

# **INTEGRATING RICE HUSK UTILIZATION INTO THE DESIGN OF RICE MILLING FACTORY IN DASS LOCAL GOVERNMENT BAUCHI STATE: A SUSTAINABLE WASTE MANAGEMENT APPROACH**

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## ***Abstract***

*This study investigates the integration of rice husk utilization and sustainable energy systems into the architectural and industrial design of a modern rice milling facility. Rice milling plays a vital role in food production; however, it generates significant solid waste, primarily in the form of rice husk, which constitutes approximately 20% of paddy weight. Conventional disposal practices, such as open-air burning and indiscriminate dumping, contribute to environmental degradation and public health risks. This research addresses these challenges by proposing an innovative design strategy that incorporates rice husk waste into the functional and spatial framework of a rice milling factory.*

*The study adopts a circular economy approach, positioning the facility as an integrated hub for both primary rice processing and secondary by-product valorization. A multi-stage milling system is proposed, emphasizing vertical gravity flow to enhance energy efficiency and improve head rice yield. The research is guided by three objectives: to assess the quantity of rice husk generated in the study area, examine existing disposal practices, and develop an architectural model that facilitates waste integration.*

*A qualitative methodology was employed, including an extensive literature review and case study analysis of comparable industrial facilities. Findings reveal a significant gap in current practices, where secondary production processes are rarely integrated within milling operations. In response, the proposed design incorporates dedicated systems for rice husk storage and processing into value-added products such as ceiling and particle boards. This study contributes to sustainable industrial development by presenting a resource-efficient architectural framework tailored to rice production in Dass Local Government Area, Bauchi State.*

## **1.0 INTRODUCTION**

### **1.1 Background of the Study**

Rice is a staple food consumed by more than half of the global population, making it one of the most important agricultural commodities worldwide (Mohidem et al., 2022). Beyond its role in food security, rice production serves as a major source of employment and income, particularly in developing countries. According to Sadiq et al. (2022), rice production and processing activities provide livelihoods for a significant proportion of rural populations. In rice-producing

regions, over 80% of inhabitants are engaged in various stages of the value chain, including cultivation, processing, distribution, and marketing (Izuogu et al., 2022). In Nigeria specifically, the rice milling industry holds substantial potential for employment generation, economic growth, and the enhancement of national food security.

Harvested paddy rice undergoes a series of mechanical processing stages before it becomes suitable for consumption. Paddy grains are naturally enclosed in a hard, protective husk that must be removed through milling. This process is critical not only for improving the edibility of rice but also for maintaining quality and market value (Yanter et al., 2021). The transformation of paddy into polished white rice involves multiple stages, including pre-cleaning, parboiling, drying, dehusking, whitening, and polishing. These processes must be carefully managed to ensure high-quality output (International Rice Research Institute [IRRI], 2025).

Despite its economic importance, rice milling generates substantial quantities of agricultural waste, particularly rice husk, which constitutes approximately 20% of the total paddy weight. Globally, this results in millions of tons of biomass waste annually, much of which is either underutilized or improperly managed. El Safty (2025) observes that rice husk is often disposed of through environmentally harmful practices such as open-field burning and indiscriminate dumping, contributing to air pollution and environmental degradation.

Recent studies, however, emphasize the potential of rice husk as a valuable resource within sustainable production systems. Chakranarayan et al. (2024) argue that integrating value-added processes and cleaner production technologies can transform rice milling into a more sustainable and economically viable enterprise. Through the utilization of rice husk and other by-products, milling facilities can generate additional revenue streams while significantly reducing their environmental impact.

In this context, the development of a modern rice milling factory that integrates rice husk utilization into its design becomes essential. Such a facility can serve as a catalyst for industrial transformation in Bauchi State and its surrounding regions. By incorporating waste-to-resource strategies, particularly the conversion of rice husk into value-added materials, the proposed approach supports sustainable industrial development while enhancing efficiency, environmental performance, and economic viability within the rice production sector.

## **2.0 Introduction**

This chapter reviews relevant literature on rice husk utilization, circular economy, biomass waste management, and sustainable industrial architecture in relation to the integration of rice husk utilization into the design of rice milling factories. The review critically examines prior studies, identifies key themes, and highlights existing gaps that justify the present research.

### **2.1 Rice milling**

Rice milling is a fundamental post-harvest processing step that transforms harvested paddy (*Oryza sativa*) into edible and marketable rice. The primary objective of milling is to remove the outer husk and bran layers to produce polished white rice that meets quality standards for consumer

consumption. Milling not only increases the nutritional and economic value of rice but also ensures its storage stability and marketability.

