricity bills also reveal that 36.8% of the respondents have monthly electricity bills under ₦5,000, 40.4% have monthly bills between ₦5,000 and ₦10,000, 11.2% have monthly bills between ₦10,000 and ₦15,000, 5.2% have monthly bills between ₦15,000 and ₦20,000, and 6.4% have monthly electricity bills over ₦20,000, according to the characteristics of the respondents.

4.1 Effect of Socio-economic Factors on Energy Conservation Behaviour

The relationships between socioeconomic characteristics and home energy-saving practices in Akure metropolis is discussed in this section. The structural model technique was carried out after verifying measurement quality. Collinearity, R-square or coefficient of determination, path coefficient, and f-square or effect size are all involved. First and foremost, the values of the inner VIF (Table 4) showed that for the endogenous composite variable (dECB), the values were 2.085, 1.728, 1.971, 1.329, 2.491, 1.638, 2.072, 1.487, and 2.089, respectively. Given

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that all of the latent constructs are below the cutoff value of 5, the VIF test results, which checks multicollinearity among the variables, has demonstrated that there is no problem with multicollinearity among the latent constructs [34]. The PLS-algorithm (Figure 2) and bootstrapping (Figure 3) were carried out with 5000 resamples using PLS 3.3.3 to obtain the standard path coefficient, t-statistics values, standard deviations, and p-values [33]. This was done after the VIF test for the exogenous constructions had been shown to be adequate.

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Table 3: Heterotrait-Monotrait Ratio (HTMT)

	bSEFAH	bSEFEP	bSEFGA	bSEFHO	bSEFHS	bSEFI	bSEFNA	bSEFNR	bSEFW	dECBPS	dECBSCC	dECBSCM	dECBSCU
bSEFAH													
bSEFEP	0.571												
bSEFGA	0.765	0.661											
bSEFHO	0.246	0.421	0.387										
bSEFHS	0.771	0.698	0.74	0.286									
bSEFI	0.293	0.542	0.308	0.393	0.26								
bSEFNA	0.467	0.573	0.543	0.554	0.601	0.62							
bSEFNR	0.21	0.335	0.213	0.414	0.183	0.669	0.539						
bSEFW	0.533	0.519	0.597	0.573	0.623	0.53	0.921	0.484					
dECBPS	0.59	0.891	0.634	0.364	0.746	0.45	0.633	0.331	0.63				
dECBSCC	0.517	0.421	0.415	0.369	0.365	0.582	0.551	0.402	0.651	0.605			
dECBSCM	0.538	0.569	0.642	0.453	0.652	0.515	0.755	0.378	0.807	0.686	0.553		
dECBSCU	0.533	0.543	0.553	0.482	0.594	0.63	z0.863	0.45	0.789	0.755	0.683	0.825	

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Table 4: Variance Inflation Factor (Inner VIF) with Endogenous Variable (dECB)

Construct	VIF
bSEFAH	2.085
bSEFEP	1.728
bSEFGA	1.971
bSEFHO	1.329
bSEFHS	2.491
bSEFI	1.638
bSEFNA	2.072
bSEFNR	1.487
bSEFW	2.099

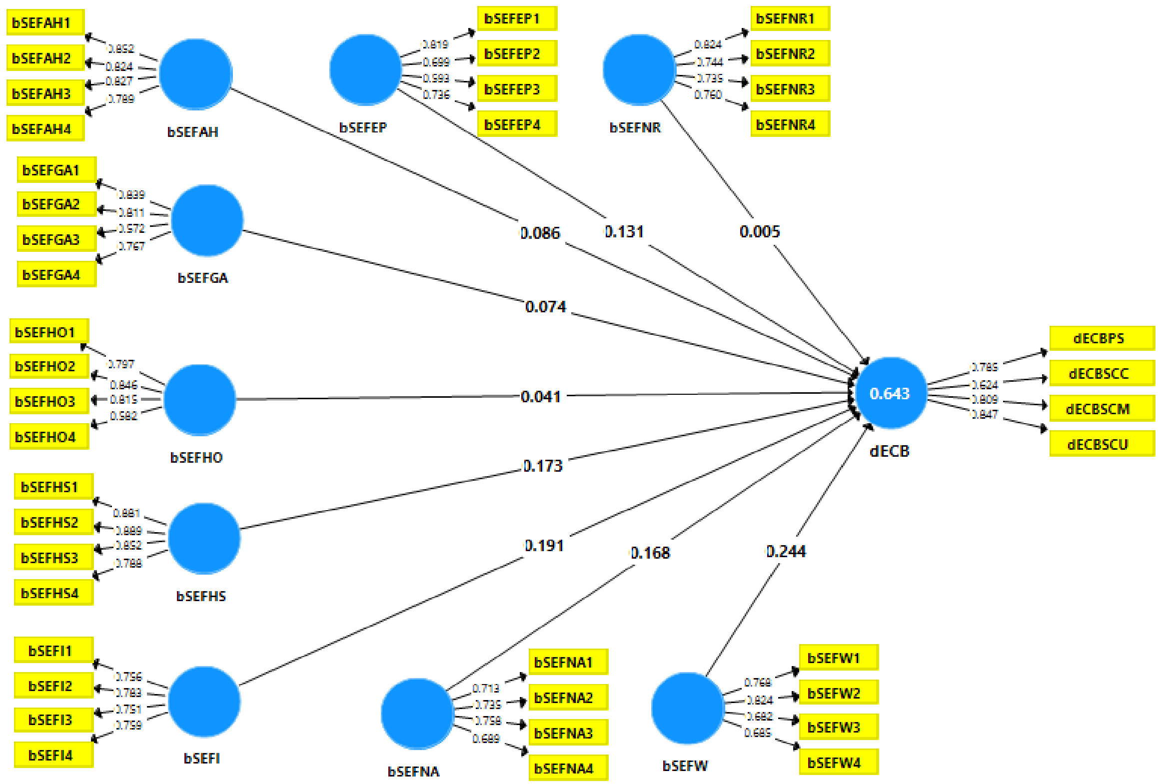

Figure 2: PLS Algorithm for Socio-economic factors and energy conservation behaviour (SM)

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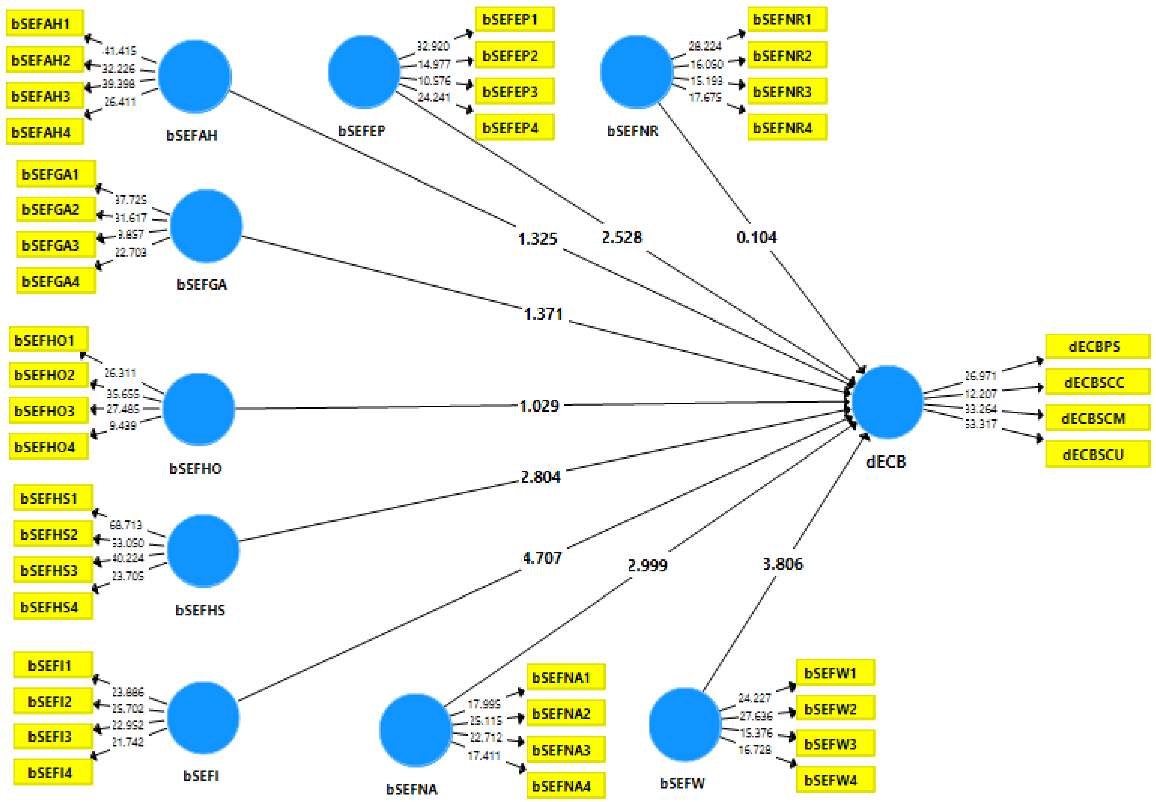

Figure 3: Bootstrapping for Socio-economic factors and energy conservation behaviour (SM)

Table 5: Structural Path Analysis for Socio Economic Factors of Energy Conservation Behaviour

Paths	Beta	(STDEV)	T Statistics (|O/STDEV|)	2.5%	97.5%	P Values	Decision
bSEFAH -> dECB	0.086	0.065	1.325	-0.041	0.211	0.185	Not Supported
bSEFEP -> dECB	0.131	0.052	2.528	0.030	0.229	0.011	Supported
bSEFGA -> dECB	0.074	0.054	1.371	-0.034	0.179	0.170	Not supported
bSEFHO -> dECB	0.041	0.040	1.029	-0.041	0.116	0.304	Not Supported
bSEFHS -> dECB	0.173	0.062	2.804	0.056	0.296	0.005	Supported
bSEFI -> dECB	0.191	0.041	4.707	0.108	0.270	0.000	Supported
bSEFNA -> dECB	0.168	0.056	2.999	0.055	0.277	0.003	Supported
bSEFNR -> dECB	0.005	0.047	0.104	-0.097	0.092	0.917	Not Supported

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bSEFW -> dECB	0.244	0.064	3.806	0.124	0.378	0.000	Supported

Note: Electricity Price (denoted "bSEFEP"), Income (bSEFI), Household Size (bSEFHS), Age of Householder (bSEFAH), Gender Attributes (bSEFGA), Home Ownership (bSEFHO), Number of Rooms (bSEFNR), Number of Appliance (bSEFNA), Weather (bSEFW), Energy Conservation Behaviour (dECB)

Table 6: R^2 Result of the model

Endogenous	R Square	R Square Adjusted
ECB	0.643	0.633

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Table 5 shows the structural path analysis of the relationship between the independent variables and the dependent variable for the study. The Beta represents the coefficient of each construct, 'STDEV' shows the standard deviation, both 't Statistics' and 'P values' show the significance of the path when t-value is greater than 1.96 and $P < 0.05$, while both '2.5% and '97.5% represent the boundary of the confidence interval at which the 'P values' can be accepted.

The results from Table 5 and Figures 2 and 3 show positive and significant relationships with bSEFEP (beta = 0.131, t = 2.528, P<0.05), bSEFHS (beta = 0.173, t = 2.804, P< 0.05), bSEFI (beta = 0.191, t = 4.707, P< 0.05), bSEFNA (beta = 0.168, t = 2.999, P <0.05), and Additionally, Table 6 lists the coefficient determination (R-sqaure) value as 0.643 and the corrected R-sqaure value as 0.633. Based on Tehseen [37] citing Cohen [38] study, advised that R-square values of 0.26, 0.13, and 0.02 be regarded as substantial, moderate, and weak, respectively. Because the R-sqaure for this study is greater than 0.26, as stated, it can be regarded to be substantial. As a result, 64.3% of the variances in the endogenous construct (dECB) could be accounted for by the exogenous constructs (bSEFAH, bSEFEP, bSEFGA, bSEFHO, bSEFHS, bSEFI, bSEFNA, bSEFNR, and bSEFW). The effect sizes were further considered in the study. The values of the f-square or effect size 0.02, 0.15, and 0.35 are regarded as small, medium, and large or significant, respectively according to Cohen's [38] suggested thresholds. Based on the results obtained the bSEFEP, bSEFHS, bSEFI, bSEFNA, and bSEFW do not have modest effect sizes: 0.028, 0.034, 0.063, 0.038, and 0.080 respectively, according to this rule they all have small effects on the endogenous construct. In the study area, bSEFAH, bSEFGA, bSEFHO, and bSEFNR have no impact on household energy conservation behavior. The findings contrast with a study by Blazquez et al. [28] that used aggregated panel data and identified price, income, and weather conditions as Spain's main determinants of electricity usage. However, the results demonstrated that weather variables had the greatest influence on consumption.

According to the most important indicator for policy implications could be found in Table 7 by the structural path analysis' outer weights. The findings of this study's analysis suggested that bSEFI (Income) in Figure 2 has the greatest structural weight, and Table 7 demonstrates that bSEFI1 ("I put my disposable income into account when buying electricity units") demonstrates that the householders or residents in the study area have acknowledged that their income is a very important factor in their energy consumption and that an increase in earning will cause them to purchase more electricity units. Therefore, any government initiative to promote energy efficiency and conservation behavior must acknowledge that households use more electricity and conserve less of it when their income is higher. The goal of energy conservation policy should be to limit home purchases of electricity. This can be done by taxing energy use to make individuals who buy and consume more electricity pay more [39]. This would encourage improvements in energy conservation in the Nigerian household sector.

5.0 Conclusion

The study empirically established the link between Akure metropolis residents' energy conservation behavior and socioeconomic variables. As a result of this finding, the study came to the conclusion that there is a substantial positive and significant relationship between socio-economic factors (SEF) and energy conservation behavior (ECB), as the exogenous constructs (bSEFAH, bSEFEP, bSEFGA, bSEFHO, bSEFHS, bSEFI, bSEFNA, bSEFNR, and bSEFW) were able to explain about 64% of the variances in the endogenous construct.

According to the study's conclusions, it is advised that policies for energy conservation focus on limiting household purchases of electricity. This can be done by taxing energy consumption to make people who use more electricity pay more (OECD, 2019). This would promote energy efficiency improvements and reduce electricity carelessness in the Nigerian domestic sector.

Only areas with a regular supply of electricity for more than 10 hours per day were covered in this study, which was focused on evaluating the impact of socio-economic factors on household energy conservation behavior in the study area. Areas with frequent power outages and irregular supply were left out. Therefore, additional

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research could include regions with erratic power supply to see if their energy-saving practices are congruent with those examined in this study.

