PROJECT CONCEPT NOTE

I. Title of Proposed Research:

Rice Husk Ash and Palm Oil Fuel Ash as Quartz Replacement for Wall, Floor and Interlock Tile Production: A Circular Economy Approach

II. **Category 2:** Science, Engineering, Technology and Innovation (SETI)
Thematic 22: Sustainable Use of Natural Resources and Terrestrial Ecosystems

III. Executive Summary

Rice husk ash (RHA) is an agro-residue or byproduct generated from the milling of rice, which is often landfilled or underutilized, resulting in adverse environmental impacts and higher economic costs for the rice manufacturers. The production of RHA has continued to increase due to the increased production of rice for consumption. For every 1 kg of rice produced, approximately 0.28kg of rice husk is generated. Over the years, rice husk produced has found limited application and are mostly used as fuel in the rice mills to generate steam for the parboiling process and approximately 25 % of the weight of this rice husk is converted into rice husk ash (RHA). Palm oil industry has been remarkably growing over the past few decades, thus becoming a vital agricultural based industry. This agricultural-based industry has contributed to the socio-economic growth of many countries including Nigeria. The industries burn palm oil waste to heat the boiler and generate electricity which subsequently produced another waste known as Palm Oil Fuel Ash (POFA). As the palm oil plantations increased yearly, the production of POFA is expected to also increase. Some researchers argued that, since POFA is rich in silica, recent research pave way for the production of sustainable materials and also reduce the environmental pollution caused by POFA disposal. This ash is cheap and available in abundance, also looking at the properties of palm oil ash it can be used as substitution for quartz in porcelain tile production. Porcelain tile is a highly vitreous ceramic material that is heated at high temperatures. Standard porcelain tile consist of 50% clay, 25% feldspar and 25% quartz, hence the name triaxial porcelain. The need to reduce the emissions caused by cement production and usage, as well as incessant exploitation of non-renewable natural resources provide justifiable reason to find an alternative replacement that is sustainable and has less carbon footprint. The use of agro-industrial wastes such as RHA and POFA as replacements in concrete and interlock tile could be an alternative pathway to valorize industrial wastes and reduce environmental pollution associated with cement production. The aim of this research project is to use agricultural wastes (RHA and POFA) as the replacement of quartz in the production of wall and floor tile and as cement partial and full replacement in the production of interlock tile. Raw RHA and POFA will be treated with acid and calcination to remove the unburned carbon and enhance the purity and silica content, quartz will be replaced with RHA and POFA at 0, 10,15,20 and 25% and cement for the production of wall, floor and interlock tile. XRD,

SEM, XRF will be employed to investigate the effect of treatments done. Compressive strength, Vickers micro hardness and bulk density will be used to determine the physico-mechanical properties of the final product produced. A prediction model will be developed for wall, floor and interlock tile. This research will provide avenue for circular economy for the country and will serve as source of cost reduction to the industries by replacing one of the most expensive component with more abundance and cheap agro-residue or byproduct. Furthermore, it is expected that, findings of this research work will pave way for researchers on the promising nature of RHA and POFA for industrial use. It is expected that, cost reduction in the production of interlock tile will provide an opportunity for the industries to employ more staff and produced an improved interlock tile. The research work will cost the total sum of **Twenty Two Million Three Hundred and Fourty Thousand Seven Hundred and five Naira Only (₦ 22,340,705.00)** to be completed.

IV. Background to the Research

Palm oil trees (Elaeis Guineensis) is an African tree used as ornamental plants that turn out nowadays to be commercial trees. These trees can be found abundantly in Nigeria (Scrivener et al., 2018). Disposal and management of palm oil fuel ash (POFA) have been the greatest challenge faced by the palm oil milling industries all over the world, disposal of POFA indiscriminately lead to environmental pollution as POFA take a long time to biodegrade, hence a need for proper production, utilization and disposal is inevitable. To generate electricity by the palm oil industries, palm fibres, shells, and empty fruits were burnt in-house at 800 ℃ to heat the boiler and generate electricity (Alnahhal et al., 2021), thus, ash is produced known as Palm Oil Fuel Ash POFA (Filippo et al., 2019)). According to the United States Department of Agriculture in 2017, the global palm oil production is around 64.5 tonnes. Furthermore, only limited amount of POFA is used currently, whereas most of it is abandon in landfill and waterways. Accordingly, several environmental pollutions have been reported (Juenger et al., 2011). Usage of waste ash from palm oil industries such as palm oil fuel ash (POFA), fly ash (FA) and bottom ash (BA) has been projected to be the only way forward to save the environment from degradation (Provis, 2018). It is further revealed that the use of POFA can also improve the strength, surface resistance, and water permeability of concrete containing a high amount of recycled concrete aggregates used for interlock (Adesanya et al., 2021).

Rice, *Oryza glaberrima* or *Oryza sativa*, is normally grown in Nigeria. It is normally grown as an annual plant, although in tropical areas it can survive as a perennial and can produce crop for many years. It is the predominant dietary energy source for 8 countries in Africa, 17 countries in Asia and Pacific and 9 countries in North and South America It is a staple food of over half the world's population. Rice provides 20 % of the world's dietary energy supply, while wheat supplies 19 % and maize 5% (Kimpa et al., 2024). No other crop residue generates such quantity of ash when burnt like rice husks (Biernacki et al., 2017). Furthermore, the use of rice husk ash (RHA) as a supplementary material is of interest to many developing countries. The global rice husk ash production is estimated at 21 million tons per year (Provis et al., 2018), Nigeria alone produced total amount of 121 thousand tons of rice husk annually (Adesanya et al., 2021).

In 2022, the annual paddy output in Nigeria was around 5.4 million metric tonnes (Sasu, 2022), out of this amount, rice husk accounted for 22 %, which is approximately 1.2 million metric tonnes per annum. Rice husk is considered as a form of waste from rice milling processes and are often left to rot slowly in the field or burnt in the open area. Although a small portion of the rice husk is used as a component in animal beddings, the fact that it is a cheap and abundant source of silica remains largely unrealized. To some extent, rice husk has been utilized as fuel for cooking and parboiling of paddy rice in some developing country, but it is neither fully nor efficiently utilized. Such underutilization clearly shows the wastage and loss of resources which in reality could generate revenue through extraction of silica via methods such as combustion.

Rich husk ash is a general term describing all forms of the ash produced from burning rice husk. In practice, the form of ash obtained varies considerably according to the burning temperature. The silica in the ash undergoes structural transformation depending on the condition i.e time, temperature etc. of combustion. At 550 - 800 °C amorphous ash is formed and at temperature greater than this crystalline ash is formed (Rajeshkumar et al., 2016). Rice husk ash (RHA) has many applications due to its properties. It is an excellent insulator because of its low thermal conductivity and has applications in steel foundries and refractory bricks. It is an active pozzolan and has several applications in the cement and concrete industries. In its purified form it can be used in silicon chip manufacture (Celestine et al., 2013).