In a typical rice mill, various operations are undertaken, including pre-cleaning, de-husking, de-branding, whitening, and polishing. De-husking removes the hard-outer shell of the paddy, while de-branding and polishing improve the appearance, texture, and edibility of rice (Mihretu, 2025). In an ideal milling process this will result in the following fractions: 20% husk, 8-12% bran depending on the milling degree and 68-72% milled rice or white rice depending on the variety.

## **2.2 Milling Technologies and Processes**

Modern rice milling systems can range from simple single-pass units to multi-stage processes involving advanced machinery. Mills designed for commercial use generally incorporate automated and integrated workflows to enhance efficiency and throughput. These designs often include rubber roller de-huskers, friction polishers, graders, and electronic sorting systems to enhance head-rice yield and reduce breakage Industry overview, (Nextech Agrisolutions, 2026)

## **2.3 Rice Milling Options**

Four basic options have been identified and highlighted and explained below:

1. Hand Milling
2. One step milling process
3. Two-step process and
4. Multistage process

*Source: International Rice Research Institute*

### **2.3.1 Equipment Use for Rice processing.** This include:

Pre-Cleaning Equipment, De-Stoner, De-husker Equipment, Under Runner Disc Sheller, Paddy Separator, Gravity Separator, Friction Polisher, Steel Polisher-Horizontal Friction (Engelberg Type), Abrasive Polisher, Polishing- Conical Stone, Polisher-Horizontal Abrasive, Oscillating Screen Separator, Length Grader, Separating Bins, Mist Polisher, Color Sorter, Bagging Station, Rice Husk Storage Tank

## **2.4 Rice Mill Factory**

A rice mill factory is defined as an industrial facility where harvested paddy rice undergoes a series of mechanical transformations—including cleaning, de-hulling, milling, polishing, grading, and packaging—to produce edible rice (Kumar & Singh, 2025). Beyond simple processing, these facilities are essential pillars of agricultural economies, driving food security and value addition by transforming a raw byproduct into a high-value commodity (Adewumi et al., 2024; GRRI, 2023)

## 2.5 Industrial Architecture

Industrial Architecture has evolved significantly over the year, with a growing focus on sustainable energy efficiency, and innovative design (S3DA Design. 2026). It is regarded as a kind of independent building type that stems from the second half of the 19<sup>th</sup> century. The idea that industrial architecture became a distinct "building type" in the 19th century is a foundational concept in the field, while the shift toward "sustainability" is the contemporary layer of that evolution Bradley, (2023). Its main task is to provide good working conditions for the production process and the workers in it (Nigerian Factory Act, 1987). The design of industrial buildings has shifted from a focus on functionality and efficiency to a more holistic approach that incorporates sustainability, flexibility, and aesthetics MDPI (2026).

## 2.6 Rice Husk Generation and Utilization

Rice husk is a major by-product of rice milling, accounting for approximately 20% of the total paddy weight (Singh et al., 2021). With global rice production generating millions of tons of husk annually, its management has become a significant environmental concern, particularly in developing countries where disposal methods such as open burning and dumping are prevalent (Mishra & Mohanty, 2023).

Recent studies have demonstrated that rice husk is a valuable lignocellulosic biomass resource with diverse applications. Thermochemical conversion technologies such as pyrolysis and gasification enable the production of biochar, bio-oil, and biogas, contributing to renewable energy generation and reduction of greenhouse gas emissions (Chen et al., 2025). In addition, rice husk ash (RHA), a by-product of controlled combustion, has been widely used as a supplementary cementitious material in concrete, improving strength and durability while reducing carbon emissions (Li et al., 2025).

Furthermore, rice husk has been explored for advanced applications, including the production of silica nanoparticles, bio-composites, and materials for additive manufacturing (Rahman et al., 2025; Zhang et al., 2023). These developments highlight its potential as a sustainable industrial resource.

Despite these advancements, most studies focus on **single-use applications** of rice husk and are largely confined to laboratory or pilot-scale experiments. There is limited emphasis on integrating these utilization pathways into the operational systems of rice mills.

## 2.7 Circular Economy and Rice Husk Valorization

The circular economy (CE) framework promotes resource efficiency through waste minimization and reuse. Rice husk has been widely identified as a suitable material for CE systems due to its abundance and versatility (Ghosh et al., 2024).

Studies show that converting rice husk into energy and value-added products contributes to environmental sustainability and economic benefits by creating new value chains (Singh et al.,

2021). Additionally, industrial symbiosis models propose linking rice mills with other industries such as construction and energy sectors to optimize resource use (Ghosh et al., 2024).

While CE principles are well established, their application in rice milling is often **conceptual and technology-driven**, with minimal focus on spatial and architectural integration.