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Table 7: Outer Weight of Indicators

	bSEFAH	bSEFEP	bSEFGA	bSEFHO	bSEFHS	bSEFI	bSEFNA	bSEFNR	bSEFW	dECB
bSEFAH1	0.355									
bSEFAH2	0.290									
bSEFAH3	0.294									
bSEFAH4	0.273									
bSEFEP1		0.409								
bSEFEP2		0.350								
bSEFEP3		0.231								
bSEFEP4		0.385								
bSEFGA1			0.407							
bSEFGA2			0.317							
bSEFGA3			0.249							
bSEFGA4			0.337							
bSEFHO1				0.336						
bSEFHO2				0.346						
bSEFHO3				0.355						
bSEFHO4				0.258						
bSEFHS1					0.361					
bSEFHS2					0.288					
bSEFHS3					0.277					
bSEFHS4					0.241					
bSEFI1						0.376				
bSEFI2						0.311				
bSEFI3						0.263				
bSEFI4						0.363				
bSEFNA1							0.343			
bSEFNA2							0.385			
bSEFNA3							0.344			
bSEFNA4							0.307			
bSEFNR1								0.426		
bSEFNR2								0.256		
bSEFNR3								0.274		
bSEFNR4								0.339		
bSEFW1									0.339	
bSEFW2									0.348	
bSEFW3									0.335	
bSEFW4									0.329	
dECBPS										0.334
dECBSCC										0.235
dECBSCM										0.353
dECBSCU										0.361

Note: Electricity Price (denoted "bSEFEP"), Income (bSEFI), Household Size (bSEFHS), Age of Householder (bSEFAH), Gender Attributes (bSEFGA), Home Ownership (bSEFHO), Number of Rooms (bSEFNR), Number of Appliance (bSEFNA), Weather (bSEFW), Energy Conservation Behaviour (dECB), Price Sensitivity

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(dECBPS), Self-Control Cutting (dECBSCC), Self-Control Monitoring (dECBSCM), Self-Control Upgrading (dECBSCU)

References

[1] Farrell, L., & Fry, J. M. Australia's gambling epidemic and energy poverty. *Energy economics*, *97*, (2021) 105218.

[2] Adepoju A., Jesuleye O., and Arigbede O. Solar Photo Voltaic Contributions to Energy Mix in Selected Nigerian Estates. *Archives of Business Research* 8 (3), (2020)131-164.

[3] Ceylan, R., & Özbakır, A. Increasing Energy Conservation Behaviour of Individuals towards Sustainable and Energy-Efficient Communities. *Smart Cities*, *5*(4), (2022) 1611-1634.

[4] Nguyen, Q. N., & Hoang, T. H. L. Applying the theory of planned behavior to analyze household energy-saving behavior. *International Journal of Energy Economics and Policy*, *12*(5), (2022)287-293.

[5] Suntornsan, S., Chudech, S., & Janmaimool, P. The Role of the Theory of Planned Behavior in Explaining the Energy-Saving Behaviors of High School Students with Physical Impairments. *Behavioral Sciences*, *12*(9), (2022) 334.

[6] Wang, Q. C., Chang, R., Xu, Q., Liu, X., Jian, I. Y., Ma, Y. T., & Wang, Y. X.. The impact of personality traits on household energy conservation behavioral intentions–an empirical study based on theory of planned behavior in Xi'an. *Sustainable Energy Technologies and Assessments*, *43*, (2021) 100949.

[7] Piao, X., & Managi, S. Household energy-saving behavior, its consumption, and life satisfaction in 37 countries. *Scientific reports*, *13*(1), (2023)1382.

[8] Liu, X., Wang, Q., Wei, H., Chi, H.,Ma, Y., Jian I.Z. Psychological and Demographic Factors Affecting Household Energy-Saving Intentions: A TPB-Based Study in Northwest China. *Sustainability*, 12, (2020).836

[9] Jiang, T., Li, H., Mao, P., Wu, T., Skitmore, M., & Talebian, N. Strategy of Energy Conservation and Emission Reduction in Residential Building Sector: A Case Study of Jiangsu Province, China. *Journal of Environmental and Public Health*, (2023).

[10] Andersen, F. M., Gunkel, P. A., Jacobsen, H. K., and Kitzing, L. Residential electricity consumption and household characteristics: an econometric analysis of Danish smart meter data. *Energy Econ*. 100: (2021)105341.

[11] Kumar, P., Caggiano, H., Shwom, R., Felder, F. A., & Andrews, C. J. Saving from home! How income, efficiency, and curtailment behaviors shape energy consumption dynamics in US households?. *Energy*, *271*, (2023)126988.

[12] Ali, S. S. S., Razman, M. R., Awang, A., Asyraf, M. R. M., Ishak, M. R., Ilyas, R. A., & Lawrence, R. J.. Critical determinants of household electricity consumption in a rapidly growing city. *Sustainability*, *13*(8), (2021) 4441.

[13] Shang, Y., Lian, Y., Chen, H., & Qian, F. The impacts of energy resource and tourism on green growth: evidence from Asian economies. *Resources Policy*, *81*, (2023)103359.

[14] Yang, S., Jahanger, A., & Hossain, M. R. Does China's low-carbon city pilot intervention limit electricity consumption? An analysis of industrial energy efficiency using time-varying DID model. *Energy Economics*, *121*, (2023)106636.

[15] Parag, Y., Fawcett, T., Hampton, S., & Eyre, N. Energy saving in a hurry: A research agenda and guidelines to study European responses to the 2022–2023 energy crisis. *Energy Research & Social Science*, *97*, (2023)102999.

[17] Belaïd, F. & Flambard, V. Impacts of income poverty and high housing costs on fuel poverty in Egypt: An empirical modelling approach. *Energy Policy*, *175*, (2023) 113450.

[18] Lee, C. C., & Hussain, J. An assessment of socioeconomic indicators and energy consumption by considering green financing. *Resources Policy*, *81*, (2022)103374.

[19] Ahmad, T. I., Nawaz, M. A., Kiran, K., Dagar, V., Bhatti, M. A., & Hussain, A. Dirty versus clean fuel for cooking in Pakistan: regional mapping and correlates. *Environmental Science and Pollution Research*, *30*(10), (2023) 26458- 26471.

[20] Chen, Y., Li, S., Zhou, T., Lei, X., Liu, X., & Wang, Y. Household cooking energy transition in rural mountainous areas of China: Characteristics, drivers, and effects. *Journal of Cleaner Production*, *385*, (2023). 135728.

[21] Issa, A. Shaping a sustainable future: The impact of board gender diversity on clean energy use and the moderating role of environmental, social and governance controversies. *Corporate Social Responsibility and Environmental Management*. (2023)

JDFEWS 4(1): 1-24, 2023
ISSN 2709-4529

[22] Kyaw, K., Treepongkaruna, S., & Jiraporn, P. Board gender diversity and environmental emissions. *Business Strategy and the Environment*, *31*(7), 2871-2881.

[23] Galvin, R. Policy pressure to retrofit Germany's residential buildings to higher energy efficiency standards: A cost-effective way to reduce CO2 emissions? *Building and Environment*, *237*, (2023) 110316.

[23] Wassie, Y. T., & Ahlgren, E. O. Determinants of electricity consumption from decentralized solar PV mini-grids in rural East Africa: An econometric analysis. *Energy*, *274*, (2023)127351.

[24] Khaleel, M., Yusupov, Z., Ahmed, A. A., Alsharif, A., Alarga, A., & Imbayah, I. The effect of digital technologies on energy efficiency policy. *International Journal of Electrical Engineering and Sustainability (IJEES)*, (2023) 1-8.

[25] Jain, M. Estimates of energy savings from energy efficiency improvements in India using Index Decomposition Analysis. *Energy for Sustainable Development*, *74*, (2023) 285- 296.

[26] Hu, Q., Tang, J., Gao, X., Wang, S., Zhang, D., Qin, Y., & Lun, F. Future hotter summer greatly increases residential electricity consumption in Beijing: A study based on different house layouts and shared socioeconomic pathways. *Sustainable Cities and Society*, *91*, (2023)104453.

[27] Huang W. The determinants of household electricity consumption in Taiwan: Evidence from Quantile regression *Energy*; 87: (2015) 120–33. http://dx.doi.org/10.1016/J.ENERGY.2015.04.101.

[28] Blázquez L, Boogen N, Filippini M. Residential electricity demand in Spain: New empirical evidence using aggregate data. *EnergyEcon*; 36: (2013) 648–57. http://dx.doi.org/10.1016/j.eneco.2012.11.010

[29] Ackah I, Bukari D, Banye EZ, Bobio C Transitioning towards cleaner cooking fuels: an analysis of consumer preferences in Ghana's cookstoves market. *Environ Sci Pollut Res* 28(39): (2021) 54936–54949

[30] Ye Y, Kocha FS, Zhang J. Determinants of household electricity consumption in South Africa.*EnergyEcon*;75(C):(2018).120–33. http://dx.doi.org/10.1016/j.eneco.2018.08.005.

[31] Al-Bajjali SK, Shamayleh AY. Estimating the determinants of electricity in Jordan. *Energy*; 147: (2018)1311–20. http://dx.doi.org/10.1016/j.energy.2018.01.010.

[32] Sakah M, De la Rue du Can S, Diawuo AF, Sedzro DM, Kuhn C.. A study of appliance ownership and electricity consumption determinants in urban Ghanaian households. *Sustainable Cities Soc*;44: (2019)559–81. http://dx.doi.org/10.1016/J.SCS..10.019.

[33] Hair, J.F., Hult, G.T.M., Ringle, C.M., Sarstedt, M.. A Primer on Partial Least Squares Structural Equation Modelling (PLS-SEM) (J. Hair (ed.); (2017) Second Edi). Sage.

[34] Adepoju A. and Adeniji A. Technology Acceptance of E-Banking Services in an Unnatural Environment. *Journal of Management* 3(3), (2020) 34-50.

[34] Herath, T., & Rao, H. R. Protection motivation and deterrence: A framework for security policy compliance in organisations. *European Journal of Information Systems.* (2009). https://doi.org/10.1057/ejis.2009.6

[35] Gefen, D., & Straub, D. A Practical Guide to Factorial Validity Using PLS Graph: Tutorial and Annotated Example. *Communications of the Association for Information Systems,* 16(5), (2005) 91–109. https://doi.org/DOI: 10.17705/1CAIS.01605

[36] Roemer, E., Schuberth, F., & Henseler, J.. HTMT2–an improved criterion for assessing discriminant validity in structural equation modeling. *Industrial management & data systems*, *121*(12), (2021) 2637-2650.

[37] Tehseen, S., Ahmed, F. U., Qureshi, Z. H., Uddin, M. J., & Ramayah, T. Entrepreneurial competencies and SMEs' growth: the mediating role of network competence. *Asia-Pacific Journal of Business Administration*, *11*(1), (2019) 2-29.

[38] Cohen, J. Statistical power analysis. *Current directions in psychological science*, *1*(3), (1992) 98-101.

[39] Bashir, M. F., Benjiang, M. A., Shahbaz, M., Shahzad, U., & Vo, X. V. Unveiling the heterogeneous impacts of environmental taxes on energy consumption and energy intensity: empirical evidence from OECD countries. *Energy*, *226,* (2021). 120366.

[40] Sun, Y., Gao, P., Tian, W., & Guan, W. Green innovation for resource efficiency and sustainability: Empirical analysis and policy. *Resources Policy, 81*, (2023)103369.

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Appendix I

Cross-Loading

	bSEFAH	bSEFEP	bSEFGA	bSEFHO	bSEFHS	bSEFI	bSEFNA	bSEFNR	bSEFW	dECB	dECBPS	dECBSCC	dECBSCM	dECBSCU
bSEFAH1	0.853	0.477	0.594	0.272	0.622	0.289	0.396	0.179	0.406	0.509	0.419	0.281	0.421	0.419
bSEFAH2	0.824	0.34	0.432	0.076	0.5	0.238	0.218	0.173	0.357	0.414	0.285	0.319	0.34	0.341
bSEFAH3	0.827	0.341	0.526	0.214	0.523	0.146	0.326	0.126	0.349	0.421	0.346	0.252	0.374	0.311
bSEFAH4	0.788	0.341	0.467	0.029	0.522	0.12	0.275	0.079	0.261	0.386	0.379	0.264	0.246	0.315
bSEFEP1	0.486	0.819	0.523	0.214	0.548	0.274	0.289	0.139	0.342	0.457	0.505	0.225	0.352	0.315
bSEFEP2	0.451	0.701	0.464	0.134	0.552	0.065	0.282	-0.022	0.256	0.393	0.463	0.152	0.309	0.258
bSEFEP3	0.118	0.59	0.159	0.243	0.152	0.414	0.223	0.273	0.167	0.254	0.269	0.147	0.188	0.191
bSEFEP4	0.198	0.736	0.205	0.291	0.296	0.378	0.367	0.246	0.28	0.429	0.475	0.197	0.293	0.341
bSEFGA1	0.566	0.435	0.838	0.178	0.565	0.186	0.363	0.134	0.404	0.488	0.45	0.283	0.416	0.342
bSEFGA2	0.474	0.286	0.811	0.223	0.429	0.171	0.291	0.079	0.347	0.384	0.262	0.224	0.357	0.312
bSEFGA3	0.329	0.298	0.571	0.312	0.25	0.328	0.258	0.214	0.22	0.299	0.23	0.146	0.213	0.309
bSEFGA4	0.462	0.449	0.769	0.163	0.543	0.04	0.28	0.021	0.345	0.41	0.384	0.136	0.423	0.259
bSEFHO1	0.126	0.242	0.231	0.796	0.209	0.279	0.314	0.271	0.323	0.306	0.246	0.17	0.235	0.282
bSEFHO2	0.166	0.269	0.255	0.845	0.255	0.236	0.323	0.283	0.309	0.316	0.251	0.181	0.257	0.273
bSEFHO3	0.144	0.278	0.198	0.815	0.189	0.203	0.308	0.205	0.315	0.325	0.216	0.208	0.267	0.3
bSEFHO4	0.15	0.115	0.155	0.586	0.078	0.21	0.27	0.241	0.348	0.24	0.074	0.17	0.261	0.217
bSEFHS1	0.559	0.497	0.529	0.283	0.881	0.274	0.498	0.242	0.527	0.64	0.529	0.283	0.534	0.559
bSEFHS2	0.564	0.531	0.561	0.236	0.889	0.176	0.411	0.095	0.418	0.511	0.49	0.192	0.48	0.349
bSEFHS3	0.556	0.457	0.491	0.13	0.852	0.176	0.367	0.08	0.411	0.489	0.492	0.185	0.385	0.392
bSEFHS4	0.597	0.45	0.51	0.163	0.788	0.128	0.375	0.133	0.341	0.428	0.4	0.167	0.371	0.331
bSEFI1	0.247	0.339	0.252	0.168	0.212	0.756	0.37	0.372	0.304	0.428	0.311	0.327	0.359	0.347
bSEFI2	0.154	0.245	0.187	0.202	0.105	0.783	0.311	0.309	0.281	0.356	0.186	0.288	0.301	0.337