Wall and floor tile, has been characterized as one of the high performance ceramic material produced from triaxial composition of 50 % clay, 25 % feldspar and 25 % quartz, this is done to achieve desired formulation together with other components (Noni et al., 2008). One of the outstanding scientific features of wall and floor tiles that attracted industries to use it for different applications are its surface hardness, impermeability and high mechanical resistance (Lee et al., 2008). Tile is characterized to be partially transparent ceramic material and white non porous material. Each component of porcelain wall and floor tile plays a specific role in making the final product, for the clay fraction, it helps in forming by providing plasticity and dry mechanical strength during processing and develops mullite and crystalline phase during firing (Noni et al., 2008). At low temperature, feldspars develop a glassy phase, assisting the sintering process, and enabling virtually zero (<0.5%) open porosity and a low level of closed porosity (<10%) to be achieved. Quartz is responsible of providing thermal and dimensional stability due to its high melting point (Lee et al., 2008).

According to Araújo, polynomial regression analysis is a statistical modelling for estimating relationship between a dependent variable y and two or more independent variables in which xi = xi, where by i = 1,2,…,m, and the function is expressed as follows (Araujo, 2018):

$$y = f(x) = a_0 + a_1 x_1 + \cdots + a_m x_m \quad (1)$$

V. Statement of the Problem

Due to high demand of flexibility in production of Wall and floor tile ranging from customizing, prototyping to several series of art, researchers reported a difficulty in producing an intricate Wall and floor tile shapes (Lima et al., 2018). Researchers suggest the use of palm oil fuel ash (POFA) and rice husk ash (RHA) to enable solve the pressing challenge of shape modification. The researchers further revealed that, incorporation of these ashes enable innovative shaping with the possibility of modifying the traditional Wall and floor tile production.

To mitigate the waste disposed from oil palm industries, some research have been conducted on how to use POFA in industries such as construction and ceramic industry (as quartz replacement). It is revealed that POFA is a good pozzolanic and therefore can be used as an additive in the production of cement and interlock for medium particle size and small particle size to a certain level up to 20 % and 30 % (Jamo et al., 2014).

Rice milling generates a by product known as rice husk. During milling of paddy about 78 % of weight is received as rice, broken rice and bran. The rest of 22 % of the weight of paddy is received as rice husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. Rice husk contains about 75 % organic volatile matter and the balance of 25 % of the weight is converted into ash during the firing process and is known as rice husk ash (RHA). RHA in turn contains around 85 % - 90 % amorphous silica. So for every 1000 kg of paddy milled, about 220 kg (22 %) of husk is produced, and when this husk is burnt in the boilers, about 55 kg (25 %) of RHA is generated (Nagrale et al 2012).

Portland cement (PC), which is the most important part of interlock is the most widely used cementitious material in the construction and building industry (Scrivener et al., 2018). However, their continuous production and usage have resulted in adverse environmental impacts. For instance, the global production of PC was estimated to be 4.1 billion tons in 2017, which account for about 5-8% of global anthropogenic CO_2 emissions (Alnahhal et al., 2021). This amount is expected to rise due to a gradual increase in population and infrastructural development in developed and developing countries (Juenger et al., 2011). Besides the environmental impacts of PC, other limitations such as significant consumption of energy and excessive use of non-renewable, naturally occurring raw materials have raised serious concerns about its sustainability (Biernacki et al., 2017). Therefore, there is an increasing demand for an alternative binder with lower carbon emissions that could at least partly or wholly replace PC such as Rice Husk Ash (RHA) and Palm Oil Fuel Ash (POFA).

Production of Wall and floor tile is faced with economic and technical difficulties as result of high demand for high purity in the raw materials and need for enriched glassy phase required to produce less porous and low water absorbing tile, this forced researchers and industries to investigate alternative raw materials such as POFA and RHA (Ediz et al., 2009). Several researchers have reported the use of wastes ash like RHA and POFA to enhance mechanical and physical properties of Wall and floor tile (Dana et al., 2004).

VI. <u>Objectives of the Research</u>

The objectives are to:

i. To optimize the methods of RHA and POFA preparation/modification to be used as quartz replacement for the production of Wall, floor and interlock tile.
ii. To investigate the effect of substitution of quartz with RHA and POFA on physico-mechanical properties of Wall, floor and interlock tile.
iii. To develop a model that optimizes physical and mechanical properties of wall, floor and interlock tile production.

VII. Research Questions

i. How to optimize the methods of RHA and POFA preparation/modification to be used as quartz replacement for the production of Wall, floor and interlock tile.
ii. What are the effect of substitution of quartz with RHA and POFA on physico-mechanical properties of Wall, floor and interlock tile.
iii. How to develop a model that optimizes physical and mechanical properties of wall, floor and interlock tile production.

VIII. Literature Review

Due to the amount of biomass from palm oil plantation and milling activities, POFA is available in large quantities at very low cost. In order to solve most of the environmental problems associated with POFA, several research have been carried out and find out that, utilization of POFA would be the best solution. To reduce the production cost of wall and floor tile, it is good to reuse the low cost industrial agricultural waste. Consequently, the large amount of palm oil fuel ash that is disposed in landfill can be reduced (Tangchirapat et al., 2009).
Research by Sata et al., (2012), shows that, palm oil fuel ash consists of a spherical particle with a median size of 183.0 µm, whereas the medium and small particles ground palm oil ash contains crushed shaped structure with a median of 15.9 µm and 7.4 µm respectively. POFA differs in color because of the heating condition and carbon content in it.
POFA, silica fume and rice husk ash (RHA) are waste product that are pozzolanic materials that incorporating such ashes in self-compacting concrete, interlock, wall,and floor tile is proven to enhances material and energy conservation. Use of these materials reduces heat hydration and increase durability performance, job site productivity, construction sustainability and its cost efficient. Furthermore, the waste are environmental friendly as their incorporation as cementitious supplementary materials in interlock and as replacement of quartz in wall and floor tile lead to saving resources and energy due to reducing greenhouse gas emission as a result of fuel