## 2.8 Biomass Waste Management in Rice Milling

Effective biomass waste management is critical for reducing environmental impacts associated with rice husk disposal. Improper practices such as open burning contribute to air pollution and greenhouse gas emissions (Oladejo et al., 2024).

Modern waste management strategies emphasize converting biomass into useful products through technologies such as pyrolysis and hydrothermal carbonization (Chen et al., 2025). These approaches align with sustainable development goals by reducing waste and promoting renewable energy use.

Existing research primarily focuses on **conversion technologies and efficiency**, neglecting the spatial and logistical aspects of waste management within industrial settings.

## 2.9 Sustainable Industrial Architecture

Sustainable industrial architecture aims to optimize energy use, material efficiency, and environmental performance. Recent studies highlight the use of biomass-based materials, including rice husk derivatives, in sustainable construction (Zhang et al., 2023).

However, the integration of industrial processes and architectural design remains limited. Most approaches focus on energy efficiency rather than material flow and waste utilization.

Architectural studies often operate independently of industrial systems, resulting in a disconnect between building design and production processes.

## 2.10 Synthesis of Research Gaps

The literature reveals the following key gaps:

- Fragmentation between rice husk utilization, circular economy, and architectural design
- Lack of integration of waste utilization systems into rice milling facilities
- Limited consideration of spatial and functional design in biomass management
- Insufficient context-specific studies for developing regions such as Bauchi State