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bSEFI3	0.114	0.162	0.045	0.189	0.072	0.751	0.309	0.357	0.288	0.3	0.187	0.225	0.248	0.277
bSEFI4	0.213	0.354	0.163	0.346	0.27	0.758	0.359	0.517	0.328	0.414	0.314	0.276	0.261	0.434
bSEFNA1	0.24	0.206	0.139	0.262	0.247	0.439	0.712	0.436	0.473	0.455	0.237	0.321	0.39	0.445
bSEFNA2	0.443	0.462	0.456	0.262	0.571	0.142	0.735	0.092	0.48	0.515	0.441	0.226	0.45	0.415
bSEFNA3	0.194	0.308	0.266	0.272	0.329	0.342	0.758	0.323	0.471	0.459	0.359	0.176	0.375	0.444
bSEFNA4	0.18	0.179	0.271	0.365	0.236	0.404	0.69	0.289	0.475	0.412	0.206	0.206	0.336	0.47
bSEFNR1	0.251	0.229	0.164	0.325	0.189	0.396	0.375	0.826	0.37	0.347	0.193	0.239	0.337	0.292
bSEFNR2	0.011	0.111	0.065	0.221	0.059	0.415	0.218	0.742	0.244	0.203	0.126	0.177	0.135	0.21
bSEFNR3	0.139	0.132	0.073	0.197	0.118	0.385	0.276	0.735	0.26	0.222	0.151	0.124	0.191	0.208
bSEFNR4	0.069	0.127	0.096	0.219	0.121	0.405	0.274	0.757	0.236	0.269	0.147	0.264	0.158	0.298
bSEFW1	0.351	0.337	0.38	0.297	0.425	0.297	0.513	0.259	0.768	0.492	0.354	0.267	0.458	0.4
bSEFW2	0.332	0.283	0.403	0.3	0.444	0.263	0.547	0.235	0.825	0.504	0.352	0.303	0.461	0.411
bSEFW3	0.286	0.225	0.28	0.4	0.262	0.345	0.448	0.367	0.681	0.484	0.304	0.305	0.38	0.482
bSEFW4	0.278	0.269	0.253	0.239	0.367	0.27	0.43	0.243	0.685	0.475	0.315	0.305	0.428	0.403
dECBPS1	0.201	0.409	0.218	0.281	0.215	0.551	0.412	0.412	0.402	0.629	0.705	0.392	0.38	0.507
dECBPS1	0.201	0.409	0.218	0.281	0.215	0.551	0.412	0.412	0.402	0.629	0.705	0.392	0.38	0.507
dECBPS2	0.429	0.545	0.463	0.194	0.602	0.159	0.368	0.062	0.38	0.663	0.888	0.278	0.42	0.449
dECBPS2	0.429	0.545	0.463	0.194	0.602	0.159	0.368	0.062	0.38	0.663	0.888	0.278	0.42	0.449
dECBPS4	0.398	0.474	0.375	0.123	0.51	0.021	0.205	-0.04	0.229	0.469	0.718	0.145	0.3	0.265
dECBPS4	0.398	0.474	0.375	0.123	0.51	0.021	0.205	-0.04	0.229	0.469	0.718	0.145	0.3	0.265
dECBSCC3	0.16	0.117	0.108	0.088	0.091	0.26	0.239	0.155	0.297	0.378	0.234	0.699	0.171	0.281
dECBSCC3	0.16	0.117	0.108	0.088	0.091	0.26	0.239	0.155	0.297	0.378	0.234	0.699	0.171	0.281
dECBSCC4	0.299	0.21	0.18	0.123	0.289	0.2	0.154	0.082	0.189	0.396	0.251	0.654	0.212	0.291
dECBSCC4	0.299	0.21	0.18	0.123	0.289	0.2	0.154	0.082	0.189	0.396	0.251	0.654	0.212	0.291
dECBSCC5	0.256	0.208	0.265	0.271	0.153	0.322	0.281	0.314	0.35	0.475	0.287	0.768	0.328	0.292
dECBSCC5	0.256	0.208	0.265	0.271	0.153	0.322	0.281	0.314	0.35	0.475	0.287	0.768	0.328	0.292

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dECBSCM1	0.204	0.27	0.248	0.282	0.274	0.493	0.408	0.401	0.448	0.637	0.343	0.359	0.771	0.437
dECBSCM1	0.204	0.27	0.248	0.282	0.274	0.493	0.408	0.401	0.448	0.637	0.343	0.359	0.771	0.437
dECBSCM2	0.218	0.233	0.279	0.263	0.269	0.361	0.351	0.219	0.389	0.579	0.286	0.267	0.735	0.414
dECBSCM2	0.218	0.233	0.279	0.263	0.269	0.361	0.351	0.219	0.389	0.579	0.286	0.267	0.735	0.414
dECBSCM3	0.469	0.379	0.529	0.199	0.536	0.159	0.403	0.041	0.484	0.625	0.438	0.193	0.767	0.393
dECBSCM3	0.469	0.379	0.529	0.199	0.536	0.159	0.403	0.041	0.484	0.625	0.438	0.193	0.767	0.393
dECBSCM4	0.361	0.32	0.351	0.23	0.472	0.128	0.426	0.175	0.395	0.6	0.346	0.187	0.674	0.507
dECBSCM4	0.361	0.32	0.351	0.23	0.472	0.128	0.426	0.175	0.395	0.6	0.346	0.187	0.674	0.507
dECBSCU1	0.268	0.201	0.25	0.271	0.268	0.461	0.52	0.406	0.482	0.649	0.361	0.286	0.451	0.808
dECBSCU1	0.268	0.201	0.25	0.271	0.268	0.461	0.52	0.406	0.482	0.649	0.361	0.286	0.451	0.808
dECBSCU2	0.29	0.269	0.261	0.249	0.322	0.382	0.505	0.291	0.459	0.638	0.391	0.306	0.434	0.764
dECBSCU2	0.29	0.269	0.261	0.249	0.322	0.382	0.505	0.291	0.459	0.638	0.391	0.306	0.434	0.764
dECBSCU3	0.458	0.486	0.443	0.255	0.576	0.174	0.415	0.072	0.43	0.675	0.537	0.293	0.496	0.67
dECBSCU3	0.458	0.486	0.443	0.255	0.576	0.174	0.415	0.072	0.43	0.675	0.537	0.293	0.496	0.67
dECBSCU4	0.191	0.158	0.19	0.25	0.227	0.35	0.312	0.212	0.265	0.508	0.253	0.299	0.323	0.661
dECBSCU4	0.191	0.158	0.19	0.25	0.227	0.35	0.312	0.212	0.265	0.508	0.253	0.299	0.323	0.661

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Combating Consumer Food Waste – An Exploration of Information Communication Technology Approach

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Abstract: Existing food production and consumption rate, especially from consumer's point of view, cannot be measured as viable due to varieties of social economic factors involved in the food supply chain. Combating food waste contributes extensively to food security measures and easing conservational burden thus improving justifiable consumption of food. Food waste emanating from consumers especially individual households is huge. A systematic approach to mitigate this is creatively enlightening consumers through alertness and campaigns. However, literature reveals that complimentary initiatives are required to confront the problem of consumer waste. Emerging technologies and their uniqueness are comparatively gaining attention to lead consumers carefully using improved technical platforms and solutions in the right direction towards reducing food waste. This study tackles this research gap by conducting comprehensive reviews of articles pointing to food wastage prevention, weaknesses, and potential usage of ICT tools to positively impact consumers and reduce food wastage. The study focuses on the use of ICT tools and techniques as a means to reduce food wastage. The reviews covered existing food wastage-saving measures and applications (e.g., smart kitchen appliances, smart packaging and mobile applications). It further proposed a broad ICT driven food wastage avoidance framework that deals with the problem holistically. The framework shows how various levels of the food supply chain can be integrated to tackle wastages from top to bottom in avoiding consumer wastage. However, future research is required to validate and build on this framework.

Keywords: *food waste; food production; Information technology; supply chain, smart systems*

1.0 Introduction

Food waste has been recognized as a major global problem impacting the economy, the environment, and food security. Food and Agriculture Organization (FAO) estimates that roughly 1.3 billion tons of food are lost or wasted annually, or about one-third of all food produced worldwide [1], [2]. The complete food supply system, from production to consumption, is affected by this waste. Most food waste in developed nations happens during consumption, with households and food service businesses being the primary offenders. Contrarily, in developing nations, most food waste occurs during the manufacturing and post-harvest phases [3]. Food waste has serious and wide-ranging effects. First, it adds to global greenhouse gas emissions, with about 6% of all greenhouse gas emissions coming from food waste. [4]. Second, it results in the inefficient use of resources necessary for food production, such as water and territory. Third, food waste worsens food insecurity, with an estimated 828 million people going hungry worldwide [5]. Also, food waste places a heavy financial load on the world economy, costing it $940 billion annually [6]. Given the significant negative effects of food waste, it is essential to avoid and manage food waste effectively. Preventing and managing food loss can lower greenhouse gas emissions, protect natural resources, ease food insecurity, and have a positive economic impact. The accomplishment of several

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Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), and SDG 13, can be facilitated through effective methods for preventing and managing food waste [7], [8]. A potential remedy for the problem of food waste has been identified in the form of information and communication technology (ICT) tools [9].

The term "ICT tools" refers to various digital platforms and technologies that can aid communication, data gathering, and analysis[10-12]. By facilitating food donation and redistribution, enhancing food inventory management, and encouraging customer behavior change, these tools can aid in managing and preventing food waste. Several ICT tools, such as mobile apps [13], cloud-based platforms [14], and sensor technologies [15], have been created to address food waste. For instance, smartphone apps like Too Good To Go and OLIO enable customers to buy leftover food from nearby restaurants and grocery stores at a discount [16], [17]. To enable food donation and redistribution, cloud-based systems like FoodCloud link food donors with regional charities and food banks [18]. By providing real-time data on food waste generation, sensor technologies, such as those created by Winnow Solutions and Leanpath, assist food service businesses in monitoring and reducing food waste [19]. This review aims to examine how Information Communication Technology (ICT) tools can be used to avoid and manage consumer food waste. An overview of the present state of study on ICT tools for managing and preventing food waste, including their efficacy, drawbacks, and potential for expansion, will be provided in the review. The review will also point out gaps in the body of knowledge and recommend places for further investigation. This review seeks to shed light on the function of ICT tools in addressing the problem of food waste and encouraging sustainable consumption and production patterns by synthesizing the available literature.

2.0 Role of Consumers in Reducing Food Waste

Consumers are a major cause of food waste. According to studies, households account for more than 50% of food waste worldwide [20]. This issue is exacerbated by consumer behaviors like over-purchasing, inadequate storing, and disregarding food approaching its expiration date [21]. Therefore, to decrease food waste, it is essential to concentrate on consumer behavior. Proper planning of meals is one method to lessen food waste. Meal planning has been shown in WRAP's (Waste & Resources Action Programme) research to reduce household food waste [22]. Additionally, consumers can give food to food banks, compost food scraps, and repurpose leftovers for new meals [23]. Meanwhile, various social-economic factors in the food supply chain contribute to wastage [24]. These factors begin with consumer's attitude, especially at homes or restaurants where applicable; individual beliefs, behaviour, and attitudes are also considered. For illustrative purposes; in some parts of the world, certain consumers do not eat a chicken's head/feet; in other parts, the feet of a chicken are a complete meal. In other words, in area where this is not been consumed, it could be regarded as food wastage. Other social cultural factors include but not limited to shopping routines, nature of packaging and kinds of food being purchased per time.

However, consumers might not be conscious of these options and might not prioritize reducing food waste. ICT resources can be very helpful in educating and motivating customers to act in this situation. ICT tools, such as mobile apps, have been created to encourage consumer behavior change and decrease food waste. These resources offer advice on proper food storage, portion management, and strategies for reducing food waste. For instance, the smartphone application "Too Good to Go" links customers with nearby restaurants and grocery shops to buy food that would otherwise go to waste [25]. The "Love Food Hate Waste" and "NoWaste" applications are two additional instances of ICT tools designed to decrease consumer food waste [26], [27]. Overall, educating and

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encouraging consumers to reduce food waste is essential. ICT tools can play a vital role by providing information and promoting behavior change.

3.0 Collaboration of Stakeholders in Food Waste Prevention and Management

Collaboration between stakeholders is essential for successful food waste control and prevention. To minimize food waste and increase its worth, various players in the food supply chain, such as farmers, food manufacturers, retailers, and consumers, must be involved [28]. Initiatives to avoid and manage food waste rely heavily on the degree of cooperation and coordination among stakeholders. In recent years, there has been an increasing understanding of the value of stakeholder cooperation in reducing food waste. Governments, non-profit organizations, and private businesses have started numerous initiatives to encourage cooperation and facilitate information sharing among stakeholders. For instance, the United Kingdom's Food Waste Reduction Roadmap, unveiled in 2018, is a joint effort between the government, retailers, and food producers to decrease food waste by 20% by 2025 [29].

Partnerships between various participants in the food supply chain are another type of collaboration. For instance, by enhancing inventory control, packaging design, and distribution procedures, food producers and merchants can collaborate to streamline the supply chain and cut waste [30]. Another illustration is the collaboration between supermarkets and charities, where extra food is given to organizations that serve the hungry [31]. ICT tools can significantly aid in fostering stakeholder cooperation by offering a forum for information exchange and communication. For instance, the FUSIONS project, which received funding from the EU, created an online platform that enables stakeholders to exchange information and best practices for managing and preventing food waste [32]. Another illustration is the FoodCloud network, which links merchants and charities to make donating surplus food easier [18].

Based on the aforementioned, stakeholder collaboration is crucial in reducing food waste and maximizing its value. ICT tools facilitate collaboration by providing a platform for information sharing and communication. Through collaboration, stakeholders can identify and implement effective solutions for preventing and managing food waste.

4.0 Overview of ICT Tools and Services for Food Waste Management

ICT tools and services have shown great potential in food waste management by supporting consumers and other stakeholders in making informed decisions to prevent and reduce food waste. This section provides an overview of three main categories of ICT tools and services for food waste management: mobile applications, smart kitchen appliances, and smart packaging.

4.1 Mobile Applications

Consumers now frequently use mobile applications and related services, also referred to as apps, to control their food waste. These applications offer functions such as meal planning, inventory monitoring, and reminders for expiration dates. Too Good to Go, Olio, and NoWaste are well-known food waste control applications with various services embedded to combat food waste. Through Too Good to Go, customers can get discounted access to eatery and grocery store surplus food. Conversely, OLIO allows customers to share leftover food with their neighbors. Finally, NoWaste offers recipes using leftover ingredients and assists customers in keeping track of their food inventory and expiration dates. By providing consumers with relevant information and resources, these tools

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can increase awareness, facilitate behavior change, and promote collaboration among stakeholders in the food supply chain. For instance, the Too Good To Go app (Table 1.) allows users to purchase surplus food from restaurants and supermarkets at discounted prices, reducing food waste generated in these outlets ([33]. Similarly, the Love Food Hate Waste campaign offers online resources, such as recipes and meal planning tools, to support consumers in managing their food waste [29]. Using mobile applications to manage food waste has several advantages, including lowering food waste, raising awareness, and saving money. Consumers have reported that using food waste management apps can reduce household food waste by up to 50% [34].

Table 1: Description of a surplus food purchasing applications

ICT Tools and Services	Information Provided
Too Good To Go app	Allows users to buy surplus food from local restaurants and shops at a reduced price [25].
OLIO app	Connects users with surplus food from local households and retailers, reducing food waste
Love Food Hate Waste	Provides information on how to reduce food waste at home, including recipes and meal plans
Waste Less, Save More	Provides tips for reducing food waste and tracks the user's progress toward waste reduction
FoodKeeper app	Provides information on food storage, including recommended storage times and optimal storage conditions
Spoiler Alert	Connects food businesses with surplus food to food banks and charities

4.2 Smart Kitchen Appliances

Internet-connected, smart kitchen appliances can aid in the control and prevention of food waste. Smart ovens, freezers, and scales are a few of these products. For instance, Samsung has created a smart refrigerator that keeps track of food inventory and expiration dates and can even recommend recipes based on the materials on hand. Another example is the Drop smart scale, which can adjust a recipe based on the ingredients on hand and recommend recipes based on the weight of the ingredients. Increasing food preparation efficiency, reducing food waste, and saving money are all advantages of smart kitchen tools. For example, it has been reported that smart refrigerators decreased household food waste by up to 20% [35].

4.3 Smart Packaging

The term "smart packaging" refers to intelligent packing that can reduce food waste by conveying details about the product's freshness and quality. The technical flow of a typical smart packaging process is illustrated in Figure 1. Sensors or other signs in smart packaging can detect changes in temperature, humidity, or gas composition. For instance, the Time Temperature Indicator (TTI), which changes hue according to temperature and time, can give a clue as to the quality and freshness of a food product. Increased food quality and freshness transparency, decreased food waste, and possible cost savings are all advantages of smart packaging. According to research, the use of TTI reduced food wastage [36].