combustion in the furnace, limestone calcination, process of transportation and manufacturing related to production (Ranjbar et al., 2016).
According to Abdul and Warid (1999), incorporation of pozzolans such as POFA, either naturally occurring or artificially made into concrete/interlock and wall and floor tile has been in practice since the early civilization. Besides its economic advantages, the main reason for their use is that they can give useful modification or enhancements final product properties. Some researchers have studied the use of agricultural wastes as constituents in normal weight concrete and cement mortar, namely rice-husk ash, sawdust ash, and POFA. The study has revealed that the agricultural waste ashes could be used as pozzolanic materials due to high amount of silica in amorphous form and this is the major composition of quartz, hence can be use as quartz replacement in wall and floor tile (Kang et al.,2013).
POFA, which constitute mainly silica, it can be used as pozzolanic material, researchers proposed its usage as replacement of Portland cement in interlock. It is proven that, use of POFA as cement replacement reduce porosity that lead to the improvement in the durability of interlock (due to calcium hydroxide reduction in the cement matrix), enhanced resistance to chloride penetration and sulfate attack (Ranjbar et al., 2016).
POFA recently received attention in the ceramic industry due its chemical properties that are similar to quartz, research on effect of substitution of quartz with POFA indicated that, by replacing quartz with POFA at 15 wt.%, the compressive strength is reported to increase and it is attributed to the development of mullite along the liquid phase.
Over the years, ground granulated blast furnace slags (GGBFS) and fly ash (FA) are the most widely studied and utilized precursors for AAMs and are currently almost fully used as supplementary cementitious materials (SCMs) for cement and interlock production (Adediran et al., 2019). Therefore, other industrial residues such as rice husk ash (RHA) and palm oil fuel ash (POFA) with different chemical and mineralogical compositions are currently being investigated for their suitability as alternative SCMs. RHA is an agro-residue or byproduct generated from the milling of rice, which is often landfilled or underutilized, resulting in adverse environmental impacts and higher economic costs for the rice manufacturers (Jittin et a.,2020). The production of RHA has continued to increase due to the increased production of rice for consumption (Siddika et al., 2021). The global production of rice in 2020 was estimated at 499.31 million metric tons, and for every 1 kg of rice produced, approximately 0.28kg of rice husk is generated (De Sensale, 2003). Over the years, rice husk produced has found limited application and are mostly used as fuel in the rice mills to generate steam for the parboiling process and approximately 25 % of the weight of this rice husk is converted into rice husk ash (RHA) (Zhu et a., 2019). With the ever-growing population and increasing demand for rice as important staple food worldwide, the amount of RHA emanating from cogeneration plants is expected to increase significantly. In the future, the number of available landfill spaces will be limited, making the disposal and effective management of the RHA difficult. Reuse and recycling of RHA as secondary raw materials in cement and interlock production or as precursors for AAMs have proven to be a sustainable alternative to avert this significant problem. Therefore, studies on the utilization of RHA as

precursors and co-binders in concrete and interlocks production have increased significantly over the last decade (Jittin et a., 2020).
Roughly, it was estimated that the production of paddy in Nigeria stand at about 1.5 million metric tons, producing huge amount of rice husk from rice mills (Sasu, 2022). The Husk is usually burnt resulting in large amount of ash in and around the mills, causing major health problem and pollution. Using rice husk as the raw material, thousand metric tonnes of pure high grade silica can be produce to meet the high demand of various industries, especially ceramic and porcelain industries.
The amount of rice husk generated is enormous, necessitating their reuse in bioethanol production and as fuel for heat production in industries (Abbas & Ansumali, 2010). The use of rice husk instead of coal as fuel in industries could lower the carbon emissions associated with coal combustion and support environmental preservation, thus complying with the European Union directive on waste management (EU Directives, 2015). The combustion of rice husk when used as fuel in the boiler generates a by-product known as RHA, which accounts for about 20-25% of the weight of rice husk (Jittin et al., 2020).
Production of wall and floor tile porcelain have been the best product evolved from the ceramic industry, the product is a result of careful industrial research and sequence of preliminary work such as preparation of slip, mixing, drying of the slip and grinding of the raw material. Lack of controlled procedure lead to technological deficiency in the final product such as grooves, scratches, subsurface cracks and material detachment (Jittin et al., 2020). In the search for alternative cementitious materials and binder, alkali-activated materials (AAMs) have received wide attention (Provis, 2018). AAMs including those classified as geopolymers and inorganic polymers (IP) can be derived from a reaction between alkali activator (waste-based and non-waste based) and aluminosilicate precursors (such as palm oil fuel ash (POFA), rice husk ash (RHA) and fly ashes (Adesanya et al., 2021), The development of AAMs using such materials can provide numerous benefits such as reduced CO_2 emissions and can also exhibit superior or similar properties in comparison to PC based binders for interlock production (Lemougna et al., 2020).
Due to the availability of data and its increasing trend in recent time, there is need to model this data in order to have a meaningful information like prediction. To make an accurate prediction there is a need of using techniques such as regression analysis (Deshmukh and Gore, 2017). According to Olaniyi et al., (2011), regression analysis help scientist to determine how a dependent variable X (also known as criterion variable) change in a situation where an independent variable Y is varied or change, whereas other independent variables are kept constant.
Among the regression techniques available, linear regression is commonly used for data mining and future predictions of variables using a linear relationship the variable have with other variables (Kannan et al., 2010)
Regression analysis is a statistical modelling for estimation of relationship between dependent variable y and independent variables $x_1, x_2, \ldots, x_m$. The function is expressed as follows (Araujo, 2018):

$$y = f\,(x_1, x_2, \ldots, x_m) \qquad (1)$$

Whereas for linear regression analysis the dependent variable y has a free parameter ($a_0, a_1, \dots, a_m$) that are linear in nature and expressed as:

$$f\,(x_1, x_2, \dots, x_m) = a_0, a_1, \dots, a_m + \dots + a_m a_m \qquad (2)$$

IX. References

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X. Theoretical Framework

Rice is an essential food item consumed by approximately half of the world's population (Siddika et al ., 2021). They are grown in significant quantities in Nigeria, China, India, Indonesia, and other countries around the world. In many rice-producing countries of the world, rice husk is one of the most common waste or by-products generated in large quantities (De Senale, 2003). Rice husks are hard-protective layer that surrounds the paddy grain, which are separated from rice seed during the milling process (Siddika et al., 2021). They are lignocellulosic materials and it was estimated that during the milling process, about one ton of rice husk is produced from five tonnes of rice paddy and approximately 120 million tonnes of rice husk is produced annually (Zhu et al., 2019). Rice Husk Ash (RHA) is produced by open burning or controlled incineration of rice husk in the rice mill industry. RHA has many application due to its numerous properties, thus it can be used as quartz replacement for wall and floor tile production and as cement replacement in interlock.

POFA, silica fume, fly ash (FA) and rice husk ash (RHA) are waste product that are pozzolanic materials that incorporating such ashes in self-compacting concrete is proven to enhances material and energy conservation, these materials reduce heat hydration and increase durability performance, job site productivity, construction sustainability and its cost efficient (ASTM, 2005). Furthermore, the waste are environmental friendly as their incorporation as cementitious supplementary materials lead to saving resources and energy due to reducing greenhouse gas emission as a result of fuel combustion in the furnace, limestone calcination, process of transportation and manufacturing related to production of ordinary Portland cement (Rukzon et al., 2009).

This research aimed at using agricultural wastes (RHA and POFA) as replacement of quartz in the production of wall and floor tile. Furthermore, the waste ashes (RHA and POFA0 will be used a cement partial replacement in the production of interlock. Based on the previous research on these agricultural waste ashes, they can be used as cementicious material and due their silica rich nature as quartz replacement. Consequently, the circular economy nature of this research will reduce cost of wall, floor and interlock tile production and subsequently solve environmental pollution threatening the milling industries and the country at large. Similarly, a model that optimizes physical and mechanical properties of wall, floor tile and interlock production will be developed.