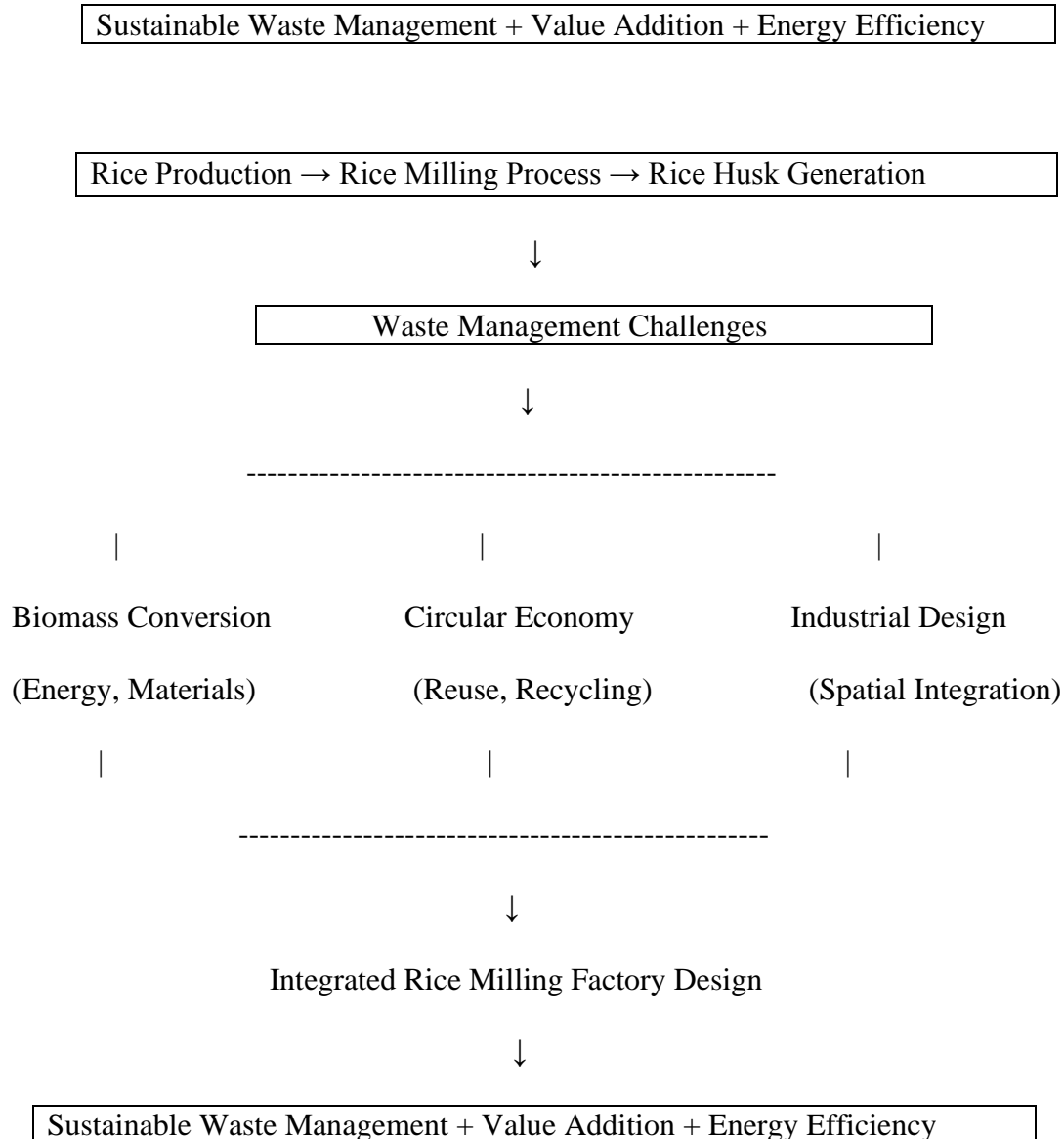
## 2.11 Conceptual Framework

The conceptual framework illustrates the relationship between rice milling operations and rice husk generation, which creates waste management challenges. These challenges are addressed through three interconnected components:

1. **Biomass Conversion** – transforming rice husk into energy and materials
2. **Circular Economy Principles** – promoting reuse and resource efficiency
3. **Industrial Architectural Design** – integrating these systems into spatial and functional layouts

The interaction of these components results in an **integrated rice milling factory design**, which supports sustainable waste management, energy efficiency, and value addition.

### 2.11.1 Conceptual Framework Diagram (Textual Representation)



### 2.12 Implication for the Study

This study builds on existing literature by proposing a **design-oriented approach** that integrates rice husk utilization into the architectural framework of a rice milling facility. It addresses

identified gaps by combining principles of circular economy, biomass waste management, and sustainable industrial design within the context of Dass Local Government Area, Bauchi State.

## **2.13 Research Gap**

A critical synthesis of the reviewed literature reveals that, although substantial progress has been made in the areas of rice husk utilization, circular economy, biomass waste management, and sustainable industrial architecture, these domains largely remain fragmented and insufficiently integrated. Existing studies extensively explore the conversion of rice husk into energy, construction materials, and high-value industrial products, demonstrating its significant potential as a renewable resource (Chen et al., 2025; Li et al., 2025; Rahman et al., 2025). Similarly, the circular economy framework provides a strong theoretical basis for waste valorization and resource efficiency, while biomass management studies offer technological solutions for reducing environmental impacts (Ghosh et al., 2024; Mishra & Mohanty, 2023).

However, these studies are predominantly technology-driven and process-oriented, with minimal attention given to the spatial, functional, and architectural implications of integrating such systems within industrial facilities. In particular, there is a notable absence of research that translates these concepts into practical design strategies for rice milling factories, where rice husk is generated in large quantities. The architectural dimension of industrial sustainability is often treated independently from production processes, resulting in a disconnect between waste generation, resource recovery, and building design.

Furthermore, most existing research is conducted at laboratory or pilot scales, with limited application to real-world industrial settings, especially in developing regions such as Nigeria. There is also a lack of context-specific studies that consider local production systems, environmental conditions, and socio-economic factors influencing waste management practices.

Therefore, the key gap lies in the absence of a comprehensive, design-based framework that integrates rice husk utilization into the architectural and operational design of rice milling facilities. This includes the need to address:

- The spatial organization of rice husk processing and storage
- The integration of biomass conversion technologies within factory layouts
- The application of circular economy principles at the building scale
- The development of context-responsive industrial design solutions

This study seeks to bridge this gap by proposing an integrated architectural model that combines rice milling operations with rice husk valorization systems, thereby advancing sustainable waste management and promoting resource-efficient industrial development

## **3.0 Research Methodology**

Ethical Considerations:

To ensure ethical considerations, the research was guided by the four ethical principles: truthfulness, thoroughness, objectivity and relevance. All information and data collected from the case studies conducted are a true reflection of the cases as at the time the data were collected.

### **3.1 Data Presentation:**

This data presentation and analysis provides an overview of the research data collection and analysis procedures and key findings. The result of this study will contribute to the growing body of knowledge on waste management, and innovative building materials, ultimately informing the design of more environmentally conscious and socially responsible rice milling factories. To get accurate result base on the objective of the research the whole wards in Dass local government were visited and various result were presented base on the following criteria;

- The number of rice mill in each ward
- The milling options
- The milling capacity of the mills
- The quantity of rice husk per each bag 100kg of paddy
- An average milling production per annual

### **3.2 Research Design**

In this research, qualitative design is adopted (case studies and interviews). however qualitative research is described by Denzin and Lincoln, (2011), as a methodological approach that focusses on gaining deeper understanding of social phenomena through the collection and analysis of non – Numerical data. It involves exploring and interpreting the meanings, experiences, and perspectives of individuals or groups in a particular context.