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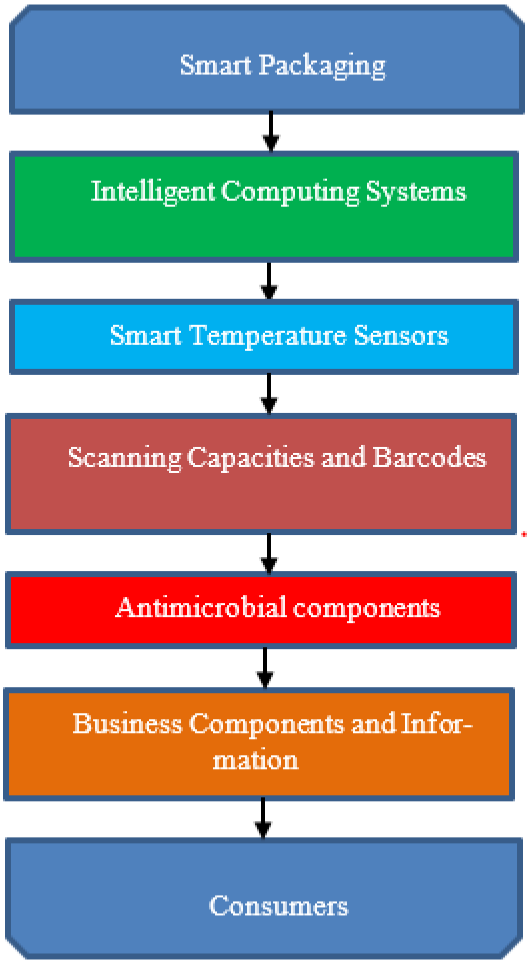

Figure 1: The technical flow of a typical smart packaging System

5.0 Limitations of current ICT tools and Services used in food waste reduction

Despite the ICT tools' promise to manage and prevent food waste, some issues still need to be resolved. The lack of user engagement by ICT professionals to drive adoption of available tools and services is one of the major margins. Despite the abundance of ICT tools at their disposal, not all consumers are conscious of them, and even those who are may not regularly use them. Thus, user involvement and adoption are key factors in determining whether these tools are successful. Studies have shown that when consumers believe ICT tools are simple to use, helpful, and reliable, they are more apt to use them for managing food waste [35]. Therefore, developers must create engaging software and hardware solutions that are user-friendly to the extent of satisfying user requirements.

Another area for improvement of current ICT tools is the need for integration and interoperability. Many ICT tools for food waste management operate in silos, meaning they are not connected to other tools or platforms. This can limit their effectiveness in providing holistic food waste prevention and management solutions.

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Interoperability among ICT tools would allow for seamless data sharing and stakeholder collaboration. This will allow portable flow of information usage from one system to another. Furthermore, the reliability and precision of ICT tools' data are other limitations. For instance, apps that track food waste depend on user input, which can sometimes be biased or subject to human error. More effective strategies and methods for managing food waste can result from accurate data. The implementation of efficient data validation methods and quality control measures by developers is necessary to increase the accuracy and reliability of data.

The lack of standardization and regulation is a limitation for the development and deployment of ICT tools and also affects the effectiveness of ICT tools in curbing food waste. Currently, there are no standard guidelines or regulations for developing and deploying food waste management ICT tools. This lack of standardization and regulation can lead to confusion among consumers and stakeholders and hinder the widespread adoption of these tools. Therefore, policymakers and regulatory bodies need to establish guidelines and standards to ensure the quality and effectiveness of ICT tools for food waste prevention and management. Addressing these limitations will improve the effectiveness and uptake of ICT tools for food waste prevention and management, ultimately contributing to a more sustainable and environmentally friendly food system.

5.1 Proposed Framework and Suggestions for future developments

Future developments should prioritize enhancing accessibility, customizability, and effectiveness to resolve the shortcomings of current ICT tools. For instance, efforts should be made to guarantee that ICT tools are accessible to a wider variety of consumers, including those with lower levels of digital literacy. ICT tools should also be customized to particular cultural and regional eating habits to ensure they are applicable and helpful in various settings. Additionally, rather than merely managing the waste after it has been produced, future developments should address the underlying causes of food waste, such as overproduction and oversupply. This may entail using predictive analytics to assist food producers and retailers forecast demand and modify their supply accordingly. Finally, future developments should improve consumers' input accuracy and consistency to ensure that ICT tools effectively reduce food waste. This could involve using sensors and other technologies to automate data collection and reduce the burden on consumers. This work further provides a proposed framework to tackle some of the identified limitations of food waste management and the existing ICT tools deployment through mobile applications. The framework proposed in Figure 2 is all-inclusive.

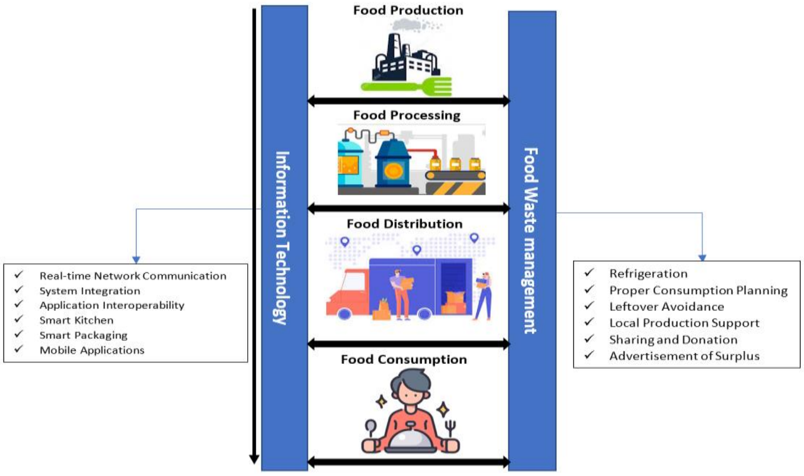

Figure 2: Proposed Framework for Food Waste Management

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The encompassing nature of this framework considers the holistic food supply chain from production, processing, distribution, and consumption. Unlike previous approaches which applications are limited to distribution and consumption. The proposed framework tends to fill in the consumption gap from the source. Smart ICT functionalities such as real-time network communication, smart kitchen, and smart packaging are well integrated into the framework in figure 2. This refers to an augmented kitchen and packaging process with smart incorporations of different sensors for effective temperature monitoring. The smart nature of this aspect of the framework will help improve the shelf life of foods, display real-time information related to freshness and quality, and convenience of consumption. Intelligent and smart kitchen appliances are gradually covering the usage of domestic food preparation devices (such as ovens, dishwashers, coffee makers, refrigerators etc). Emerging technologies are enhancing their functionalities for remote monitoring by receiving frequent notifications/alerts about potential damage of food. Kitchen appliances can be controlled with smartphones and other internet-connected gadgets. The framework is flexible and expandable to capture other smart ICT areas such as Big Data, Cloud computing, Internet of Things (IoT). IoT is an integral part of Home [37] and this is the situation for taking advantage of network communication functionalities to reduce food waste as quick as possible even when not physically present in the food location. Other digital technologies that tend to speedily identify issues associated with food waste and mitigate it can be easily deployed using advance communication technologies.

The framework proposed in this study further identified various food waste management measures with integrated information communication technologies such as real time network communication systems, smart and mobile systems, and several other ICT techniques that can facilitate stakeholder's collaboration in combating food wastage.

6.0 Conclusion

Overall, the efficacy of ICT tools for food waste prevention and management will rely on their capacity to address the underlying causes of food waste and their accessibility, adaptability, and effectiveness for various settings and consumer groups at all levels. A crucial component of sustainable food production and consumption is preventing and controlling food waste through the supply chain process. Food waste has major negative effects on the environment, the economy, and society, requiring immediate attention. A potential answer to successfully address the problem of food waste is the introduction of ICT tools. The proposed framework in this study ad its review emphasizes how ICT tools can support consumers, promote stakeholder cooperation and lessen food waste. Numerous studies have demonstrated the efficiency of ICT tools in decreasing food waste, and the advantages are numerous.

ICT tools today do, however, still have some drawbacks, such as poor adoption rates, little awareness, and accessibility issues. Future research is necessary to overcome these obstacles and unlock the full potential of ICT tools by implementing the proposed framework. ICT tools must be adopted by all parties involved in the food industry, including consumers, retailers, manufacturers, and policymakers, to produce and utilize food sustainably as indicated in the output of this findings (proposed framework). The potential benefits are significant, and the call to action is clear: work together to prevent and manage food waste effectively using innovative and technology-driven solutions, as illustrated in the proposed framework. This will improve the current ICT tools and its need for integration and interoperability Doing so can lead to a more sustainable food system and a better future in combating food wastage not only at the consumer level but at every stage of the supply chain.

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Authors contribution

John Adebisi: *Preliminary studies, framework design, results interpretation, and report writing.*, Khadeejah A. Abdulsalam: *Literature review, report writing and editing*, Michael Emezirinwune: *data gathering and report writing*, Ndjuluwa N.P. Leokadia: *Problem formulation, result analysis, and report writing.*

References

[1] M. V. Vilariño, C. Franco, and C. Quarrington, "Food loss and waste reduction as an integral part of a circular economy," *Front. Environ. Sci.*, vol. 5, p. 21, 2017.

[2] H. Zhen *et al.*, "Eco-compensation quantification of sustainable food waste management alternatives based on economic and environmental life cycle cost-benefit assessment," *J. Clean. Prod.*, vol. 382, p. 135289, 2023.

[3] G. FAO and others, "Global food losses and food waste--Extent, causes and prevention," *SAVE FOOD An Initiat. food loss waste Reduct.*, vol. 9, p. 2011, 2011.

[4] H. Ritchie, "Food Waste is Responsible for 6% of Global Greenhouse Gas Emissions. 2020," 2020.

[5] World Health Organization(WHO), "UN Report: Global hunger numbers rose to as many as 828 million in 2021," 2022.

[6] United States Environmental Protection Agency, "International Efforts on Wasted Food Recovery," 2022.

[7] K. Obaideen, N. Shehata, E. T. Sayed, M. A. Abdelkareem, M. S. Mahmoud, and A. G. Olabi, "The role of wastewater treatment in achieving sustainable development goals (SDGs) and sustainability guideline," *Energy Nexus*, vol. 7, p. 100112, 2022.

[8] I. Vazquez-Rowe, K. Ziegler-Rodriguez, M. Margallo, R. Kahhat, and R. Aldaco, "Climate action and food security: Strategies to reduce GHG emissions from food loss and waste in emerging economies," *Resour. Conserv. Recycl.*, vol. 170, p. 105562, 2021.

[9] A. Ciaghi and A. Villafiorita, "Beyond food sharing: Supporting food waste reduction with ICTs," in *2016 IEEE International Smart Cities Conference (ISC2)*, 2016, pp. 1–6.

[10] J. A. Adebisi and K. A. Abdusalam, "Design and Construction of a Secured Wireless EVoting System Using Crystal Oscillator," in *14th International Conference of the Nigeria Computer Society*, 2019, pp. 194–203.

[11] K. A. Abdulsalam, J. Adebisi, M. Emezirinwune, and O. Babatunde, "An overview and multicriteria analysis of communication technologies for smart grid applications," *e-Prime-Advances Electr. Eng. Electron. Energy*, vol. 3, p. 100121, 2023.

[12] Adebisi J.A, B. O. Moses, and others, "The Role of Network Technologies in the Enhancement of the Health, Education, and Energy Sectors," *Netw. Commun. Technol.*, vol. 7, no. 1, pp. 1–39, 2022.

[13] V. Hanson and L. Ahmadi, "Mobile applications to reduce food waste within Canada: A review," *Can. Geogr. Géographe Can.*, vol. 66, no. 2, pp. 402–411, 2022.

[14] G. Funchal, V. Melo, and P. Leitão, "Cloud-enabled Integration of IoT Applications within the Farm to Fork to Reduce the Food Waste," in *2022 IEEE 31st International Symposium on Industrial Electronics (ISIE)*, 2022, pp. 824–829.

[15] S. Ahmadzadeh, T. Ajmal, R. Ramanathan, and Y. Duan, "A Comprehensive Review on Food Waste Reduction Based on IoT and Big Data Technologies," *Sustainability*, vol. 15, no. 4, p. 3482, 2023.

[16] X. Yang, "The Role of Too Good To Go in Addressing Food Waste in Sweden," 2021.

[17] F. de Almeida Oroski, "Exploring food waste reducing apps—a business model lens," *Food Waste Manag. Solving Wicked Probl.*, pp. 367–387, 2020.

[18] E. Caffrey *et al.*, "FoodCloud: Stimulating Kindness Towards Making the World a Fairer Place-One Step at a Time.," *Int. Rev. Entrep.*, vol. 18, no. 2, 2020.

[19] C. Martin-Rios, A. Hofmann, and N. Mackenzie, "Sustainability-oriented innovations in food waste management

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ISSN 2709-4529

technology,” *Sustainability*, vol. 13, no. 1, p. 210, 2020.

[20] K. Parizeau, M. Von Massow, and R. Martin, “Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario,” *Waste Manag.*, vol. 35, pp. 207–217, 2015.

[21] J. C. Buzby and J. Hyman, “Total and per capita value of food loss in the United States,” *Food Policy*, vol. 37, no. 5, pp. 561–570, 2012.

[22] C. Reynolds *et al.*, “Consumption-stage food waste reduction interventions--What works and how to design better interventions,” *Food Policy*, vol. 83, pp. 7–27, 2019.

[23] A. Halloran, J. Clement, N. Kornum, C. Bucatariu, and J. Magid, “Addressing food waste reduction in Denmark,” *Food Policy*, vol. 49, pp. 294–301, 2014.

[24] A. Seberini, “Economic, social and environmental world impacts of food waste on society and Zero waste as a global approach to their elimination,” in *SHS Web of Conferences*, 2020, vol. 74, p. 3010.

[25] S. Fragapane and A. Mortara, “The Value of Networks Against Food Waste: The Case of ‘Too Good To Go,’” *Ital. Sociol. Rev.*, vol. 12, no. 3, 2022.

[26] H. Yamakawa, I. Williams, P. Shaw, and K. Watanabe, “Food waste prevention: Lessons from the Love Food, Hate Waste campaign in the UK,” in *Proceedings of the 16th International Waste Management and Landfill Symposium, S. Margherita di Pula, Sardinia, Italy*, 2017, pp. 2–6.

[27] C. Council and S. Silpakar, “Food waste: Extent of the Issue and Current Interventions in ACT,” 2014.

[28] F. Girotto, L. Alibardi, and R. Cossu, “Food waste generation and industrial uses: A review,” *Waste Manag.*, vol. 45, pp. 32–41, 2015.

[29] WRAP, “Food Waste Reduction Roadmap,” 2018.

[30] K. Verghese, H. Lewis, S. Lockrey, and H. Williams, “Packaging’s role in minimizing food loss and waste across the supply chain,” *Packag. Technol. Sci.*, vol. 28, no. 7, pp. 603–620, 2015.

[31] T. E. Quested, E. Marsh, D. Stunell, and A. D. Parry, “Spaghetti soup: The complex world of food waste behaviours,” *Resour. Conserv. Recycl.*, vol. 79, pp. 43–51, 2013.

[32] FUSIONS, “About FUSIONS,” 2016.

[33] Too Good To Go, “Let’s fight food waste together,” 2022.