XI. Research Methodology

For the first phase of this experiment to determine the suitable treatment for optimum physico-mechanical properties, there are 16 number of trials for 1 molar, 2 molar and 3 molar treatments and heat treated, for this the total number of trial is 64, composition of RHA and POFA and sintering temperature will be varied while soaking time and mould pressure will be kept constant for the trials. The selection of different molarity of HCl acid treatment was done based on the literature report that HCl treatment enhance the production of silica, therefore different molarities were selected to find the optimum one. Similarly, the sintering temperature of wall and floor tile was reported in the literature to be between 1100 °C to 1350 °C, therefore ranges of 1100 °C to 1250 will be selected to find the optimum. Thus, the optimum composition of RHA and POFA as reported in the literature range from 15 wt.% to 30 wt.%, hence the selection was made to find the optimum. Figure 1 below shows the flowchart for RHA and POFA treatment.

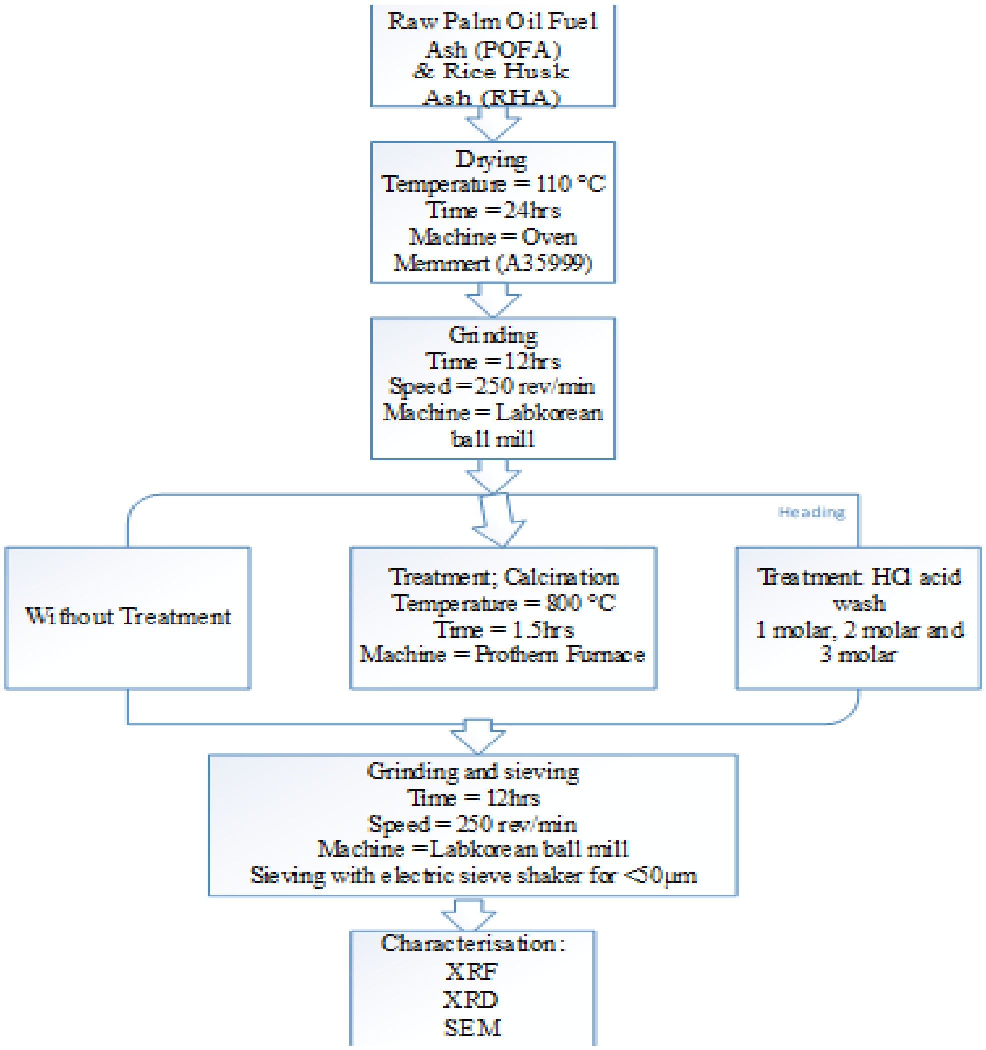

Figure 1. Flow chart for RHA and POFA preparation

Similarly, the second part of the research concentrate on the continuation of the first part, the best result obtained from the above treatment is used in wall, floor and interlock tile preparation. wall, floor and interlock tile preparation are produced with substitution of quartz with treated RHA and POFA at 0, 15, 20 and 25 weight percent to see the effect of treatment, sintering temperature and composition on the production of wall, floor and interlock tile.