### **3.3 Population of the Study**

A population is a group of individuals, persons, objects, or items from which samples are taken for measurement. these derive information from people, animals or things from which the information can be gotten. According to Inuwa (2016), population can be a total number of subjects, or total area of interest to the researcher. Additionally - Yin (2014) describes population as a very large number of persons or objects or items which is not feasible to manage. For this research purpose a part of the population is to be selected. For the purpose of this research data is collected through four modern rice milling factory, three locally and one internationally and also data were collected from the milling process of rice in the ten wards in Dass local Government area. This would be done to provide wide consultation and sufficient information directly from the people to whom the research is targeted.

### **3.4 Sampling Technique**

Sampling is a process of selecting a representative fraction of the study population; it is a subset of the population that can be used to generalize on the population (Oso & Onen, 2011; Kothari, 2004). Because in most cases it is practically impossible to access the individuals, things, or events that make up the composition of a population or universe in an investigation, therefore, it is curtail by selecting the subset (individuals, things, or events) that constitute what is technically called a sample.

For the purpose of this research, non-probability sampling research would be used in which data would be collected through case studies. With regards to the later, case studies focus on samples and examine real life phenomenon (Yin, 2003).

### **3.5 Instrument for Data Collection**

The instruments used for data collection in any research is determined by the type of research design adopted Inuwa, (2014). The instrument use for data collection is case study which is use to collect the primary data, the selected cases visited, and is guided by the tour-guide working in the selected cases in order to obtain the needed information through pictures, observations and checklist. The methods chosen for data collections are:

- (a) Observation
- (b) Informal interview
- (c) Case studies

Other instruments used for data gathering in this research include: checklist, photographs, google maps, note taking and sketches.

Therefore, Observation checklist will is used in ticking appropriate rating spaces available on the existing buildings to be studied.

### **3.6 Techniques**

The research objectives are specifically achieved using techniques as follows:

Objective (i) is achieved through personal visit to the site and making interview to locally owners of rice mills around Dass

Objective (ii) would be achieved through case study and interviews.

Objective (iii) would be achieved through application of findings in the proposed design to suit the proposed integrated rice milling factory.

### **3.6 Method of Data Collection**

For this research, two main sources of data are collected, these include Primary sources, and, Secondary sources.

Primary sources of data collected include the information about the features of the existing rice mills, its characteristics, waste generated methods of use for disposal among others. This is achieved through site visits.

### **3.7 Method of Data Analyses**

The strength and viability of any research, (Durotolu 2001) are determined by the type of data collected and the mode of collecting them. Both primary and secondary data is collected for the

purpose of this research, the research objectives is specifically achieved using relevant and viable techniques; while oral interview, literature review and Case studies was employed. Data from the case studies was analyzed using cross-case analysis as suggested by Yin (2009). Cross-case analysis is a research method that can mobilize knowledge from individual case studies

#### **4.1 Data Presentation:**

This data presentation and analysis provides an overview of the research data collection and analysis procedures and key findings. The result of this study will contribute to the growing body of knowledge on waste management, and innovative building materials, ultimately informing the design of more environmentally conscious and socially responsible rice milling factories. To get accurate result base on the objective of the research the whole wards in Dass local government were visited and various result were presented base on the following criteria;

- The number of rice mill in each ward
- The milling options
- The milling capacity of the mills
- The quantity of rice husk per each bag 100kg of paddy
- An average milling production per annual

#### **4.2 Milling Options.**

All the mills visited makes use of the of One Step Milling Process. This method usually involves a single machine and single process of milling which can be repeated till desired result is obtained, below are some of its characteristics base on the literature

- Steel friction mill
- Very high pressure
- Low white rice recovery (50-55%)
- Head rice less than 30%
- Often used for par boiled rice



Plate I: one of the milling shade in Baraza Ward  
Source: Researcher's case study, 2023



*Plate II: one of the milling shade in Durr Ward*  
Source: Researcher's case study, 2023



*Plate III: one of the milling shade in Polchi Ward*



*Plate IV: one of the milling shade in Wandu Ward*



*Plate V: one of the milling shade in Bununu South Ward*



*Plate VI: one of the milling shade in Bununu Central Ward*



*Plate VII: one of the milling shade in Bundot Ward*



Plate VIII: one of the milling shade in Dot Ward

### **4.3 The milling capacity of the mills.**

This differ from months and days with all the millers given a response of milling of up to 30-50 bags of 100kg per day in the month of October to December which is usually the peak period of milling as a result of harvest period while in other months of January to September the milling declines to sometimes 0 per day with the exception of Tuesdays and Wednesdays with a milling capacity of 10- 25bag of 100kg as a result of the market day usually on Wednesdays of every week. The milling capacity differs from one mill to the other depending on customer's preference and services provided by millers. Also those milling around the main Dass market tends to have more patronage than those around the villages as people tend to mill around the market for easy access on market days