[34] V. B. Varela, “12 Apps Preventing Household Food Waste and Protecting the Planet,” 2021.

[35] V. Stancu, P. Haugaard, and L. Lähteenmäki, “Determinants of consumer food waste behaviour: Two routes to food waste,” *Appetite*, vol. 96, pp. 7–17, 2016.

[36] F. Lehn, Y. Goossens, and T. Schmidt, “Economic and environmental assessment of food waste reduction measures--Trialing a time-temperature indicator on salmon in HelloFresh meal boxes,” *J. Clean. Prod.*, vol. 392, p. 136183, 2023.

[37] K. A. Adebisi, J. A., & Abdulsalam, “IOT Smart Home: Implementation of a real-time Energy Monitoring Pressing Iron,” in *International Conference on Innovative Systems for Digital Economy| ISDE*, 2021, pp. 7–18.

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Assessment of Stakeholder Involvement and Borehole Water Projects Delivery in Kogi West Senatorial District, Nigeria

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Abstract- The involvement of stakeholders along the project life cycle is crucial to the delivery of community-based projects, particularly Nigeria Kogi West Senatorial District's water projects. This is to provide safe and clean water for consumption and usage. Thus, this study examined at which stage of the cycle was involvement more important to the delivery of water projects in the study area. We rely on 234 completed questionnaires, which included employees of Lower Niger River Basin Development Authority, community leaders, and others. They all provided information through a structured questionnaire. Both descriptive (Mean Ranking) and inferential statistics (Partial Least Square Structural Equation Modelling, PLS-SEM) were deployed in the analyses. The results of the descriptive analysis showed that stakeholder involvement in the delivery of borehole water projects was the highest during the execution stages (bES), with a mean of 3.918, whereas, the lowest average was observed during the planning stages (bPS) with a mean of 2.745. The empirical results showed that stakeholders' involvement recorded the largest significant path with the execution phase on stakeholder satisfaction having a coefficient of 0.495 and a p-value of 6.366, and the least significant path with the monitoring and closing stage on budget (0.164, 2.643). This suggested that many promises from the government have mostly not been fulfilled, but those that were executed always bring satisfaction to the stakeholders, especially the host communities which may be influenced by too many empty promises. Other highlights of the results obtained showed that the paths of involvement at the initial stages were not significant with the constructs of project delivery, which implied that most water projects were pushed rather than pulled.

Keywords: *Stakeholders' involvement, borehole water projects, initiation, planning, execution, monitoring, closure, post-construction.*

1. Introduction

Water is an essential human right and a requirement for achieving sustainable development goal of access to clean and safe water [1]. However, there is a considerable gap in access to dependable water supply systems in many parts of the world, especially in rural areas and developing nations [2]. Water scarcity, health concerns, and slowed socioeconomic development are all consequences of inadequate centralized water infrastructure and unreliable water supplies [3]. Borehole water projects have become more popular as a feasible response to these issues. In order to supply local communities with a decentralized and independent water delivery system, borehole water projects entail

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drilling wells to access subterranean water sources [2]. In addition to enhancing community livelihoods and fostering economic activities including agriculture, industry, and sanitation, boreholes have the ability to provide dependable and sustainable access to water [4].

However, technical factors like drilling and infrastructure installation are not the only factors that determine whether borehole water projects are successful. To guarantee project delivery, sustainability, and community satisfaction, effective stakeholder involvement is essential throughout the project lifetime [5]. Local communities, government organizations, non-governmental organizations (NGOs), businesses, and water management authorities are just a few examples of the wide spectrum of actors that make up stakeholders [6]. Their active participation and engagement are crucial to address the particular difficulties and complications connected with borehole water projects. In borehole water projects, stakeholders play a variety of roles and have unique interests and obligations. The water supply is essential to local communities' daily requirements, means of subsistence, and general well-being. Their participation in decision-making procedures guarantees that the project satisfies their unique needs and takes into account their cultural customs, tastes, and goals [5]. The ability to actively monitor and maintain the water supply systems is made possible through community participation, which develops a sense of ownership, accountability, and sustainability [7]. Governmental organizations and water management bodies are in charge of governance and regulation. Their participation guarantees that borehole water projects adhere to pertinent policies, norms, and laws. These participants contribute technical know-how, oversight, and funding to help with project implementation and sustainability. Collaboration between local communities and government organizations improves project accountability, transparency, and long-term support [5]. In borehole water initiatives, non-governmental organizations (NGOs) and civil society organizations frequently play a crucial role. They help local populations get safe water by offering technical assistance, capacity building, and advocacy. The involvement of stakeholders in decision-making processes can be facilitated by NGOs, who can also fill up gaps in the availability of resources and guarantee the inclusion of marginalized groups [8]. Their participation supports social justice, local empowerment, and sustainable development. A crucial player in borehole water projects is the private sector, which includes drilling companies, equipment suppliers, and maintenance contractors [9]. By including the private sector, borehole water projects can be made more innovative, efficient, and financially viable because to their technical know-how, resources, and market-driven techniques. To make sure that private sector participation is in line with community needs and sustainable development objectives, it is essential to carefully assess the social and environmental implications and equitable benefit sharing [8].

Many African nations struggle to give their citizens access to safe and clean water for drinking and domestic usage. The situation is getting worse as Africa's population continues to grow over time, and many people are migrating into cities with an increased need for piped water [40]. In Sub-Saharan Africa (SSA), only 56% of the entire population is covered by the water delivery system, and 48% of rural inhabitants use unimproved water sources, with 22.5% of these rural water services being inoperable [10]. Half of the population in SSA countries lacks access to safe water, fourteen countries have recorded incidents of severe water stress, and another eleven countries will join the increasing list of African nations by 2025 that will have a severe water stress condition, according to Dos Santos, et al. [11]. Similar issues with water supply services that have an impact on sanitation and public health also exist in Nigeria [37]. Despite significant investment on the part of the federal, state, and donor communities, the situation has not improved. The lack of a functioning water supply infrastructure in rural areas and the densely populated, impoverished urban areas, or slums, make the situation regarding water supply extremely terrible. Like in the majority of Nigeria's developing states, Kogi State's rural communities lack access to good, safe drinking water as well as other difficult issues like adequate access to a quality healthcare system, conducive educational environments, structures, and facilities, year-round motorable roads, electrical sources, contemporary market structures and facilities, and

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environmental/ecological and sanitary control [12]. The Directorate for Rural Development (DRD), the National Poverty Eradication Program for Kogi State, and other organizations working to reduce poverty in the state are obligated to address difficulties with contaminated and frequently inaccessible water supplies, among other things. But it is shocking that these inequalities still exist when poverty reduction is evaluated in light of the agencies' work. Over-centralization, unsustainable design, uncoordinated administration, excessive politicking, irregular payment, a lack of monitoring logistics, and corruption are the causes of the gaps [13]. Water supply rose due to increasing investment and water projects, although some projects collapsed due to poor management and little to no maintenance, which prevented the achievement of higher water delivery rates. Water supply continues to be problematic as a result of project failure and collapse. Thus, the absence of water supply continues to negatively impact people's health, wellbeing, growth, and development as stated in [12] and [14]. It is crucial to look into the best ways to guarantee the supply and functionality of water projects in order to provide enhanced human development and well-being. The delivery of community water supply projects must be successful and efficient, according to the literature that has been published. According to Kisang [15] it is important to train the locals to carry out small repairs, take part in project launch activities, and own the project for its maintenance when it comes to delivering water projects that donors support. According to Ben-Daoud [5], community involvement and engagement will improve the performance of the water projects and raise the likelihood that they will be sustained and continue to benefit the nearby communities for many years to come. According to Koros [13], integrating the project's beneficiaries in its execution fosters a sense of ownership. At every point leading up to the project's completion and commissioning, all stakeholders must be represented on the project planning teams and teams that carry out the plans. However, there are few empirical research on the relationship between stakeholder participation and the delivery of borehole water projects in Nigeria. Furthermore, prior researchers that looked into stakeholders' involvement only connected it to initiatives in Nigeria or other nations. For instance, Magassouba et al. [16] investigated how the performance of development projects in Guinea was impacted by stakeholder involvement. The stakeholder engagement in energy transitions was studied by Marcon-Nora et al. [17]. Furthermore, Jabbour et al. [18] evaluated stakeholders' creative business models for the circular economy and sustainable performance of firms in an emerging economy facing institutional voids. A study also investigated stakeholder engagement in business models for sustainability and their value flow model for sustainability [20]. However, this study examined the level of stakeholder involvement in borehole water with special attention paid to the life cycle of the projects, and the impact of such involvement on the delivery of borehole water projects in Kogi West senatorial district in order to contribute to the existing studies and identify the stage that most impacted on the success of borehole water projects in Nigeria.

The sections in this study is further divided thereafter the introduction into literature review, where related concepts were reviewed. This is followed by the methodology, results and discussion, and lastly the conclusion.

2. Literature Review

2.1 Concept of stakeholders involvement review

Involving interested parties in a planning or decision-making process is known as stakeholder involvement [17].There are both primary and secondary stakeholders. The primary stakeholders must be involved for the activity to proceed because they directly and immediately affect the choice. According to Parboteeah and Cullen [19], secondary stakeholders are those who do not directly benefit from or are influenced by decisions made about the delivery of operations and maintenance (O&M) services. Stakeholder involvement entails locating, categorizing, and ranking them to choose the best communication tactics and utilize the resources at hand. Most stakeholders want to participate because they are interested in the resources. It is usually difficult to implement management decisions established independently by the regulatory body without society support, but stakeholder involvement is crucial. One alternative

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is to actively participate in the decision-making process directly, while another is to participate indirectly through elected officials and other representatives [18].

Owners and non-owners, capital or intangible asset holders, agents or actants, right holders, contractors, or influencers are some of the stakeholder types that might impact a project's outcomes as cited in [17] and [38]. They may be connected to the organization freely or involuntarily, serve as their resource providers, or depend financially on their work [20]. Generally speaking, primary stakeholders are those who have power over the resources, whereas secondary stakeholders are unable to directly influence companies but must instead take part in collective efforts to do so [39].

2.2 Stakeholder Involvement in project initiation

The initial steps define and outline the project's nature and scope. It's possible that the project won't be able to meet community expectations if this phase is badly executed [21]. Benefits of the project should be realized, a project manager should be chosen, goals should be realistically based on needs and requirements, costs and benefits should be analysed from a financial, social, and economic perspective, a funding source should be found, and a stakeholder survey should be carried out [22]. The project's initiation stage plan, which marks the beginning of project implementation, should comprise these tasks. In order to manage their possible impact on the project, genuine and legitimate stakeholders must be identified, and their strength, proximity, and influence must be understood [7].

2.3 Stakeholder Involvement in project planning

Stakeholder involvement in project planning activities includes specifying and allocating the required resources, defining the timetable, assessing various risks, and choosing delivery methods, as well as defining the project's work needs, quality standards, and objective. Project managers can enhance a project's execution plan or final results by incorporating stakeholders early in the planning process. Involving stakeholders in the planning process, according to Mambwe et al. [7], helps to understand their position and roles in creating milestones, and scope statements, assigning the planning team, identifying deliverables, creating the work breakdown structure (WBS), estimating the resources needed for the activities, developing schedules, estimating the time and cost required for the activities, risk planning, and obtaining formal approval to proceed. Magassouba et al. [16] assert that the attitudes of various stakeholders significantly influence the success of development projects. The project's performance will suffer if key stakeholders are not committed to carrying out their duties during implementation to the best of their abilities. According to Spadaro et al. [23], a project's success depends on stakeholder involvement, as a result, it is crucial to consider their claims and interests when the project is put into effect to fulfill its goals.

2.4 Stakeholder Involvement in project implementation

One of the most crucial aspects of project management is involving stakeholders in the execution of the project. In order to carry out the specified project plan, project managers during the implementation stage support the coordination of people, efficient exploitation of resources, and appropriate appraisal of risks [23]. By way of illustration, Magassouba et al. [16] noted that stakeholder involvement in project execution is important to translate a project's planned programs and objectives into realistic, well-structured tasks and activities to meet the project goals.

According to Ebekozien et al. [24], the difficulty of stakeholder engagement in project implementation is related to the features of projects, such as their lengthy duration, significant financial investment, and numerous unanticipated and emerging aspects. The risks and problems connected to stakeholder participation in project execution and project performance can be categorized in a number of different ways. According to Magassouba et al. [16] some examples

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include project sponsorship development, business environment, governmental laws, political influence, financial feasibility, procurement, and social acceptability.

According to Ben-Daoud et al. [5], the performance of development projects is significantly influenced by the attitudes of various stakeholders. As a result, the performance of the project as a whole will suffer if key stakeholders are not committed to carrying out their obligations to the best of their abilities during implementation. According to Attanasio et al. [20] taking into account stakeholder claims and interests during the project implementation stages is mainly necessary to achieve project objectives. Stakeholder participation is crucial to the success of the project.

It should be emphasized that there is a reciprocal relationship between initiatives and stakeholders' involvement. In other words, while stakeholders can somewhat influence project performance, stakeholders can also be somewhat impacted by development programs. For instance, executing better standard projects in the mining or construction sectors might transform and improve people's living standards, but the environmental damage and pollution would disclose the project's negative consequences on some stakeholders [7]. Additionally, as stated by Magassouba et al. [16] using the right stakeholder involvement strategy when implementing a project will make it simpler to manage their needs and foresee potential risks that could impact the project's success.

2.5 Stakeholder Involvement in project monitoring

A project needs to be meticulously managed, assessed and tracked. Tegan and Aigbavboa's [25] noted that performance and progress can be judged by contrasting the intended task with the final outcome. To ascertain a project's present state, an evaluation method is used. This assessment is required to determine whether the project is being managed effectively. The quality of a project is significantly impacted by project monitoring. A suitable control method that offers organized and ongoing information on the project's development is essential [26]. A project must be evaluated before and after implementation, claim Nguyen and Mohamed [26]. For instance, monitoring and control aim to ascertain each item's effects before evaluating how effectively each component contributes to the project's success.

Control is the process of ensuring everything happens according to established law and explicit instructions." The specific target is to establish a comprehensive strategy for planning, sustainability, and decision-making [24]. Stakeholder participation in monitoring, according to Tegan and Aigbavboa [25], affects development project performance since it increases the likelihood of success. Stakeholder reporting and monitoring of development projects helps to spot issues and difficulties with the efforts. Organizational top management has an opportunity to influence and advance project success through stakeholder participation in monitoring. Therefore, having a supportive and capable stakeholder in project monitoring will help the companies because it will make the project run much more smoothly.

2.6 Concept of project delivery

Maintaining the project's final delivery within the allotted budget, schedule, and scope, as well as adhering to the necessary technical standards for quality, operations, functionality, safety, and environmental protection, is how this is accomplished [27]. In terms of delivering the project's goals, project delivery ensures that businesses maximize profitability and reduce the effects of risks and unforeseen events [28]. Cost, time, scope, and quality are the fundamental elements and criteria to gauge project delivery, according to Magasouba et al. [16], and they are also broadly acknowledged by project management past reviewers. For instance, project quality is the key need when determining whether clients will accept a project. The specification of quality requirements should be expressly and properly expressed in planning and contract documents to assure conformance and effectiveness of quality

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performance. In Nigeria, project success is typically determined by characteristics such as project cost, quality, user satisfaction, punctuality, and attaining the project's ultimate aim. These factors are frequently used to evaluate project delivery [16].

Project delivery refers to the entire process of carrying out and finishing projects, including the construction or refurbishment of a facility or building, among other things, for the purposes of this study. It necessitates meticulous planning, designing, and building procedures from numerous actors. To move forward, the project delivery system needs a variety of responsibilities, a set of standards, and a clear set of guidelines.