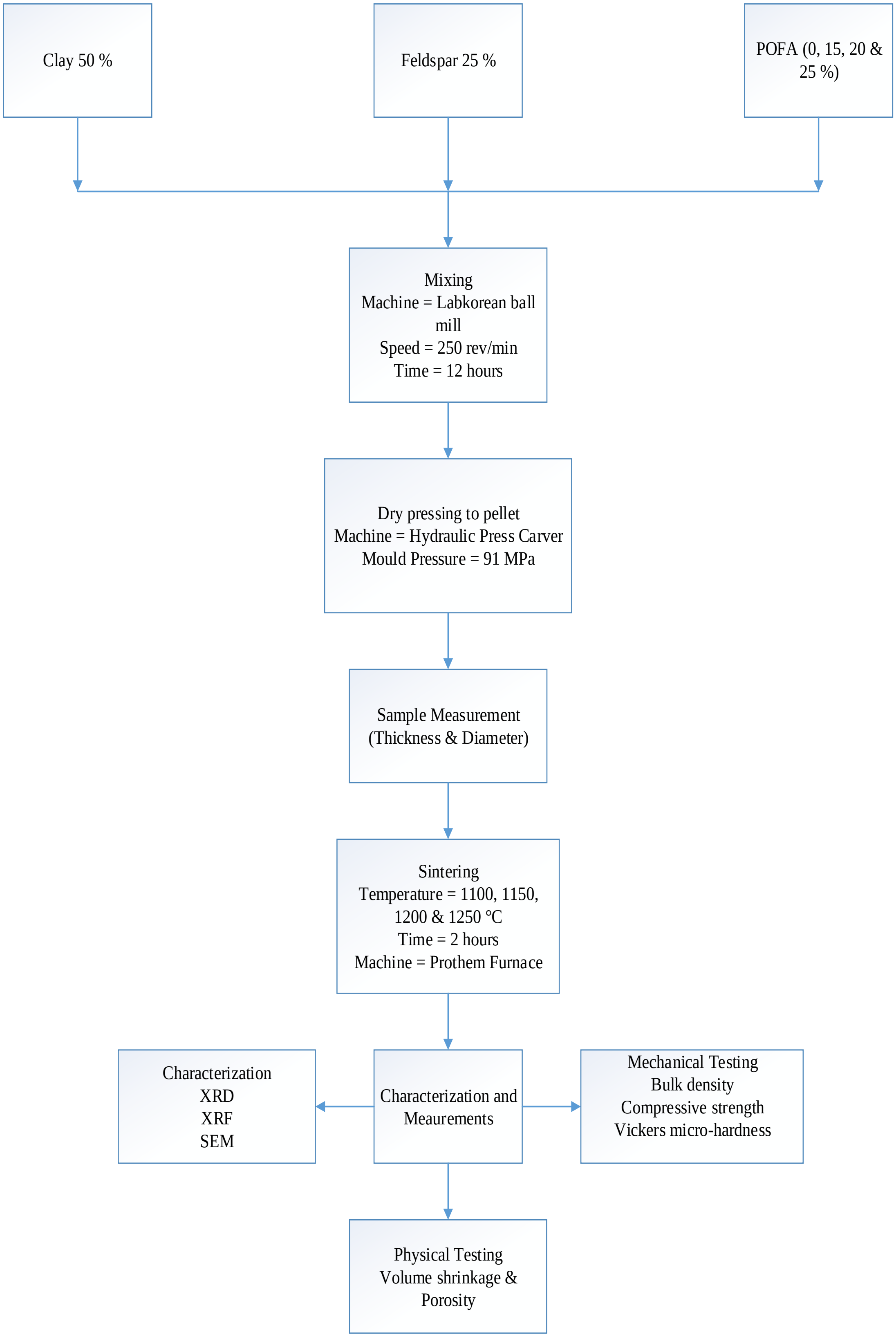

Figure 2. Flow Chart for Wall and floor tile Production

-The same procedure will be repeated for Rice Husk Ash (RHA). So the flowcharts are similar.

The third stage of the project concentrates on production of interlock tile. The following materials will be used in the preparation of the interlock tile specimens: fine aggregate (local natural sand) with maximum aggregate size of 4.75 mm; coarse aggregate (crushed granite) with maximum aggregate size of 6.5 mm; Portland Cement type I (normal portland cement); and superplasticizer. Rice Husk Ash (RHA) and Palm Oil Fuel Ash (POFA) will be used as additive and replacements for Portland cement at 0, 10, 15, 20 and 25 wt% respectively. The result will undergoes compressive strength and hardness tests to determine the effect of addition and partial replacements of these agricultural wastes ashes.

The fourth part of the research is development of Formulation using polynomial regression analysis. Polynomial regression analysis is a procedure to develop a statistical model that explains the effect of a single independent variable X on the dependent variable Y. After running the test to determine the order of polynomial, the one with powers of X and its square is the best model to develop an estimation/prediction model. Polynomial regression analysis as an advanced statistical approach used in different field of research to determine how two predictors variables relate to outcome variable. In this research polynomial regression analysis was adopted due to the fact that, R-squared (R^2) or coefficient of determination is almost equal to unity for polynomial regression analysis.

The Equation below shows polynomial regression analysis;

$$Y = \beta o + \beta 1xi + \beta 2xi2 + \beta 3xi3 + \ldots \beta ixi + \varepsilon$$

Where *Y* is the dependent variable

Xi is the independent variable *(i = 1,2…, k*)

βi is the model parameter (*i = 1,2…, k*)

ε is the random error of the model-

XII. Research Outputs and Outcomes

-	Outcome
Literature Review on Palm Oil Fuel Ash (POFA) and Rice Husk Ash (RHA) as replacement in production of Wall, Floor and Interlock Tile	To find the research gap on the use of agriculture wastes for environmental protection and industrial used to enhance and improved the technological properties of Wall, Floor and Interlock Tile
Sample Preparation	To obtain the best method for treating POFA and RHA for optimum silica production for proper replacement of wall, floor and interlock tile composition
Sample Characterization EDX, XRF, SEM, XRD, TGA, Particle Size analysis, Compressive Strength, Bulk Density, Vickers Microhardness,	Characterization is done on two stages. First. After sample preparation to ensure the type of sample used for proper replacement and Second. After production to ensure the physical and mechanical properties of the final product are consistent with ASTM standard.
Analysis of the Samples and development of the model	To ensure the result is in consistent with present trend in the literature review. To also obtained an improved and enhanced physic-mechanical properties of wall, floor and interlock tile. Statistical analysis software will be used to develop a prediction model for optimum technological properties of wall, floor and interlock tile production.
Dissemination	Preparation of the report for journal, conference and workshop presentation to ensure the acceptability of the work and for assessment of the result.
General Output of the Research	1. Quartz composition in the wall and floor tile will be replaced with agricultural waste POFA and RHA to produce a new material, which will be an improved version of the previous material. 2. POFA and RHA will be used as

	partial replacement of cement and additive in some composition to produce interlock tile. 3. Physico-Mechanical properties of new materials (wall, floor and interlock tile) produced in 1 and 2 will be determined and compared with ASTM Standard. 4. Development of a model that optimizes physical and mechanical properties of wall, floor tile and interlock production.
General Report writing	This will be done by 2 Msc and 1 PhD students.

XIII. Time Frame

	JAN 2025 TO DEC 2025						JAN 2026 TO DEC 2026					
	Jan-Feb	Mar-April	May - June	Jul-Aug	Sep - Oct	Nov - Dec	Jan-Feb	Mar-April	May - June	Jul-Aug	Sep - Oct	Nov - Dec
Literature Review												
Purchase of equipment and Chemicals												
Laboratory setup												
Sample preparation and treatment (RHA and POFA)												
Characterization of the samples using SEM, XRF, XRD, EDX												
Production of Wall, floor and interlock tile using RHA and POFA												
New product characterization XRF, SEM, XRD, TGA, Compressive Strength, Bulk												
Analysis of the Samples and development of the model												

Workshop and Conferences												
Dissemination of research												
Report Writing and Submission												

S/N	Description of Activity	Duration	Year	Quarter			
				1st	2nd	3rd	4th
1	Literature Review	24 Month	2025/2026	1st	2nd	3rd	
2	Materials purchase and Survey	6 Month	2025	1st	2nd		
3	Experimental design and materials characterization	6 Month	2025			3rd	4th
4	Material Characterizations	4 Month	2025/2026	1st			4th
5	Result and Discussion	7 Month	2025/2026	1st	2nd	3rd	
6	Conference and Journals	6 Month	2025/2026		2nd	3rd	
7	Report Writing	2 Month	2026				4th
8	Submission	1 Month	2026				4th

XIV. Key Performance Indicator

S/N	**Key Activity**	**Indicator**
1	Literature review on the use of agricultural waste ashes (Rice Husk Ash and Palm Oil Fuel Ash) as replacement of Quartz, Clay or Feldspar for production of wall, floor and interlock tile.	Finding the research gap and detailed understanding of the novelty of the research, improved understanding of the study area and finding proper methods for treatment of RHA and POFA for optimum and compatibility of the materials.
2	Preparation and treatment of RHA and POFA	This gives way for the next stage of the research. This stage in necessary to find the best treatment method for enhanced silica production.