### **4.4 The quantity of rice husk per each bag 100kg of paddy.**

This differ from the type of rice and the level of ripeness of the paddy the more the ripeness of the paddy the less the quantity of rice husk from the paddy and vice versa, also the quantity of rice husk differs from parboiled and raw paddy, as more rice husk is generated from raw rice as compared to parboiled rice however for every 3bags of 100kg milled rice there is an average full up of 1bag of 100kg



Plate IX: gathering of husk in sacks for disposal

Table 1 showing the average milling in various wards of Dass local Government Area of Bauchi State

SN	WARDS	NO OF MILL	AVERAGE MILLING (TON)				AVERAGE WASTE GENERATED (TON)			
			Below 10T.	10-50T.	50-100T.	above 100T	Below 10T.	10-50T.	50-100T.	above 100T
1	BAGEL/BAJAR	2		√			√			
2	BUNDOT	15				√				√
3	BUNUNU	10			√			√		
4	BUNU SOUTH	5		√			√			
5	BARAZA	5		√			√			
6	DOT	8			√			√		
7	DUR	6		√			√			
8	POLCHI	4		√			√			
9	WANDI	8			√			√		
10	ZUMBUL	2	√				√			

Waste Disposal. To determine the methods used for the disposing of rice husk waste in the study area the Integrated Sustainable Waste Management (ISWM) approach was used as yardstick of measurement, they include: Recycle, Reuse, Reduce, Land fill, burning (open burning), animal feeds, and composting. However cross case analysis is used to analyse the waste disposal methods in various locations



Plate X: open dumping of rice husk at Bundot dass,



Plate XI: feeding Animal with rice husk at Wandu ward of dass local government



Plate XII: Rice husk spread on the filled to decay and serve as compost at Wandu ward of Dass Local Government



Plate XIII: open dumping of rice husk at Dot Dass

Table 2 showing the Waste disposal methods Adopted by various Wards

S/N	WARD	Open burning	Animal feed	Open Dumping	Reduce	Reuse	Recycle	composting
1	Bagel/ Bajar	√	√	√	-	-	-	√
2	Bundot	√	√	√	-	-	-	-
3	Bununu Central	√	√	√	-	-	-	-
4	Bununu South	√	√	√	-	-	-	-
5	Baraza	√	√	√	-	-	-	√
6	Dot	√	√	√	-	-	-	-
7	Durr	√	√	√	-	-	-	√
8	Polchi	√	√	√	-	-	-	√
9	Wandi	√	√	√	-	-	-	√
10	Zumbul/ lukshi	√	√	√	-	-	-	√

**5.0 Case Study;** This work studies some factories within and outside the country Nigeria. Case study of factories include industrial buildings that process and mill rice. The case study analysis brief history and growth scope of the buildings, mode of operation, schedule of accommodations and appraisal.

### 5.1 Case Study one: IRS RICE Milling factory Kano

Founded in 2003 by the Islamic Scholar and Industrialist Sheik Khalifa. The Rice mill received a boost in 2011 by a huge investment made by Fidelity Bank. It has continually grown since then. It is 100% indigenous and make use of indigenous rice. It has the 24,000 metric tons Capacity per annum Products of white parboiled rice it have 231 staff: 76 permanent staff and 152 temporary staff, it source it raw materials from industrial farmers, local markets and company. It has the following facilities: Administrative block, Production hall, Ware House, Functional generator room



Plate XIV: IRS rice milling factory kano

Source: [www. U. Tube.com](http://www.U.Tube.com) (2020)

#### 5.1.1 Mode of Operation

The machines are installed to produce white parboiled rice by the use of modern processing and milling equipment. Some of the equipment are modern rice hullers, husking machine, whitening

machines, sorting machines, length grading machines and the automatic weighing and bagging machines.

### **5.1.2 Architecture**

The use of simple portal frame steel structures with cladding made of roofing sheets except for the administration building which is sandcrete block work well finished. The functional activity of the factory can easily be supervised by the strategic citing of the administrative block.

### **4.1.3 Materials and Construction**

Portal frame roofing system is used for the production hall. Some parts of the exterior walls are only covered with roofing sheets. The roof is pitched with long span aluminum roofing sheets laid on the steel sections of the partial frames. Parts of the exterior walls are painted with text coat paints while some parts with gloss paints.