3. Methodology

The study deployed a survey research design to execute the relationship between stakeholders' involvement and the delivery of borehole water projects in the study area. The study area, Nigeria's West Senatorial District in Kogi State, is situated between latitudes 070 30'N and 80 50'N and longitudes 050 21'E and 70 00E. With Kwara and Niger States to the north, Okehi LGA to the east, Ogori/Magongo LGA to the south, and Ondo and Ekiti States to the west, the study area shares shared borders. Seven Local Government Areas, including Yagba West, Yagba East, Mopamuro, Ijumu, Kotokarfi, Lokoja, and Kabba/Banu LGAs, make up the research area. Farming and mining are the main economic activities in the study area, and these jobs account for the majority of local employment. Eight hundred and three (803) of borehole water projects were completed in the Kogi-West senatorial region during the course of the previous ten years (2012–2022) based on the Lower Niger River Basin Development Agency (LNRBDA, 2022) directory. The LNRBDA staff, community leaders, and community members dispersed across the 127 communities in the seven Local Government Areas that comprise the senatorial districts formed the study's target population. The total population of these senatorial districts is 906,244 (Nigerian Bureau of Statistics, 2021) and from sample size formular we obtained approximately 400 respondents. However, the study could rely on 234 questionnaire which were properly completed and returned representing a percentage of 58.5 per cent. The questionnaire was divided into sections covering the demographic information about the respondents and the involvement in the stages of project and delivery. The study used a 5-point Likert scale and the statistical package for social sciences (SPSS) and partial least square structural equation modelling (PLS-SEM) were used for the analyses. The stakeholder involvement is the independent variable with five sub-constructs, while borehole water project delivery is the dependent variable with three sub-constructs as reflected in Table 1.

4. Results and Discussion

The study was able to receive 267 questionnaire returned with only 234 of those copies returned useful, representing 87.6 per cent of the total returned and 58.5 per cent of total distributed. According to Moser and Kalton [29], a survey response can be considered significant if the rate is between 30 and 40%, which supports the adequacy of the response rate obtained for this study.

Table 1: Variables used for the Study

S/N	Construct	Sub-Construct	No. of items	Code
1	Stakeholder Involvement in the life cycle of borehole water projects	Initiation stage	9	bIS
2		Planning stage	5	bPS
3		Execution stage	5	bES
4		Monitoring and closure stage	5	bMS
5		Post-construction stage	6	bPCS

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6	Borehole water project delivery	Time of delivery	3	cTD
7		Budget	3	cBG
8		Stakeholder satisfaction	5	cSS

4.2 Data on the Respondents' Demographics

Table 2 revealed that respondents within the age group 40–49 made up the majority (39.7%) of the sample population, while respondents under the age of 30 formed the least representation (1.3%). Seventeen percent of respondents (17.1%) were between the ages of 30 and 39; 29.5% were between the ages of 50 and 59; and 12.4% were for ages of 59 and above. Since nearly all of the respondents (98.7%, according to the Table 2) were older than the middle-aged group, the information gathered in this research was credible enough as it composed of knowledgeable age groups rather than dependants. Table 2 also demonstrates that there were more men than women among the respondents, with 68.4% of the men and the rest of respondents being women. However, this won't impact the respondents' answers, eliminating any possibility of gender bias.

Table 2: Demographic information of the respondents

Age	Frequency	Percent
Less than 30	3	1.3
30-39	40	17.1
40-49	93	39.7
50-59	69	29.5
59 and above	29	12.4
Total	234	100.0
Sex	**Frequency**	**Percent**
Male	160	68.4
Female	74	31.6
Total	234	100.0
Level of Education	**Frequency**	**Percent**
SSCE	73	32.9
Diploma	38	17.1
BSC/HND	74	33.3
Post graduate	37	16.7
Total	234	100.0
Profession	**Frequency**	**Percent**
Civil servant	93	43.7
Farmer	25	11.7
Trader	44	20.7

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Self employed	46	21.6
Unemployed	5	2.3
Total	234	100.0
Categories of Stakeholder	Frequency	Percent
Lower Niger River Basin Development Authority (LNRBDA) Staff	79	33.9
Community Leader	102	43.8
Community member	53	22.3
Total	234	100.0

Additionally, the data on the level of education showed that 16.7% of respondents have postgraduate degrees, 33.3% have either a bachelor degree or higher national diploma, 17.1% have diploma certificates, and 32.9% have either SSCE certificate. As a result, it can be inferred that the respondents are well-informed and have the capacity to evaluate and process information in order to come to a decision that is consistent with the involvement of stakeholders and the economic analysis of the delivery of borehole water projects because at least 67.9% of them have educational certificates from tertiary institutions. 43.7% of respondents are civil workers, 11.7% are farmers, 20.7% are traders, 21.6% are self-employed, and 2.3% are unemployed, according to the results of their profession. Furthermore, Table 2 results presented stakeholder categories, revealing that community members comprised 22.3% of respondents, 43.8% were community leaders, and 33.9% worked for the Lower Niger River Basin Development Authority (LNRBDA) and reside in those communities.

4.3 Level of stakeholders' involvement in borehole water projects

There were 30 indicators derived from five constructs (Table 3), with 9 indicators from the Initiation stage (BIS1 to BIS9), 5 indicators from the Planning stage (BPS1 -BPS5), 5 indicators from the Execution stage (BES1-BES5), 5 indicators from the Monitoring and closure stage (BMS1-BMS5), and 6 indicators from the Post construction stage (BPCS1-BPCS6). The indicators of stakeholder involvement in the life cycle of borehole water projects in the study area are all considered important (having between high and moderate ratings) and can be used to track the delivery of borehole water projects, as shown in Table 3, where the mean response rating values range from a maximum of 4.009 (BES2) to a minimum of 2.654 (BPS4). The local ranking means the rating of the items within their sub-constructs, whereas the global ranking involves rating the indicators when the entire construct of stakeholder involvement in project life cycle is considered.

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Table 3: Mean and Standard Deviation for Stakeholders' Involvement Indicators

SN	Latent Variable	Item	Description	Mean	Std.	*Local Rank	**Global Rank
1	**Initiation Stage**	BIS1	Lower Niger River Basin Development Authority involves all project stakeholders during the initiation stage of water borehole projects in my community	3.154	0.769	1	14
2		BIS2	Lower Niger River Basin Development Authority considers opinions presented by each category of stakeholders during the initiation stage	2.962	0.770	2	18
3		BIS3	All the stakeholders get information on the borehole projects regularly during the initiation stage	2.838	0.727	6	24
4		BIS4	All stakeholders are consulted before making decisions on the borehole projects during the initiation stage	2.821	0.786	8	26
5		BIS5	All stakeholders are involved in defining and addressing water issues in my community	2.863	0.756	5	22
6		BIS6	All the stakeholders were involved in the discussion concerning the location of the borehole projects in my community	2.872	0.838	3	20
7		BIS7	Majority of the stakeholders agreed to location of the borehole projects	2.816	0.798	9	27
8		BIS8	The stakeholders have formal and informal discussions during the initiation stage regarding water use in my community	2.829	0.708	7	25

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9		BIS9	Each category of stakeholder conducts formal and informal discussions regarding water issues in my community	2.864	0.704	4	21
10	**Planning Stage**	BPS1	Lower Niger River Basin Development Authority involves all project stakeholders during the planning stage of water borehole projects in my community	2.896	0.767	1	19
11		BPS2	Lower Niger River Basin Development Authority considers opinions presented by each category of stakeholders during the planning stage	2.840	0.809	2	23
12		BPS3	All the stakeholders get information on the borehole projects regularly during the planning stage	2.659	0.758	4	29
13		BPS4	All stakeholders are consulted before making decisions on the borehole projects during the planning stage	2.654	0.761	5	30
14		BPS5	The stakeholders have formal and informal discussions during the planning stage regarding water use in my community	2.674	0.755	3	28
15	**Execution Stage**	BES1	Lower Niger River Basin Development Authority involves all project stakeholders during the execution stage of water borehole projects in my community	3.992	0.547	3	3
16		BES2	Lower Niger River Basin Development Authority considers opinions presented by each category of stakeholders during the execution stage	4.009	0.555	1	1

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17		BES3	All the stakeholders get information on the borehole projects regularly during the execution stage	4.000	0.606	2	2
18		BES4	All stakeholders are consulted before making decisions on the borehole projects during the execution stage	3.800	0.619	4	4
19		BES5	The stakeholders have formal and informal discussions during the execution stage regarding water use in my community	3.790	0.602	5	5
20	**Monitoring and Closure Stage**	BMS1	Lower Niger River Basin Development Authority involves all project stakeholders during the monitoring and closure stage of water borehole projects in my community	3.673	0.677	1	6
21							
22		BMS2	Lower Niger River Basin Development Authority considers opinions presented by each category of stakeholders during the monitoring and closure stage	3.673	0.677	1	6
23		BMS3	All the stakeholders get information on the borehole projects regularly during the monitoring and closure stage	3.462	0.667	3	9
24		BMS4	All stakeholders are consulted before making decisions on the borehole projects during the monitoring and closure stage	3.389	0.697	5	11
25		BMS5	The stakeholders have formal and informal discussions during the monitoring and closure stage regarding water use in my community	3.451	0.639	4	10

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26	**Post Construction Stage**	BPCS1	Lower Niger River Basin Development Authority involves all project stakeholders during the post-construction stage of water borehole projects in my community	3.315	0.747	2	12
27		BPCS2	Lower Niger River Basin Development Authority considers opinions presented by each category of stakeholders during the post-construction stage	3.077	0.724	4	15
28		BPCS3	All the stakeholders get information on the borehole projects regularly during the post-construction stage	3.000	0.745	6	17
29		BPCS4	All stakeholders are consulted before making decisions on the borehole projects during the post-construction stage	3.056	0.699	5	16
30		BPCS5	The stakeholders have formal and informal discussions during the post-construction stage regarding water use in my community	3.239	0.849	3	13
31		BPCS6	There are interactions between stakeholders within a category regarding water borehole projects management	3.474	0.992	1	8

*Global rank is the overall ranking when all the items were considered irrespective of the constructs.
**Local rank is the ranking of indicators/items at each latent variable level.

Note: BIS is Initiation Stage; BPS is Planning Stage; BES is Execution Stage; BMS is Monitoring and Closure Stage; and BPCS is Post Construction Stage.

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According to the findings, BES2 ("Lower Niger River Basin Development Authority considers opinions presented by each category of stakeholders during the execution stage"), with a mean of 4.009 and standard deviation 0.555 represents the highest level of stakeholder involvement in the delivery of borehole water projects, and BPS4 ("All stakeholders are consulted before making decisions on the borehole projects during the planning stage") with a mean of 2.654 and standard deviation 0.761, represents the least level of stakeholder involvement in the delivery of borehole water projects.

In general, Table 4 shows that the Execution stage (bES) has the highest stakeholder involvement in the delivery of borehole water projects with a mean of 3.918 and standard deviation 0.595, while the Planning stage (bPS) has the lowest involvement with a mean of 2.745 and standard deviation 0.777 in the study area. This indicates that most government projects are push rather than pull of projects from the communities which represent the end-users. This evident in the results obtained as both initiation and planning phases constitute the least involvement, it may also be a signal that the communities' involvement at these preliminary stages is without renumeration since they are at the conceptualisation and screening stages.

Table 4: Overall Statistics for Sub-constructs of Stakeholder Involvement

SN	Item	Description	Mean	Std.	Overall Rank
1	bES	Execution Stage	3.918	0.595	1
2	bMS	Monitoring and Closure Stage	3.498	0.672	2
3	bPCS	Post-Construction Stage	3.194	0.816	3
4	bIS	Initiation Stage	2.891	0.770	4
5	bPS	Planning Stage	2.745	0.777	5

4.3.2 Effects of stakeholders' involvement on borehole water projects delivery

The partial least squares approach to structural equation modelling was used to analyse the effects of sub-constructs of independent variable on the dependent latent variables. A measurement model that connects the manifest variables to their corresponding latent variables and a structural model that shows how various latent variables relate to one another make up the model two main assessments, in general [30]. Henseler et al. [31] describe a two-step procedure that starts with estimating the path coefficients of the structural model and ends with independently calculating the PLS model parameters by identifying the components of the measurement model [30]. These two sequences were carried out in this study to show that the indicators from each of the constructs are valid and reliable before the study could draw any conclusions regarding the relationships presented.

(a) Assessment of the measurement Model

The investigation followed the procedures presented by Hair et al. [30] for SmartPLS. Figure 1 shows how each item was modelled as a reflecting indication for the relevant component. Three constructs: budget (cBG), time delivery (cTD), and stakeholder satisfaction (cSS) were utilized in this study to measure project delivery as contained in [41]. They referred to the three constructs as the dominants measures that determine the output and success of a project, where in this case satisfaction represents the proxy for quality. Secondly, five constructs were employed to captured stakeholders' involvement at each stage of the water project: the Initiation stage (bIS), Planning stage (bPS), Execution stage ("bES"), Monitoring and closing stage (bMS), and Post construction stage (bPCS). The total collection of

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variables used to assess stakeholder involvement and delivery of borehole water projects in the research area consists of eight (8) latent variables and forty-one (41) manifest variables.

The measurement model evaluation tries to determine the validity and dependability of the manifest variables. Consistency is evaluated using individual manifest and construct reliability tests. The variables' validity is assessed using convergent and discriminant validity [30]. The individual manifest dependability can be used to explain the variation of an individual manifest in relation to a latent variable by determining the standardized outer loadings of the manifest variables. According to Hair et al. [30], a manifest variable with an outside loading of 0.7 or more is considered to be very good. While Henseler et al. [31] advised examining manifest variables with loading values between 0.4 and 0.7 before deletion, Hair et al. [30] assert that 0.4 should be the acceptable loading value. Manifest variables should be removed if their loading values are less than 0.5, which is the accepted threshold. If eliminating these signals resulted in an increase in the composite dependability value, remove or keep the variables. While Henseler et al. [31] recommendations are taken into consideration, an iterative technique is used to remove the manifest variables even if the cut-off value for outer loading in this study is 0.5.

The second metric for constructing reliability evaluations of internal consistency is composed of Cronbach's alpha (CA) and Composite Reliability (CR), both presented by Hair et al. [30]. According to Herath and Rao [32], both CA and CR have a threshold of 0.700, with higher values signifying a better level of reliability. While a suitable validity coefficient was anticipated for the other factor, some study areas agreed that an acceptable reliability range between 0.600 and 0.700 was required [30]. According to Table 5, the CA values vary from 0.794 to 0.925 and the CR values range from 0.878 to 0.937. These values, which are greater than the required threshold for both tests, demonstrate that the constructs easily link to reliabilities [30]. In Table 5 the findings of the average- variance extracted (AVE), convergent validity indicator, were also shown. The AVE determines how much measurement error-related variance a latent variable collects from related manifest variables. According to Hair et al. [30], latent variables should account for at least 50% of the variance from manifest variables. This implies that the AVE value of the construct should be more than 0.5. The number ranged from 0.590 to 0.772 and was above the recommended range of 0.5 as cited in [30]. The measuring approach further demonstrates the value of the indicators by evaluating the discriminant validity of the constructs. Discriminant validity is utilized to verify if a variable is pertinent to the designated latent variable when its cross-loading value in the defined latent variable is higher than that in any other constructs.