3	Wall, floor and interlock tile production with RHA and POFA as partial and total replacements of existing compositions.	improved final product (Wall, floor and interlock tile) with enhanced technological properties, such as: Compressive strength, bulk density and vicker micro hardness.
4	Characterization of the new product.	XRD, SEM, XRD and TGA to confirm the physic-mechanical properties of the new product compared to ASTM standard.
5	Analysis of the Result	Comprehensive report on the Wall, floor and interlock tile with RHA and POFA as partial and total replacement for industrial and commercial use.
6	Writing final report	Research team including Msc and PhD students.

XV. Monitoring and Evaluation Mechanism

Monitoring

The monitoring procedures of the research project are as follows:

1. The principal researcher will intensively supervised all the project activities and sections to ensure compliance and due process.
2. Retirement of all the expenses will be done at the end of each major activity and must be verified of the principal researcher.

Evaluation Mechanism

The evaluation mechanisms to be adopted for proper achievement of the objectives are as follows:

1. Meeting of the research team will be organized regularly especially after achieving a major objective before going to another step to ensure the objectives of the research project are achieved.
2. The findings of the research project will be presented in workshops, seminars and conferences and journal publication for better scrutiny of the results and other inputs.

XVI. Dissemination Strategies

The dissemination of the findings of this research project are as follows:

1. Presentation of the research results in workshops, seminars and conferences.
2. Presentation of research finding in indexed journals locally and internationally.
3. Through presentations of the results in conferences and workshops, possible collaborations will be made on the ways to use our local content for industrial and commercial purpose.
4. Findings of this research (especially treatment of RHA and POFA for silica production) will provide an avenue for collaboration with industries that used silica in their production.

XVII. Brief Profile of the Research Team

1. Principal Researcher

Name: Dr. Sani Garba Durumin Iya
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2. Co-Researcher

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7. **Mentee**

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XVIII. Research Work to Date

1. **Sani Garba Durumin Iya**, Noh, M. Z., Ab Razak, S. N., & Kutty, N. A. A. (2017). Physical and Mechanical Properties of Porcelain Formed by Substituting Quartz with HCl Treated Palm Oil Fuel Ash. Journal of Science and Technology, 9(3).

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XIX. Previous Research Grants

1. Optimization and technological properties of porcelain Using Rice Husk Ash in triaxial composition. TETFund Institutional Based Research (₦1,827,094.24), January 2023.

2. The role of calcinated egg shell as heterogeneous catalyst in the production of biodiesel via trans-esterification of Jatropha oil. Sule Lamido University Research Grant (₦600,000.00), July 2024.
3. Health risk assessment of heavy metals contamination in soil, water, fish tissue and rice within Kafin Hausa region, Jigawa State. TETFund Institutional Based Research (₦1,930,000.00), January 2024.
4. Development of novel Rice Husk Ash biosorbent augmented with nanoparticles for effective wastewater treatment. The Academy of Science (TWAS), ($60,000), October 2024.

XX. Research Group (Role of Each Member)

Material Science and Agricultural Waste Management Research Group have been in existence for quite some time which consists of the Dr. Sani Garba Durumin Iya who is the Principal Researcher as the head of the research group, my area of specialization os porcelain tile. So I will be involved in all the procedures and steps of this research and I will coordinate the research to achieve the objectives. I have been an active researcher in this area and won some research grants in the area. Dr. Ibrahim Garba Shitu is the coordinator of the research team. We have secured at least two research grants, one through TETFund and the other one from the World Academy of Science

(TWAS), we are currently supervising five MSc. Students and a PhD student for the Development of novel Rice Husk Ash biosorbent augmented with nanoparticles for effective wastewater treatment. Other research members are:

Dr. Abdulkadir Shu'aibu Gidado, who is an associate professor of theoretical physics, he has so far published a number peer reviewed articles and an active researcher in his area of specialization. He will be involve in data analysis and development of the model.

Usman Idris Isma'il is an Assistant Lecturer with expertise in Material Science, he is the member of Material Science and Agricultural Waste Management Research Group. He is an active researcher and will be involved in the sample collection, preparation and treatment. He will also participate in the workshop and conference presentation and be part of laboratory activities of wall and floor tile production.

Maryam Lawan is a Lecturer I with Bayero University, she is currently undergoing her PhD at the University Malaya. She will be involved in characterization and data analysis especially that her research expertise is geophysics and hydrodynamics, she used and familiar with XRD, SEM and XRF in her research. She will be involved in article and conference paper writing.

Dr. Aisha Idris is currently a Senior Lecturer with Federal University Dutse. She have been actively participating in research and conferences. She is an expert in data analysis and used tools like XRF and SEM in her researches. Dr. Aisha Idris will be involved in laboratory works during preparation and treatment of the RHA and POFA. She will also be involved in report writing and workshop presentation and journal article writing.

Maryam Adamu Sunusi. She is a Senior Scientific Officer with National Biosafety Management Agency. She is currently undergoing her PhD in University Tun Hussein Onn Malaysia. Her area of expertise is renewable energy/Material Science, she is currently working on Palm Oil Fuel Ash in the ceramic production. She will be involved in sample characterization, especially POFA and RHA. She will also participate in international conference presentation and interpretation of results. She will actively participate in journal writing and final report writing.

XXI. Office and Laboratory Space

The research project will be conducted in Physics Laboratory III, FNAS extension and chemistry lab Sule Lamido University Kafin Hausa, Jigawa State. In the laboratories we have majority of the equipments needed for preparation and treatment of the samples.

Some of the facilities that were not available will be bought will the reaming characterization will be done at the neighboring universities of Bayero University, Umaru Musa Yar'adua University and Federal University of Technology Minna where we do most of our characterizations.

XXII. Equipments and Material Provided by the Institution

S/N	Equipment	Uses	Availability

1	Ball Mill Machine	For size reduction and homogeneous mixing of powder samples using high energy milling.	Physics Laboratory I, Department of Physics, Sule Lamido University Kafin Hausa.
2	Bulk Density Testing Kit	For density measurement of the sample	Physics Laboratory I, Department of Physics, Sule Lamido University Kafin Hausa.
3	Polishing Mashing	To polish the surface of material for XRD analysis	Physics Laboratory III, Department of Physics, Sule Lamido University Kafin Hausa.
4	Fume Cover	To protect self from acid and other hazardous chemicals	Chemistry Laboratory ,Sule Lamido University Kafin Hausa.
5	Magnetic Stirer	For homogeneous mixing and stirring of sample	Chemistry Laboratory ,Sule Lamido University Kafin Hausa.
6	Siever	For separation of mixed chemical solutions	Physics Laboratory III, Department of Physics, Sule Lamido University Kafin Hausa.
7	Conical Flask	Measurement and mixing of sample	Physics Laboratory III, Department of Physics, Sule Lamido University Kafin Hausa.
8	Weighing Balance	Determination of the mass of the sample	Physics Laboratory III, Department of Physics, Sule Lamido University Kafin Hausa.