Plate XV: IRS rice milling factory KANO

Storage tank

Source: [www. U. Tube.com](http://www.U.Tube.com) (2020)



Plate XVI

Bagging Section

Source: [www. U. Tube.com](http://www.U.Tube.com) (2020)



**Plate XVII: Milling machine**

### **5.1.4 Appraisal**

#### **Merits**

- Only one major entrance to the factory this intensify the security of products
- Good location of administrative area for easier accessibility by public
- Entirely simple design used

#### **Demerits**

- Inadequate space for expansion
- No defined parking in the site
- No off loading and loading bays within the site
- No supporting facilities for staff

### **5.2 Case Study ii. Amk Alayam Modern Rice Industry**

**Client:** Mr. AMK Duraisamy

**Location :** Tiruppur, Tamil Nadu, India.

**Year of establishment:** 1975

**Legal status:** Partnership

**Turn over:** US\$10 – 25 Million

**Nature of Business:** - Manufacture  
- Wholesaler  
- Buyer-Company  
- Trader

**Staff:** 101 to 500 people

**Architects/Engineers:** Buhler, Germany



**Plate XVIII: Picture Showing Amk Alayam Modern Rice Industry**

### **5.2.1 Brief History**

Alayam Modern Rice Industry started as a small rice factory with a capacity of very few annual turnovers which covered 13 cents at Kangeyam main road named as Valamathi Rice Mill in 1951 with manual grinding. In 1971, another rice mill was started, the mill occupied 1 acre of land and 80 cents at Coimbatore road. Five years later another 4 acres of land and 18 cents was acquired on Pharapuram road. After its venture in 1964, tamilian modern industry focuses on providing quality with good service. Having great potential Mr. AMK. Duraisamy himself has provided himself in the field of rice industries. He organized Aalayam Hi-tech Rice Industries who with diplomatic ideas bring success. From those humble beginnings they grew a vision that has converted into millions worth enterprise, turning out a wide range of rice varieties to suit diverse needs of its customers around the globe.

### **5.2.2 Production Process**

There are varying processes and stages in production of rice, the Alayam Hi-tech rice industry apply the procedure briefly describes.

Harvesting is the process of gathering the crops, this is followed by threshing which the process of beating paddy plants in order to separate the seeds or grains from the straw. This is usually followed by a primary process of cleaning, soaking, steam boiling, cooling then drying. In this primary process the cleaning is done with a paddy shaker to remove stones and dust particles.

### **5.2.3 Appraisal**

#### **Merits**

- Enough space for circulation within the production area
- Only one major entrance to the factory this intensify the security of products
- Enough site for future expansion
- Storage and production are attached and well linked to other auxiliary functions.
- Good location of administrative area for easier accessibility by public
- Entirely simple design used
- The use of modern factory layout in organization

#### **Demerits**

- Inadequate offices for administrative staff
- Few supporting facilities for staff
- Inadequate finished product storage

### **5.3 Case Study 3:** dhana lakshmi

**Client:** Dhana Lakshmi

**Location:** Dhalavaipuram, Tamillvadu, India

**Architects:** Buhler of Switzerland, and Germany

**Engineer:** Singam of India

**Products:** ADT 36, Idly Special, Raw rice Half Boiled rice, Full Boiled rice, Rosekate White parboiled rice

#### **5.3.1 Brief History**

Dhanalakshmi Hi-Tech Modern Rice Mill, shortened to DHM Rice Mill is a proud manufacturer of SINGAM MARK (Lion Brand in English) rice varieties. It is a second generation rice mill with Hi-Tech status. they inherited their brand name and expertise from Dhanalakshmi Rice Mill, an upcoming silver jubilee concern known for its best quality offering till date.



**Plate XIX: Picture Showing Dhanalakshmi Modern Rice Mill**

#### **5.3.2 Architecture**

The DMH modern rice mill has the main production plant and storage area detached from the offices and Auxiliary functions. The production plant is linked to both the raw material and finished product stored. The conveyance of rice during processing is carried out with conveyor belt and tabular pipes.

The storage of raw materials is adequately ventilated and linked to the drying area then it is transferred to the rice mill. The rice mill is fully automated. Hence, minimal or absence of manual labor at the factory production plant.

The offices are constructed using steel structural portal frames and covered with ventilated facades of aluminium and glass. The production plant is a Hi-Tech factory design. Considering the simple portal frames, thermal insulation facades of aluminium and concate and glass.