Table 5: Construct Reliability and Validity

	C A	C R	AVE
bES	0.870	0.906	0.659
bIS	0.925	0.934	0.613
bMS	0.916	0.937	0.749
bPCS	0.894	0.919	0.654
bPS	0.923	0.942	0.764
cBG	0.794	0.880	0.710
cSS	0.827	0.878	0.590
cTD	0.853	0.911	0.772

The developed model is repeatedly tested in accordance with the aforementioned criteria to weed out the weak manifest variables. This was established using their cross-loadings, the Fornell-Larcker criterion, and the Heterotrait-Monotrait (HTMT) evaluation of the correlation. The cross-loading results suggest that an indicator's outer loading on

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its latent construct (shown in Table 6) should have a greater significance than its cross-loadings on the other constructs in the model.

According to Table 6, which was reported in [33], the outer loadings of each indicator are larger on their particular construct as compared to their cross-loadings on any other constructs. This difference must be at least 0.10, as stated by Gefen and Straub [34]. The Fornell-Lacker criterion is an additional method for proving the discriminant validity. It was suggested that the squared inter-construct correlation between each construct's AVE and any other reflectively assessed constructs within the structural model should be used to compare each construct's AVEs [30]. Essentially, every model construct's shared variance should not be higher than their AVEs. The findings in Table 7 show that all constructs have been successfully evaluated according to the AVE suggestion. The study next assessed the HTMT in light of the AVE technique's limitations [30]. According to their advice, a value of 0.90 or above indicated a lack of discriminant validity [31]. Additionally, the value 1 should not be included in the HTMT confidence interval. Table 8 demonstrates that the research PLS model has met the HTMT requirement. The HTMT results end the measurement model quality standards for the reflectively organized constructs. The study constructs successfully met the necessary requirements.

Table 6: Cross Loading

	bES	bIS	bMS	bPCS	bPS	cBG	cSS	cTD
BES1	0.783	0.309	0.374	0.359	0.278	0.390	0.394	0.438
BES2	0.828	0.290	0.364	0.390	0.241	0.459	0.400	0.504
BES3	0.781	0.125	0.249	0.394	0.120	0.337	0.384	0.480
BES4	0.828	0.192	0.400	0.317	0.240	0.456	0.416	0.354
BES5	0.836	0.241	0.459	0.322	0.222	0.493	0.470	0.365
BIS1	0.242	0.778	0.298	0.347	0.419	0.217	0.071	0.240
BIS2	0.187	0.857	0.317	0.313	0.430	0.227	0.104	0.180
BIS3	0.163	0.779	0.375	0.233	0.426	0.137	-0.032	0.053
BIS4	0.106	0.783	0.349	0.267	0.507	0.160	0.064	0.066
BIS5	0.263	0.820	0.363	0.336	0.390	0.333	0.220	0.262
BIS6	0.152	0.716	0.414	0.248	0.456	0.132	0.068	-0.011
BIS7	0.213	0.741	0.502	0.378	0.466	0.167	-0.009	0.044
BIS8	0.241	0.791	0.471	0.408	0.470	0.196	0.116	0.161
BIS9	0.291	0.771	0.389	0.360	0.343	0.307	0.190	0.232
BMS1	0.447	0.432	0.849	0.327	0.371	0.327	0.247	0.162
BMS2	0.396	0.411	0.860	0.301	0.411	0.349	0.221	0.080
BMS3	0.393	0.407	0.900	0.303	0.390	0.364	0.215	0.121
BMS4	0.383	0.337	0.857	0.303	0.415	0.308	0.174	0.056
BMS5	0.361	0.448	0.860	0.356	0.424	0.383	0.277	0.181
BPCS1	0.319	0.299	0.374	0.790	0.192	0.212	0.228	0.298
BPCS2	0.344	0.446	0.443	0.800	0.353	0.340	0.200	0.355
BPCS3	0.330	0.324	0.351	0.841	0.284	0.199	0.185	0.275
BPCS4	0.345	0.363	0.343	0.821	0.366	0.215	0.165	0.264
BPCS5	0.373	0.400	0.247	0.802	0.250	0.239	0.146	0.366
BPCS6	0.400	0.217	0.065	0.795	0.087	0.227	0.181	0.446
BPS1	0.226	0.477	0.407	0.279	0.817	0.176	-0.003	0.031

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BPS2	0.174	0.458	0.389	0.323	0.834	0.156	-0.010	0.101
BPS3	0.223	0.443	0.427	0.241	0.925	0.216	0.013	0.044
BPS4	0.245	0.488	0.417	0.290	0.903	0.214	0.029	0.046
BPS5	0.300	0.456	0.400	0.244	0.888	0.219	0.081	0.136
CBG1	0.426	0.284	0.336	0.200	0.152	0.781	0.517	0.456
CBG2	0.481	0.234	0.374	0.299	0.189	0.894	0.542	0.566
CBG3	0.425	0.251	0.306	0.258	0.233	0.849	0.562	0.477
CSS1	0.337	0.113	0.179	0.104	0.041	0.467	0.760	0.349
CSS2	0.367	0.161	0.157	0.154	0.033	0.476	0.775	0.424
CSS3	0.330	0.172	0.371	0.150	0.123	0.560	0.775	0.298
CSS4	0.426	0.002	0.129	0.175	-0.070	0.427	0.782	0.422
CSS5	0.475	0.129	0.168	0.268	-0.013	0.511	0.748	0.566
CTD1	0.449	0.289	0.176	0.436	0.088	0.527	0.437	0.890
CTD2	0.491	0.211	0.138	0.332	0.135	0.553	0.529	0.888
CTD3	0.453	0.068	0.050	0.339	-0.013	0.486	0.475	0.858

Table 7: Fornell-Larcker Criterion

	bES	**bIS**	**bMS**	**bPCS**	**bPS**	**cBG**	**cSS**	**cTD**
bES	0.812							
bIS	0.287	0.783						
bMS	0.457	0.475	0.865					
bPCS	0.439	0.423	0.370	0.809				
bPS	0.272	0.528	0.465	0.310	0.874			
cBG	0.528	0.303	0.403	0.301	0.227	0.842		
cSS	0.509	0.153	0.266	0.229	0.030	0.641	0.768	
cTD	0.528	0.226	0.144	0.423	0.085	0.595	0.545	0.879

Table 8: Hetero-Monotrait Ratio (HTMT)

	Bes	**bIS**	**bMS**	**bPCS**	**bPS**	**cBG**	**cSS**	**cTD**
bES								
bIS	0.295							
bMS	0.510	0.527						
bPCS	0.494	0.448	0.413					
bPS	0.297	0.598	0.507	0.353				
cBG	0.633	0.310	0.469	0.348	0.262			
cSS	0.592	0.184	0.295	0.260	0.089	0.785		
cTD	0.613	0.218	0.150	0.468	0.109	0.719	0.639	

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The study next considered the structural models, which revealed details about the second goal of the study in terms of their hypothesis. The remaining goals for this study are presented in the next two sub-sections.

(b) Effects of Stakeholder involvement on the delivery borehole water projects

The section discussed the relationship between the stakeholder involvement and project delivery frameworks for borehole water. Following the verification of measurement quality, the structural model technique was carried out to include the collinearity, R-square or coefficient of determination, path coefficient, and F-square or effect sizes. With regard to the endogenous composite variables (cBG, cSS, and cTD), the values of the inner VIF are as revealed in Table 9. The outcome demonstrates that multicollinearity across the latent constructs is not a concern because all of them fall below the cutoff value of 5 [33]. Thus, we examined the PLS-algorithm (Figure 1) and bootstrapping (Figure 2) with 5000 resamples using SmartPLS to obtain the standard path coefficient t-statistics values, standard deviations, and P-values [30]. The path coefficients are shown in Table 10 for the following exogenous variables: Initiation (bIS), Planning (bPS), Execution ("bES"), Monitoring and Closure (bMS), Post Construction (bPCS) on each of the following endogenous variables Budget (cBG), Time Delivery (cTD), and Stakeholder Satisfaction (cSS).

Table 9: Variance Inflation Factor (VIF)

	cBG	cSS	Ctd
bES	1.416	1.416	1.416
bIS	1.642	1.642	1.642
bMS	1.619	1.619	1.619
bPCS	1.419	1.419	1.419
bPS	1.517	1.517	1.517

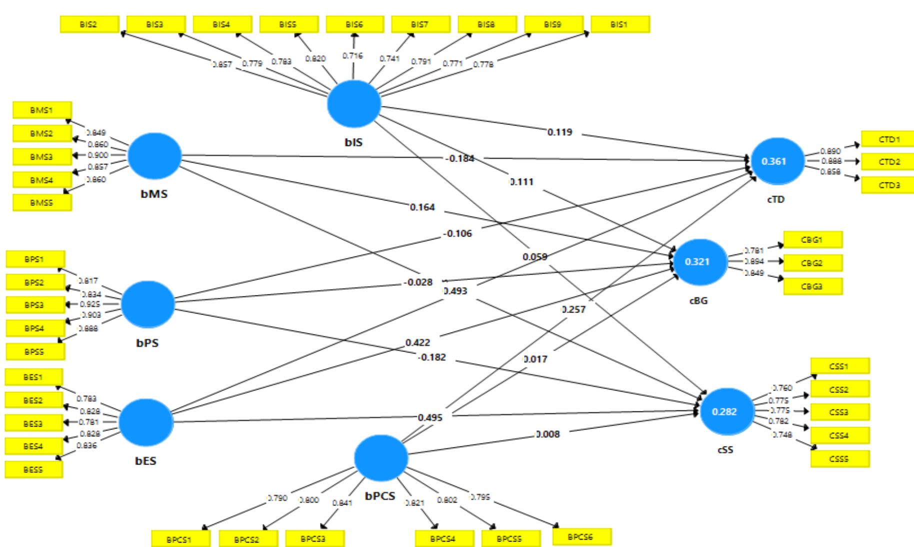

Figure 1: Algorithm of measurement model for all constructs

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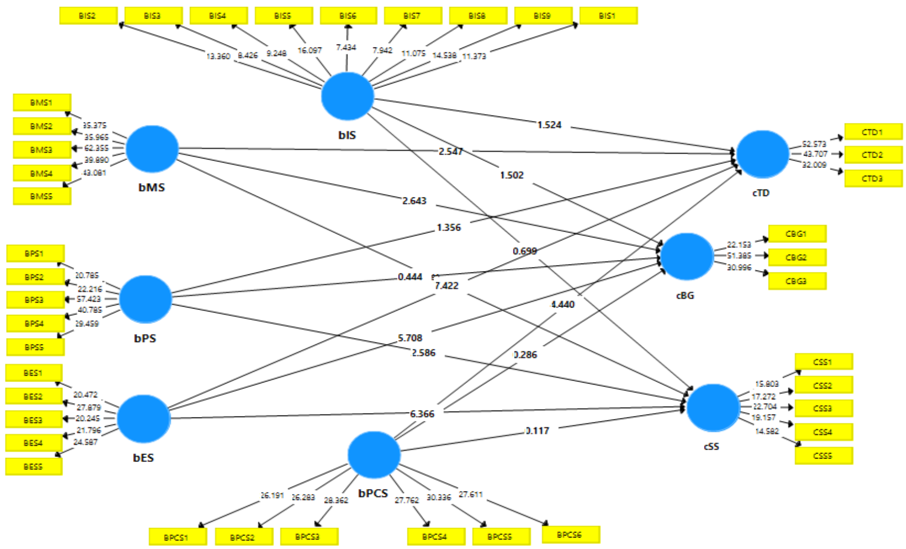

Figure 2: Bootstrapping for structural model

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Table 10: Structural Path Analysis

	Beta	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	2.5%	97.5%	Decision
bES -> cBG	0.422	0.074	5.708	**0.000**	0.253	0.551	Sig.
bES -> cSS	0.495	0.078	6.366	**0.000**	0.324	0.634	Sig.
bES -> cTD	0.493	0.066	7.422	**0.000**	0.347	0.609	Sig.
bIS -> cBG	0.111	0.074	1.502	**0.133**	-0.046	0.241	NS
bIS -> cSS	0.059	0.085	0.699	**0.485**	-0.123	0.214	NS
bIS -> cTD	0.119	0.078	1.524	**0.128**	-0.039	0.261	NS
bMS -> cBG	0.164	0.062	2.643	**0.008**	0.044	0.283	Sig.
bMS -> cSS	0.093	0.073	1.283	**0.200**	-0.048	0.233	NS
bMS -> cTD	-0.184	0.072	2.547	**0.011**	-0.327	-0.048	Sig.
bPCS->cBG	0.017	0.060	0.286	**0.775**	-0.104	0.133	NS
bPCS -> cSS	0.008	0.071	0.117	**0.907**	-0.133	0.143	NS
bPCS-> cTD	0.257	0.058	4.440	**0.000**	0.136	0.363	Sig.
bPS -> cBG	-0.028	0.063	0.444	**0.657**	-0.152	0.093	NS
bPS -> cSS	-0.182	0.070	2.586	**0.010**	-0.320	-0.047	Sig.
bPS -> cTD	-0.106	0.078	1.356	**0.175**	-0.265	0.039	NS

Note: *Sig.=Significant; NS=Not Significant

From Table 10, beta which represents the coefficient of regression for each exogenous construct, 'STDEV' shows the standard deviation. Both T Statistics and p values show the significance of the path, when T value is greater than 1.96, $p < 0.05$, and beta value fall between the values in 2.5% and 97.5% representing the boundary for the confidence interval, then the 'p values' can be accepted. Table 10 and Figure 2 show significant positive relationships between the variables bES and cBG (beta = 0.422, t = 5.708), bES and cSS (beta = 0.495, t = 6.366), bES and cTD (beta = 0.493, t = 7.422), bMS and cTD (beta = 0.257, t = 4.440), and significant negative relationships between the variables bMS and cTD (beta = -0.184, t = 2.547). There were no significant relationships between stakeholder involvement and the delivery of borehole water projects in the followings: bIS ->cBG; bIS ->cSS; bIS ->cTD; bMS -> cSS; bPCS -> cBG; bPCS -> cSS; bPS -> cBG; and bPS -> cTD.

Table 11 shows the values of the coefficient determination (R^2) as 0.321, 0.282, and 0.361; and the adjusted R^2 as 0.307, 0.267, and 0.347 for cBG, cSS, and cTD, respectively. Tehseen et al. [36], citing Cohen [35] study, advised that R^2 values of 0.26, 0.13, and 0.02 be regarded as substantial, moderate, and weak, respectively. Because the R^2 for this study is greater than 0.26, as stated, it can be regarded to be substantial. As a result, the exogenous constructs account for around 31%, 27%, and 35% of the variance in the endogenous constructs cBG, cSS, and cTD, respectively. The effect size (f-square) was also investigated in the study. The values of the f-square effect sizes 0.02, 0.15, and 0.35 are regarded as small, medium, and large significant impacts of the exogenous constructions, respectively, according to [35] suggested threshold. Table 12 illustrates that only bES has a large effect size (0.185, 0.242, and 0.269) on the endogenous constructs cBG, cSS, and cTD in accordance with this rule. Small effect sizes are shared by bIS, bMS, bPCS, and bPS on the endogenous variables.