XXIII. Equipments and Material Available In Nearby Institution

S/N	Equipment	Uses	Availability
1	Scanning Electron Microscopy (SEM)	For morphological study of the surface of the material.	Umaru Musa Yaradua University Katsina
2	X-ray Diffraction Analysis (XRD)	To determine the structure of the material To detect the mineralogical phase To study the crystal structure of the solid material.	Umaru Musa Yaradua University Katsina
3	X-ray Fluorescence Analysis (XRF)	To investigate the chemical composition of the material	Umaru Musa Yaradua University Katsina
4	Particle Size Analysis (PSA)	To measure the particle size of the material	Umaru Musa Yaradua University Katsina
5	Compressive Strength Testing Machine (UTM)	To determine the strength of the material.	Bayero University Kano
6	Hydraulic Press Carver	To mould the powder sample into pallets	To be purchase
7	Thermogravimetry Analyzer (TGA)	Uses temperature of the material to determine the physical properties of the material.	Federal University Minna

XXIV. Other Technical Support

Other technical support that may be needed will be requested from our laboratory staff or other experienced colleagues in the study area for smooth running of the research project.

XXV. Financial Aspect of the Research Project Implementation

DESCRIPTION OF ITEM	EXPECTED FROM			TOTAL
	TETFUND AND NRF	INSTITUTION	OTHER	
1.0 Personnel Costs/Allowances	**(N)**			**(N)**
1.1 Principal Researcher	1,448,950.99			
1.2 4 Co-researchers @ N600,000.00/yr	2,400,000.00			
1.3 2 Mentees @ 309,595.00/yr	619,190.00			
Sub Total (not >20% of budget)	4,468,140.99			4,468,140.99
2.0 Equipment (List & Specification)				
2.1 Hydraulic Press Carver, 3894 4PROBOO 10tons	5,050,.176.25			

2.2 Retsch Grinding Ball Zirconium Oxide 10mm Ø 05.368.0094	535,000.00			
Sub Total (not > 25% of budget)	5,585,176.25			5,585,176.25
3.0 Supplies/Consumables				
3.1 Rice Hush Ash and Palm Oil Fuel Ash	35,000.00			
3.2 Hydrochloric Acid (HCl)- 1L	84,670.00			
3.3 Hydrofluoric Acid (Hf) PN695068-25ML-1L PC	80,040.00			
3.4 Methanol @9,000.00 (QTY=5)		5,000.00		
3.5 Ethanol @9,000.00 (QTY=5)		5,000.00		
3.6 Feldspar and Clay powder	20,757.82			
3.7 Quartz Sand 400 Mesh 500g	206,332.00			
3.8 Aluminium Oxide, Al2O3 Sigma-Aldrich (QTY=2) 50g	224,266.00			
3.9 Silicon Oxide (SiO2) 25- 50g	262,275.48			
3.10 Phosphorus Pent oxide high purity industrial grade @109,792 (QTY=2)	219,584.00			
3.11 Petri dish (L × W 55 mm × 16 mm){BR452015-1620EA} Sigma-Aldrich @ N 168,175.00 (QTY=1)	168,175.00			
3.12 Magnesium oxide (199443 Sigma-Aldrich) Molecular Weight: 101.96 @ N102,489.90	102,489.90			
3.13 Iron Oxide (Fe2O3) high purity industrial grade @197,148.10	197,148.10			
3.14 Calcium Oxide high purity industrial grade	197,148.10			
3.15 High-quality Laboratory Natural Agate Mortar and Pestle (QTY = 1)	238,624.00			
3.16 Alumina Crucible (Al2O3), otoolworld 99.3% @ 142,000.00 QTY = 5)	710,000.00			
3.17 Minitab Statistical/modeling Analysis software @ 2user access	861,987.89			
3.18 Hydraulic compact mould	189,420.26			
3.19 Filter Papers 11cm (Pack of 40)		5,000.00		

3.20 Glass beaker 250ml (QTY=25)		3,000.00		
3.21 Glass beaker 500ml (QTY=25)		5,000.00		
3.22 Glass conical flask 250ml (QTY=25)		10,000.00		
3.23 Measuring cylinder glass 500ml (QTY=10)		50,000.00		
3.24 Measuring cylinder glass 1000ml		6,000.00		
3.25 Buehler CarbiMet Silicon Carbide Paper		60,000.00		
3.26 Diamond polishing paper		10,000.00		
Sub Total	3,797,919.55	159,000.00		3,956,919.55
4.0 Data Collection & Analysis				
4.1 Scanning Electron Microscopy (SEM)/Energy Dispersive Spectroscopy (EDS) @ N 20,000.00 x 40 samples	800,000.00			
4.2 X-Ray Diffraction (XRD) @20,000.00 x 40 samples	800,000.00			
4.3 X-Ray Fluorescence Analysis (XRF) @20,000.00 x 40 samples	800,000.00			
4.4 Particle size Analysis @12,500.00 x 40 samples	312,500.00			
4.5 Thermogravimetric Analyses (TGA) @ 25,800.00 x 40 samples	1,032,000.00			
4.6. Compressive Strength Testing (UTM) @ 16,000.00 x 40 samples	640,000.00			
4.7 Vickers Microhardness @ 16,000.00 x 40 samples	640,000.00			
4.8. X-ray photoelectron spectroscopy (XPS) @ 80,000.00 x 5 samples	400,000.00			
4.9 CIP @ 80,000.00 x 5 samples	160,676.00			
4.10. Assistant Technical staff		60,000.00		
4.11. Research Informants		40,000.00		
4.12 Printer		97,689.21		
Sub Total	5,585,176.25	197,689.21		5,782,865.46

5.0 Travels				
5.1 Local travels for sample collection and characterization	1,117,035.25			
Sub Total (not > 5% of budget)	1,117,035.25			1,117,035.25
6.0 Dissemination				
6.1 Publication in Journal	190,000.00			
6.2 Conferences/Workshops	357,880.75			
6.3 Feeding	100,000.00			
6.4 Hotel accommodation		50,000.00		
Sub Total (not > 3% of budget)	647,880.75	50,000.00		697,880.75
Sub Total of All Direct Costs		406,689.21		
7.0 Indirect Costs (5% of TETFUND Component to Institution)	1,139,375.95			1,139,375.95
GRAND TOTAL	22,340,705.00	406,689.21		22,747,394.20

XXVI. Budget Justification

Budget Grand Total = 22,340,705.00

The proposed budget for the implementation of this proposal is as follows::

Item	Cost (₦)	(%)
Personnel Cost	4,468,141.00	20
Equipment	5,585,176.25	25
Supplies/Consumables	3,797,919.55	17
Characterization & Data Analysis	5,585,176.25	25
Travels	1,117,035.25	5
Dissemination	647,880.75	3
Indirect Cost to Institution	1,137,375.95	5
TOTAL	**22,340,705.00**	**100**

Personnel Costs/Allowances: The sum of ₦ 4,468,140.99 representing 20 % of the total budget is estimated for this component

1. The Principal Investigator will receive the sum of ₦ 1,448,950.99 per annum to oversee day-to-day planning and execution of the project and ensure members' supervision and coordination of the project and with partners and other experts.