#### **5.3.3 Appraisal**

##### **Merits**

- Enough space for circulation within the production area
- The use of modern machines in production process
- Flexible enough to adopt to functional changes
- Wall cladding for administration unit
- Waste management is ensured by the collection of by products and putting them into re-use

### **Demerits**

- The administration unit is totally detached from the production hall
- Poor soundproof of the production hall
- Exposed sophisticated machine could cause accidents
- No enough supporting facilities for staff

### **5.4 Tiamin Rice Mill**

- Client: Tiamin Multi Services and Global Limited
- Location: Yuli Office, Maiduguri Road, Ganjuwa LGA, Nigeria
- Products: ADT 36, Idly Special, Raw rice Half Boiled rice, Full Boiled rice, Rosekate White parboiled rice

#### **5.4.1 Brief History**

Tiamin rice mill Bauchi is a part of larger rice farm project situated in udubo, Gamawa Local Government Area of Bauchi State. The project was initiated by Tiamin Rice Limited, and its managing director, Aminu Ahmed, plays a crucial role in its development. The mill was designed to process 600 metric tons of rice daily, making it a substantial contributor to Nigeria's rice production. In addition to the mill, the project also includes a massive rice farm spanning 10,000 hectares, which is expected to produce 120,000 metric tons of rice annually.



Plate XX: Picture Showing Tiamin Rice Mill General Layout



Plate XXI: Picture Showing warehousing



Plate XXII: Picture Showing Tiamin scaling area

## 5.4.2 Appraisal

### Merits

- Enough space for circulation within the production area
- The factory is easily accessible as located along an express road
- The use of modern machines in production process
- Flexible enough to adopt to functional changes
- Machine driven production process
- Waste management is ensured by the collection of by products and putting them into re-use

### Demerits

- The administration unit is totally detached from the production hall
- Poor soundproof of the production hall
- Exposed sophisticated machine could cause accidents
- There is no much space for expansion of the production area

Table 3: Cross Case analyses of IRS rice mill, AMK rice mill, Dhana Lakshin rice mill, and Tiamin rice mill

SN	List	IRS Rice mill	AMK Alayam	Dhana Lakshin	Tiami Rice mill
1	Inspection/weighing unit	+	+	+	+
2	Processing unit	+	+	+	+
3	Laboratory unit	+	+	+	+
4	Utilities unit	+	+	+	+
5	Farm workshop and maintenance unit	-	+	+	-
6	Administrative block	+	+	+	+
7	Accounting section	+	+	+	+
8	Worker's facilities	+	+	+	+
9	Staff quarters	-	-	+	-
10	Generator house	+	+	+	+
11	Clinic	-	-	+	-
12	Reservoir	+	+	+	+
13	Tools making unit (about 60% of the machine part)	-	-	+	+

	are been produced by the unit)				
14	Landscape		-	-	+
15	Adequate natural ventilation		+	+	-
16	Adequate natural lightening		+	+	-

**5.0 Summary**

This research works looks into the best practices where by waste generated in the process of milling of rice could be best handle and be used in a sustainable way within the rice milling factory, the research looks at various methods used in milling of rice and their advantages this in turns helps the researcher to know the best and effective method that is used in milling of rice thereby applying it in the research works. Based on findings by the researcher, the researcher finds out that rice husk waste is a major problem in milling and have some negative effect in the environment, however the researcher suggested solutions by coming up with design of rice mill where it serves two purposes of milling and production of ceiling board within the factory

**Conclusion**

The integration of rice husk products in the design of a rice milling factory is a viable solution towards effective waste management. Rice husk, a significant by product of rice milling, can be transformed into valuable products such as energy, animal feeds, construction and building materials. By incorporating rice husk processing facilities into the factory design, rice millers can reduce waste disposal costs, generate additional revenue, and contribute to more sustainable and environmentally friendly industry. Also the waste which was seen by millers as a problem could be directly put to use in the factory.

**6.1 Recommendation**

In area of our findings from this research, issues have been discovered and addressed using design. It is thereby recommended that Rice Mill Factory should be constructed in line with the principle of sustainability in order to reduce the rate of waste within factories.

Rice millers should conduct comprehensive feasibility studies to determine the viability of integrating rice husk processing facilities into their factory.

Rice millers should invest in modern rice husk processing technologies that can efficiently convert rice husk into valuable products

Develop strategic partnership: rice millers should develop strategic partnerships with companies that specialize in rice husk product development and marketing

Rice millers should implement effective waste management system that can handle rice husk waste efficiently and minimize environmental impacts.

Rice millers should provide training and capacity building programs for their employees to ensure they have the necessary skills and knowledge to operate and maintain rice husk processing facilities

Governments and regulatory agencies should provide policy support and incentives to encourage rice millers to adopt sustainable waste management practices and integrate rice husk processing facilities into their factory design

Lastly there is the need to promote awareness and education among rice millars, policymakers, and the general public on the importance of sustainable rice husk management and its potential benefits

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