Table 11: R Square and R Square Adjusted

	R Square	R Square Adjusted
cBG	0.321	0.307

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cSS	0.282	0.267
cTD	0.361	0.347

Table 12: Effect size

Construct	cBG	cSS	Ctd
bES	0.185	0.242	0.269
bIS	0.011	0.003	0.013
bMS	0.025	0.007	0.033
bPCS	0.000	0.000	0.073
bPS	0.001	0.030	0.012

The results of this study showed that bES (execution stage) in Figure 2 and Table 10 has the largest weight (structurally) and bES5 (the stakeholders have formal and informal discussions during the execution stage regarding water use in my community) with the largest significant path showed that the stakeholders at the execution stage have the dominant path coefficient (0.495, 0.493, and 0.422 with cSS, cTD, and cBG, respectively) when compared with others. It is further clear that BES5 (The stakeholders have formal and informal discussions during the execution stage regarding water use in my community), with 0.836 loadings, is the highest of the five items under the execution stage. It is not surprising that at this stage of execution, there are many schedule meetings for the project's success. Especially the aspect of logistics, procurement, and those that will prosecute the project is at this stage prominent. So, engaging in formal and informal meetings becomes imperative. It may also be understood that at this stage, those who want to secure contracts and the modalities become feasible at this phase, so also the local content derivatives are likely to become a matter for discussion which may warrant such formal and informal meetings. Following closely after the discussions were the BES2 (Lower Niger River Basin Development Authority considers opinions presented by each category of stakeholders during the execution stage) and BES4 (All stakeholders are consulted before making decisions on the borehole projects during the execution stage) with 0.828 loadings. This signals that the discussions at this stage are far more important than any other stages as the authority considers them for execution after their due consultations with the relevant stakeholders. We can also figure it out that execution stage had more impact on the stakeholder's satisfaction than other measures of performance as this may be linked to the movement of cash for project execution, the opportunities to strike deals and contracts, and the employment generation that the host communities tend to benefit may be the source of satisfaction.

It would be recall from Figure 1 and Table 11 that the coefficients of determination showed that cTD, time of delivery has 0.361, followed by cBG, budget with 0.321, and lastly, satisfaction which is a proxy for quality of the project with 0.282. It is evident that water is a source of life for many reasons, so the outcome of the results is not surprising as the delivery time becomes more important to the involvement of the stakeholder. They are not bothered much about the quality nor the cost of the project, but much attention is given to the time the project would be completed and ready for use.

Recall from Table 10, apart from the execution stage that has all its paths significant the monitoring and control stage also recorded two of its paths with significance at 95 percent confidence level. With the monitoring and control only the path with satisfaction remained insignificant, which is a testament that the stakeholders were not satisfied with the quality of water projects delivered to the communities or rather it is inconclusive. It is also noticed that the path with the time of delivery is negatively significant as this may results into slowing the pace of project execution if the quality is not good enough and the contractor has to rework, rescope or redesign due to lack of water with the boreholes. This is possible as the projects do not also consider the stakeholders their initial planning stages. The timely delivery may also suffer setbacks when the projects were wrongly located due to lack

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of initial engagement or involvement of the relevant stakeholders. There is also a negative relationship between the planning stage and stakeholder satisfaction in delivering borehole water projects in the study area. This arises when the planning does not conform to the quality of the products or services. Otherwise, two quality management issues may result, including quality of design and quality of conformance as cited in [42]. In this case the design quality, which may be liked to the planning stage outcome, and the conformance of quality a proxy for the reality of what was done in the borehole water projects, were in disagreement. Hence the noticeable opposite movement between the planning stage and the stakeholder satisfaction. Lastly, the importance of the initiation stage should not be undermined in providing infrastructure, such as water projects, to the people. There is none of the paths of initiation stage that was significant with the constructs of performance measures, a lot of improvement needs to go the way in sensitizing the stakeholders about the participation process and the importance of the preliminary stages on the project life cycle.

5.0 Conclusion

The study determined the level of stakeholder involvement in the execution of borehole water projects and empirically demonstrated the link between stakeholder involvement and the execution of borehole water projects in Nigeria's Kogi-West Senatorial District. This study has increased knowledge of the elements that could affect the implementation of borehole water projects and the involvement of stakeholders in an artificial setting. With a mean of 3.918 and a standard deviation of 0.595, the execution stage (bES) of this study had the highest level of stakeholder involvement in the delivery of borehole water projects, whereas the planning stage (bPS) had the lowest level of stakeholder involvement in the study area with a mean of 2.745 and a standard deviation of 0.777.

The findings indicate that the involvement of stakeholders is a significant predictor of borehole water project delivery in the study area and that stakeholders in the area recognized that their ability to formally and informally discuss during the execution stages has the greatest impact on the delivery of borehole water projects. This indicates that all parties involved in borehole water projects must come together to discuss and validate to make the execution stage successful. The results of this study have significant policy ramifications for the implementation of water projects and stakeholder involvement in Nigeria's Kogi-West Senatorial District. The author so advises that the level of participation of all pertinent stakeholders in the project initiation and planning phases of the borehole water project life cycle should be improved in light of the findings.

Involvement of Stakeholders and Borehole Water Projects Delivery in Nigeria's Kogi-West Senatorial District were the main subjects of this study. This means that the research's conclusions might not apply to other senatorial districts, regions, or zones within the nation. Therefore, the researcher proposes expanding the study's scope in follow-up research to include additional Nigerian senatorial districts, states, regions, or zones. This is due to the paucity of studies that have been done on the relationship between the involvement of stakeholders, and the execution of borehole water projects in Nigeria. Also, the modalities to improve participation at the initiation and planning stages require attention. Further studies should adopt the mixed method or rather investigate the outcomes of this work qualitatively.

References

[1] Farrell, L., & Fry, J. M. Australia's gambling epidemic and energy poverty. *Energy economics*, *97*, (2021) 105218.

[2] Adepoju A., Jesuleye O., and Arigbede O. Solar Photo Voltaic Contributions to Energy Mix in Selected Nigerian Estates. *Archives of Business Research*, 8 (3), (2020)131-164.

[3] Ceylan, R., & Özbakır, A. Increasing Energy Conservation Behaviour of Individuals towards Sustainable and Energy-Efficient Communities. *Smart Cities*, *5*(4), (2022) 1611-1634.

[4] Nguyen, Q. N., & Hoang, T. H. L. Applying the theory of planned behavior to analyze household energy-saving behavior. *International Journal of Energy Economics and Policy*, *12*(5), (2022)287-293.

JDFEWS 4 (1): 34 - 56, 2023
ISSN 2709-4529

[5] Suntornsan, S., Chudech, S., & Janmaimool, P. The Role of the Theory of Planned Behavior in Explaining the Energy-Saving Behaviors of High School Students with Physical Impairments. *Behavioral Sciences*, *12*(9), (2022) 334.

[6] Wang, Q. C., Chang, R., Xu, Q., Liu, X., Jian, I. Y., Ma, Y. T., & Wang, Y. X.. The impact of personality traits on household energy conservation behavioral intentions–an empirical study based on theory of planned behavior in Xi'an. *Sustainable Energy Technologies and Assessments*, *43*, (2021) 100949.

[7] Piao, X., & Managi, S. Household energy-saving behavior, its consumption, and life satisfaction in 37 countries. *Scientific reports*, *13*(1), (2023)1382.

[8] Liu, X., Wang, Q., Wei, H., Chi, H.,Ma, Y., Jian I.Z. Psychological and Demographic Factors Affecting Household Energy-Saving Intentions: A TPB-Based Study in Northwest China. *Sustainability*, 12, (2020).836

[9] Jiang, T., Li, H., Mao, P., Wu, T., Skitmore, M., & Talebian, N. Strategy of Energy Conservation and Emission Reduction in Residential Building Sector: A Case Study of Jiangsu Province, China. *Journal of Environmental and Public Health*, (2023).

[10] Andersen, F. M., Gunkel, P. A., Jacobsen, H. K., and Kitzing, L. Residential electricity consumption and household characteristics: an econometric analysis of Danish smart meter data. *Energy Econ*. 100: (2021)105341.

[11] Kumar, P., Caggiano, H., Shwom, R., Felder, F. A., & Andrews, C. J. Saving from home! How income, efficiency, and curtailment behaviors shape energy consumption dynamics in US households?. *Energy*, *271*, (2023)126988.

[12] Ali, S. S. S., Razman, M. R., Awang, A., Asyraf, M. R. M., Ishak, M. R., Ilyas, R. A., & Lawrence, R. J.. Critical determinants of household electricity consumption in a rapidly growing city. *Sustainability*, *13*(8), (2021) 4441.

[13] Shang, Y., Lian, Y., Chen, H., & Qian, F.. The impacts of energy resource and tourism on green growth: evidence from Asian economies. *Resources Policy*, *81*, (2023)103359.

[14] Yang, S., Jahanger, A., & Hossain, M. R. Does China's low-carbon city pilot intervention limit electricity consumption? An analysis of industrial energy efficiency using time-varying DID model. *Energy Economics*, *121*, (2023)106636.

[15] Parag, Y., Fawcett, T., Hampton, S., & Eyre, N. Energy saving in a hurry: A research agenda and guidelines to study European responses to the 2022–2023 energy crisis. *Energy Research & Social Science*, *97*, (2023)102999.

[16] Magassouba, S. M., Tambi, A. M. B. A., Alkhlaifat, B. I. and Abdullah, A. A. Influence of Stakeholders Involvement on Development Project Performance in Guinea. *International Journal of Academic Research in Business and Social Sciences*, *9*(1), (2019)1111–1120.

[17] Belaïd, F. & Flambard, V. Impacts of income poverty and high housing costs on fuel poverty in Egypt: An empirical modelling approach. *Energy Policy*, *175*, (2023) 113450.

[18] Lee, C. C., & Hussain, J. An assessment of socioeconomic indicators and energy consumption by considering green financing. *Resources Policy*, *81*, (2022)103374.

[19] Ahmad, T. I., Nawaz, M. A., Kiran, K., Dagar, V., Bhatti, M. A., & Hussain, A. Dirty versus clean fuel for cooking in Pakistan: regional mapping and correlates. *Environmental Science and Pollution Research*, *30*(10), (2023) 26458- 26471.

[20] Chen, Y., Li, S., Zhou, T., Lei, X., Liu, X., & Wang, Y. Household cooking energy transition in rural mountainous areas of China: Characteristics, drivers, and effects. *Journal of Cleaner Production*, *385*, (2023). 135728.

[21] Issa, A. Shaping a sustainable future: The impact of board gender diversity on clean energy use and the moderating role of environmental, social and governance controversies. *Corporate Social Responsibility and Environmental Management*. (2023)

[22] Kyaw, K., Treepongkaruna, S., & Jiraporn, P. Board gender diversity and environmental emissions. *Business Strategy and the Environment*, *31*(7), 2871-2881.

[23] Galvin, R. Policy pressure to retrofit Germany's residential buildings to higher energy efficiency standards: A cost-effective way to reduce CO2 emissions?. *Building and Environment*, *237*, (2023) 110316.

[23] Wassie, Y. T., & Ahlgren, E. O. Determinants of electricity consumption from decentralized solar PV mini-grids in rural East Africa: An econometric analysis. *Energy*, *274*, (2023)127351.

[24] Khaleel, M., Yusupov, Z., Ahmed, A. A., Alsharif, A., Alarga, A., & Imbayah, I. The effect of digital technologies on energy efficiency policy. *International Journal of Electrical Engineering and Sustainability (IJEES)*, (2023) 1-8.

JDFEWS 4 (1): 34 - 56, 2023
ISSN 2709-4529

[25] Jain, M.. Estimates of energy savings from energy efficiency improvements in India using Index Decomposition Analysis. *Energy for Sustainable Development*, *74*, (2023) 285- 296.

[26] Hu, Q., Tang, J., Gao, X., Wang, S., Zhang, D., Qin, Y., & Lun, F. Future hotter summer greatly increases residential electricity consumption in Beijing: A study based on different house layouts and shared socioeconomic pathways. *Sustainable Cities and Society*, *91*, (2023)104453.

[27] Huang W. The determinants of household electricity consumption in Taiwan: Evidence from Quantile regression *Energy*; 87: (2015) 120–33. http://dx.doi.org/10.1016/J.ENERGY.2015.04.101.

[28] Blázquez L, Boogen N, Filippini M. Residential electricity demand in Spain: New empirical evidence using aggregate data. *EnergyEcon*; 36: (2013) 648–57. http://dx.doi.org/10.1016/j.eneco.2012.11.010

[29] Ackah I, Bukari D, Banye EZ, Bobio C Transitioning towards cleaner cooking fuels: an analysis of consumer preferences in Ghana's cookstoves market. *Environ Sci Pollut Res* 28(39): (2021) 54936–54949

[30] Ye Y, Kocha FS, Zhang J. Determinants of household electricity consumption in South Africa.*EnergyEcon*;75(C):(2018).120–33. http://dx.doi.org/10.1016/j.eneco.2018.08.005.

[31] Al-Bajjali SK, Shamayleh AY. Estimating the determinants of electricity in Jordan. *Energy*; 147: (2018)1311–20. http://dx.doi.org/10.1016/j.energy.2018.01.010.

[32] Sakah M, De la Rue du Can S, Diawuo AF, Sedzro DM, Kuhn C.. A study of appliance ownership and electricity consumption determinants in urban Ghanaian households. *Sustainable Cities Soc*;44: (2019)559–81. http://dx.doi.org/10.1016/J.SCS..10.019.

[33] Hair, J.F., Hult, G.T.M., Ringle, C.M., Sarstedt, M.. A Primer on Partial Least Squares Structural Equation Modelling (PLS-SEM) (J. Hair (ed.); (2017) Second Edi). Sage.

[34] Adepoju A. and Adeniji A. Technology Acceptance of E-Banking Services in an Unnatural Environment. *Journal of Management* 3(3), (2020) 34-50.

[34] Herath, T., & Rao, H. R. Protection motivation and deterrence: A framework for security policy compliance in organisations. *European Journal of Information Systems.* (2009). https://doi.org/10.1057/ejis.2009.6

[35] Gefen, D., & Straub, D. A Practical Guide to Factorial Validity Using PLS Graph: Tutorial and Annotated Example. *Communications of the Association for Information Systems*, 16(5), (2005) 91–109. https://doi.org/DOI: 10.17705/1CAIS.01605

[36] Roemer, E., Schuberth, F., & Henseler, J.. HTMT2–an improved criterion for assessing discriminant validity in structural equation modeling. *Industrial management & data systems*, *121*(12), (2021) 2637-2650.

[37] Tehseen, S., Ahmed, F. U., Qureshi, Z. H., Uddin, M. J., & Ramayah, T. Entrepreneurial competencies and SMEs' growth: the mediating role of network competence. *Asia-Pacific Journal of Business Administration*, *11*(1), (2019) 2-29.

[38] Cohen, J. Statistical power analysis. *Current directions in psychological science*, *1*(3), (1992) 98-101.

[39] Bashir, M. F., Benjiang, M. A., Shahbaz, M., Shahzad, U., & Vo, X. V. Unveiling the heterogeneous impacts of environmental taxes on energy consumption and energy intensity: empirical evidence from OECD countries. *Energy*, *226*, (2021). 1-15. https://doi.org/10.1016/j.energy.2021.120366

[40] Sun, Y., Gao, P., Tian, W., & Guan, W. Green innovation for resource efficiency and sustainability: Empirical analysis and policy. *Resources Policy*, *81*, (2023)103369.

[41] Bukoye, O. T., Ejohwomu, O., Roehrich, J., & Too, J. Using nudges to realize project performance management. *International Journal of Project Management*, *40* (8), (2022) 886-905. https://doi.org/10.1016/j.ijproman.2022.10.003

[42] Meirovich, G. Quality of design and quality of conformance: Contingency and synergistic approaches. *Total Quality Management & Business Excellence*, *17*(2), (2006) 205-219. https://doi.org/10.1080/14783360500450640