2. The four co-researchers will receive the sum of ₦ 600,000.00 each per annum for handling and keeping the components of the project as clearly specified in this proposal and as may be assigned to them by the PI.

3. The two mentees will receive N 309,595.00 each per annum for providing technical assistance for the project, includes laboratory works and other minor maintenance and repair of the equipment.

Equipment: The sum of ₦ 5,585,176.25 representing 25 % of the total budget is allocated for this component

Most of the equipment required for this research are not available either within or outside of our University. The cost provided includes the cost of supply, installation of the equipment and training of technicians and research assistant who will use the equipment. Other equipment that will be used for this project are resident in the study location (Physics Laboratory III, FNAS new extension, Sule Lamido University Kafin Hausa) as shown in the Table:

Table 2: List of Equipment available in the institution

S/N	**Equipment**	**Uses**	**Availability**
1	Ball Mill Machine	For size reduction and homogeneous mixing of powder samples using high energy milling.	Physics Laboratory I, Department of Physics, Sule Lamido University Kafin Hausa.
2	Bulk Density Testing Kit	For density measurement of the sample	Physics Laboratory I, Department of Physics, Sule Lamido University Kafin Hausa.
3	Polishing Mashing	To polish the surface of material for XRD analysis	Physics Laboratory III, Department of Physics, Sule Lamido University Kafin Hausa.
4	Fume Cover	To protect self from acid and other hazardous chemicals	Chemistry Laboratory ,Sule Lamido University Kafin Hausa.
5	Magnetic Stirer	For homogeneous mixing and stirring of sample	Chemistry Laboratory ,Sule Lamido

			University Kafin Hausa.
6	Siever	For separation of mixed chemical solutions	Physics Laboratory III, Department of Physics, Sule Lamido University Kafin Hausa.
7	Conical Flask	Measurement and mixing of sample	Physics Laboratory III, Department of Physics, Sule Lamido University Kafin Hausa.
8	Weighing Balance	Determination of the mass of the sample	Physics Laboratory III, Department of Physics, Sule Lamido University Kafin Hausa.

Supplies/Consumables: The sum of ₦ 3,797,919.85 representing 17 % of the total budget is estimated for this component

The costs allocated to the purchase of each of the chemicals are guided by the current market prices which are expected not to fluctuate before the commencement of the project. All the chemical listed are analytical grade and very important to the success of this project.

Data Collection & Analysis: The sum of ₦ 5,585,176.25 representing 25 % of the total budget is allocated for this component

Some other equipment for details characterisation (SEM/EDS, XRF, XRD, TGA, VHD & CS) that are not available in the university will be sourced within and outside the country. Data collection parameters from the sample characterisation are clearly highlighted in the budget table.

Travels: The sum of ₦ 1,117,035.25 representing 5 % of the total budget is estimated for this component. Local travel is expected to be undertaken during the period of project execution. The local trips are expected to be made for conferences, stakeholders meetings, exhibitions etc.

Dissemination: The sum of ₦ 647,880.75 representing 3 % of the total budget is estimated for this component.

1. Research results will be published in reputable local and international journals.

2. Presentation of the research findings in local and international conferences and participation in exhibition by the team members. This will afford the team the opportunity to interact with stakeholders and expert in this area of study.

3. Interactive workshop will be organized for stakeholders in the area of Porcelain wall, floor and interlock tile and agricultural/environmental waste management This will aid the development of a platform for feedback from experts and other stakeholders and organization of stakeholder forum and participation in products exhibition for prospective investors.

4. Seminars will be organized for the purpose of creating awareness on the activity of the research.

Indirect cost: The sum of ₦ 1,139,375.95 representing 5% of the total budget is estimated for this component. Sule Lamido University Kafin Hausa, Jigawa State will receive 5% of the total budget for hosting and monitoring of the project.

1. Directorate of Research Infrastructure and Development, Sule Lamido University Kafin Hausa, Jigawa State is statutorily saddle with the responsibility of monitoring research fund to the University. This research will be monitored using three key performance indicators: (1) quality and timeliness of the research findings, (2) capacity building outcomes, and (3) potential for research findings to have impact on environment and socioeconomic of the country. Each indicator has their milestones and performance expectations, which will be closely monitored by the directorate of research.

2. The fund for this research will be in a dedicated account that will be created by the University Bursary and will be accessed at the beginning of every major activities of the project, next disbursement will be released to the researchers after proper retirement and approval of the previous disbursement.

3. The procurement unit of the University will monitor all the procurement and financial information related to the procurement implementation.

Auditing unit of the University will also provide check and balance services for financial management of the fund. The auditing procedure requires the researcher to present purchased items to the store officer, after which the auditing unit will certify that the items supplied meet the specifications stated in the proposal and finally recommend payments of the suppliers

XXVII. Project Impact

1. This is going to be the first work within the study area to use an agricultural waste to produce wall, floor and interlock tile.

2. A model that optimizes physical and mechanical properties of wall, floor tile and interlock production will be provided for the purpose of environmental hygiene, cost reduction as means of circular economy for the country.
3. Local interlock tile producers will be furnished with a new and improved method and model for optimum production with agricultural waste material.

XXVIII. Research Team (Name/Rank/Highest Qualification/Area of specialization)

S/N	Name	Rank	Organization	Highest Qualification	Area of Specialization	Roles in this project
1	Sani Garba Durumin Iya	Senior Lecturer	Sule Lamido University	Ph.D.	Material Science	Principal Investigator
2	Ibrahim Garba Shitu	Lecturer 1	Sule Lamido University	Ph.D	Material Science	Co-researcher
3	Abdulkadir S. Gidado	Reader	Bayero University Kano	Ph.D.	Theoretical Physics	Co-researcher
4	Usman Idris Ismail	Graduate Assistant	Sule Lamido University	M.Sc.	Material Science	Mentee
5	Maryam Lawan	Lecturer I	Bayero University Kano	M. Sc.	Geophysics and Hydrodynamics	Co-researcher
6	Aisha Idris	Lecturer I	Federal University Dutse	Ph.D.	Applied Biology	Co-researcher
7	Maryam Adamu Sunusi	Senior Scientific Officer	National biosafety management agency	M. Sc.	Renewable/ Material Science Energy	Mentee