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# A Value Added Sustainable Production Opportunity Out of Rice Straw to Economically Uplift Rice Farming Communities

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***Abstract —*** *In the Sri Lankan Agriculture Sector, rural rice cultivation farmers have found the best way of eliminating the highly generating rice straw by direct open field burning due to the high cost of straw collection and management, transportation cost, storage difficulties, shortage of rural labour, cost factors of organic fertiliser making, and lack of adequate methods and technology. These practices have created a number of environmental and social impacts .Increase of heat generation, emission of greenhouse gases, causes damage to micro organisms in the upper soil layer and reduces microbial activities, soil deterioration, damages the air quality and negatively impacts on human health. This experimental project comprised two phases, material development phase and product design phase. The concept was, management through value addition. The project approach was to come up with an effective and creative management solution for the highly- generating rice straw and minimise the current practices by introducing a method to reutilize while coming up with a value addition for the rural rice farming community. The main aim of this project was to improve rural farmers' livelihoods by fostering sustainable rice straw management into a sustainable paradigm. This experimental project focused on rice straw conversion into value-added material development which was able to create a sustainable product solution for the market while creating a production opportunity for the rural community as a secondary income source. The final goal of the project was to economically uplift the lives of rural farmers by providing an additional income mainly for the non-cultivation period.*

***Keywords:*** *Rice straw, Sustainable production, Value addition, Rice farming communities, Sustainable material innovation*

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## Introduction

Through agriculture, humans have an inseparable relationship with the land. Agriculture provides people with a link to the fertility of the earth in the production of resources for food, clothing, and shelter. The main food consumed by Sri Lankans is rice. Currently, there is estimated to be roughly 708,000 Hectares of land used primarily for paddy. The Sri Lankan agriculture sector contributes 7.4 percent to the national GDP (Sri Lanka - Agricultural Sector, n.d.). There are two agricultural seasons—Maha and Yala, which correspond to the two monsoons. Maha Season falls during the North-east monsoon from September to March in the following year. The Yala season is effective during the period from May to the end of August.

According to the International Rice Research Institute (IRRI), some 300 million tons of this rice by- product are burned every year. The latest assessment report of the intergovernmental panel on climate change projected that the burning of crop residue, including rice straw, contributes a fairly good amount of greenhouse-gas emissions by the agricultural sector (Business Mirror, 2018). The high carbon-to-nitrogen content of rice straw leads to a very low biodegradability compared to other agricultural residues (AMK, 2020). The degradation of rice straw in the field emits a significant amount of greenhouse gasses, such as methane and N2O. Many studies evaluate the environmental impact of open rice straw burning which is known to cause a substantial amount of air pollutants that contribute to serious deterioration of the ambient air quality, climatic changes, and deterioration of general population health (AMK, 2020).

## Problem Statement

Within the Sri Lankan rural rice farming communities farmers used to burn the generated rice straw quantities which caused a huge impact to the sustainability pillars.Burning of straw waste causes damage to other microorganisms present in the upper layer of the soil as well as its organic quality. Due to the loss of friendly pests, the wrath of enemy pests has increased and as a result, crops are more prone to disease. The solubility capacity of the upper layers of soil has also been reduced (Yadav, 2019). Besides causing air pollution, burning paddy straw leads to the loss of soil organic matter and essential nutrients, reduces microbial activities, and makes the land more vulnerable to soil erosion (Kumar et al., 2019).

Rice straw contains nutritional value of nitrogen, potassium, carbon, silicon, higher quantities of potassium, calcium and magnesium which is lost during the burning process. The ratio of straw to paddy ranges from 0.7-1.4 depending on the variety and growth.

## Context

According to the community visits during the project span ,within these rural rice farming communities used to burn the generated rice straw or else used to open dump it. These current actions have created a number of environmental and social sustainability impacts.

The unawareness, high cost of straw collection and management, transportation cost, storage difficulties, shortage of rural labour, cost factors of organic fertiliser making, and lack of adequate methods and technology leads to these actions. Considering the context, waste management is a difficult task to fulfil with the amount per year. Mostly farmers used to do

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open dumping and burning which causes lots of environmental impacts and directly affects the environmental sustainability pillar.

Due to the burning practice not only impacts sustainability pillars also it leads to damage the nutritional value of the rice straw material. Based on the analysed target segment findings within these rural rice farming communities cannot find a secondary income for the non-cultivation periods and are highly struggling with the day to day life expenses. It is essential to come up with a sustainable rice straw management solution for the community while generating a secondary income mode from a product designer point of view.

## Methodology

The project mainly considered rice straw generation and management difficulties and sustainability focused impacts within the rural farming communities. As a product designer while empathising and analysing rural farming lives the lack of secondary income was identified. The entire project was focused on providing a sustainable product solution for the market by introducing a method to sustainable rice straw management within the community while creating a value added opportunity for rural farming lives.

### *Material Development and Testing*

The first phase of the project was the material development stage. Initially started with identifying the raw material qualities with simple domestic testing and conducted parallel studies of the existing literature related to the project area while developing the material piece.

Once started with developments of the material pieces then to check the applicability of the pieces conducted domestic and standard lab testing experiments. Material development was conducted with three experimental phases. With gained test results and experiences during the Material testing period identified the gained material properties of the composite sample. Considering the gained material properties, based on the user requirements and market demand started with the product designing phase.

### *Product Designing*

Designing phase started with identifying stable geometric forms. Then started to develop the block forms considering the interlocking applicability's in between two units. While designing, the market demand, requirement and mainly the manufacturing capabilities (manpower and skills within the community) within the community as the production focused on making a secondary income for the community. When it comes to the manufacturing technology of the design the block mould designing plays a crucial role to make the production efficient and manufacturing friendly within the community. Based on the final design the modular design was developed considering the interlocking concept with indoor gardening approach.

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Fig.1 - Sketching and prototyping stages

Fig.2 - The biophilic modular design set up within the interior layout with 3D illustrations

### *Limitations*

Considering the rice straw generation capacity as an initial stage of the experimental project was conducted by selecting a particular rural farming community in Anuradhapura district, Nochchiyagama area. Material development experiments and testing stages had to be limited considering the transportation cost factors and the accessibility within the community while selecting additives for the material developments. The manufacturing was limited to batch production considering the available rice straw quantity within the community and based on the market need and the demand for the product solution.

### *Outcome*

At the end of the project was able to minimise the greenhouse gases emission by minimising the rice straw burning practice within the community. Also was able to provide a sustainable rice straw management solution for 735 acres of farming area. The rice straw conservation practice helps to save nutritional value of the rice straw ( N,P,K value) and adds value to the product design solution and a high price factor.

### *Conclusions*

The material development series was successful and was able to produce a product outcome with the developed composite material sample.

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The project was able to reach the short term goals,

- To come up with a sustainable and effective rice straw management solution for the rural community.
- To minimise the burning practice and be able to decrease the sustainability impact.
- Introduced a secondary income generation mode for the community and was able to improve the income level of the farming families.
- Save nutritional value of the rice straw without burning.
- Introduce sustainable rice straw management solution for 735 acres farming area.

As a long term goal, the project would be able to reach sustainable development goals with time, such as no poverty, good health and wellbeing, sustainable cities and communities, responsible consumption and production, and climate action.

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