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Residue to Resource

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Residue to Resource

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Efforts to remanufacture and reuse can drive the much-needed change in industrial production practices to reduce the dependency on virgin wood as a raw material and aid natural resource regeneration. Remanufacturing and reuse are required to foster a well-functioning ecosystem and to push back the adverse effects of climate change for a hopeful future.

Through systemic design mapping, it was observed that utilising residue from one industry as a raw material for new processes can provide an integrated solution to multiple issues at the source (Figure 1). It can reduce waste generation, create value for residual material to improve its recovery, reduce marginal cost and improve production efficiency. The proposed interventions align with the UN SDGs 8 and 12. As recommended by SDG 8 (Goal 8 |Department of Economic and Social Affairs, n.d.-b), it impacts economic productivity by contributing to diversification and innovation. The systemic approach aligns with SDG 12 (Goal 12 | Department of Economic and Social Affairs, n.d.) as it attempts to reduce waste generation through prevention, reduction and reuse to move towards sustainable production methods. The solution also focuses on improving our reliance on natural resources, contributing positively to SDG 12.

KEYWORDS: Industrial Residue, Agro-waste, Innovative Material, Residential Furniture

RSD TOPIC(S): Socioecological Design, Methods and Methodology

Context

Through several years of the industrial revolution and growth, continual production and manufacturing have led to the fast depletion of renewable and non-renewable natural resources, negatively impacting the environment in many ways, such as increased concentration of greenhouse gases, toxic waste generation, and resource depletion. However, continuous industrial activity is vital for the country's efficiency and economic growth and capacity building for economically viable alternative practices to achieve production efficiency and growth is required. The short-term solutions need to shift focus towards a transition in production and consumption methodologies for judicious resource extraction and natural regeneration of resources. The design research project looks into the production and consumption patterns of resources. At a micro-level, sub-systems were investigated under determinants classified into techniques, enablers and drivers.

According to the IMARC Group (2023), the home furnishings market in India is expected to exhibit a CAGR of 7.04% during 2024-2032 (2023). Furthermore, the home furniture segment constitutes 60% of the market in India's furniture industry, and wood is the critical input for 65% of all furniture made in the country (IKEA Report, 2021). Therefore, the primary research question investigates the ways to reduce the dependency on virgin wood and wood-based products in the home furniture segment in India.

Areas of Investigation

Aims: (a) designing to achieve a closed production loop in the Indian home furniture segment (b) finding alternate methods to improve production efficiency and economic productivity aligning with the parameters of innovative usage of resources, introducing alternative materials and reuse.

Opportunity areas: How Might We (Brown, 2009)

1. design for repair?
2. design for lesser manufacturing waste generation?
3. recover and refurbish from waste?
4. design for repurposing?
5. utilise manufacturing waste?*
6. optimise additional costs for circular products?*

*The design research was furthered concerning the fifth and sixth opportunity areas.

Primary research question: How can we reduce the dependency on virgin wood and virgin wood-based products in the home furniture segment of India?

Secondary research questions: How can manufacturing waste be utilised to create alternate materials? How can the material intervention fit into the existing manufacturing and consumption process?

Project description

The background study involved analysis of prevalent materials and manufacturing techniques in India's medium and large-scale furniture industries. Areas like marginal costs, material procurement, furniture design and product lifecycle, and production wastage were explored to understand the supply chain. Online primary research on furniture buyer preferences was also conducted across India to make informed decisions on identifying the opportunity areas. As per the Ellen MacArthur Foundation's circular economy diagram (2013), the areas of intervention for the identified problems were aligned with the least impactful steps to achieve circularity.

The project aims to find ways to bring circularity in furniture manufacturing through material innovation to address the fast consumption of natural resources. The study

investigates consumption and dependency on virgin wood in the furniture industry. It was found that existing intermediate products for the furniture industry come in material hybrids that degrade slowly due to their composition. They can increase landfills, pollute land and water resources and affect our well-being. Engineered wood panels with formaldehyde-based binders are one of the most used furniture-making products. Thus, to resolve this problem, experimentation with agro-industrial residue, naturally occurring resins and biopolymers was carried out.

Key findings

The primary stakeholders in the studied system were micro, small, and medium enterprises (MSME) furniture manufacturers, engineered wood manufacturers, and raw material processing units. The study also identifies gaps in the supply chain (Figure 1). Primary research found that the raw material processing units work with agro-field residue, agro-industrial residue, and secondary wood processing waste. Various processed raw materials are then majorly provided to particle board industries, ceramic industries and brick kilns. The gap area in the supply chain has the scope of introducing new linkages between the industries for more efficient usage of agro-waste resources already in the chain by supplying it as an alternate raw material for manufacturing engineered boards.

Based on their chemical properties, soy and cottonseed de-oiled cakes (DOC), by-products of the oil industry, were selected for experimentation along with bagasse.[1] The outcome is a potential innovative material that can reduce dependency on virgin wood resources by creating wood-free panels with variable applications.

[1] Bagasse is a by-product composed mainly of cellulose, hemicellulose, and lignin and can be used as a biofuel and in the production of various products due to its fibrous nature and potential applications.

Why agro-industrial residue?

Using agro-industrial waste adds value to the residue; subsequently, the raw material can provide better income to the farmers. Integrating the usage of agro-industrial residue into the existing supply chain is a feasible option for a mid-term solution within 2-4 years. Wood waste was also studied as a potential replacement for a short-term solution. However, it was found that wood waste has a poor recovery chain in secondary processing, i.e., furniture making and engineered panel production. Recovered wood waste is utilised to make biomass pellets with high material efficiency. A study was done on soy DOC, cottonseed DOC and neem seed DOC, which is used as a low-value fertiliser, soil additive and fuel without detoxification (Rahman et al., 2014). Cottonseed DOC is commonly used as animal fodder, and soy DOC is utilised to make poultry feed and biscuits. The material samples created using bagasse, DOC and other organic binders were found to be compatible with machinery for mechanical processes like cutting and drilling.

Way forward

The afterlife of the material would be highly dependent on its furniture application and stakeholders' practices. Compatibility of adhesives used for furniture making and appropriate surface treatment is required for fast degradation on disposal. Through interaction with MSME stakeholders, it was observed that for furniture manufacturers, adapting to a new alternate material would be driven by market value, customer awareness, and demand. Hence, strong market value creation by retail stakeholders would be essential.

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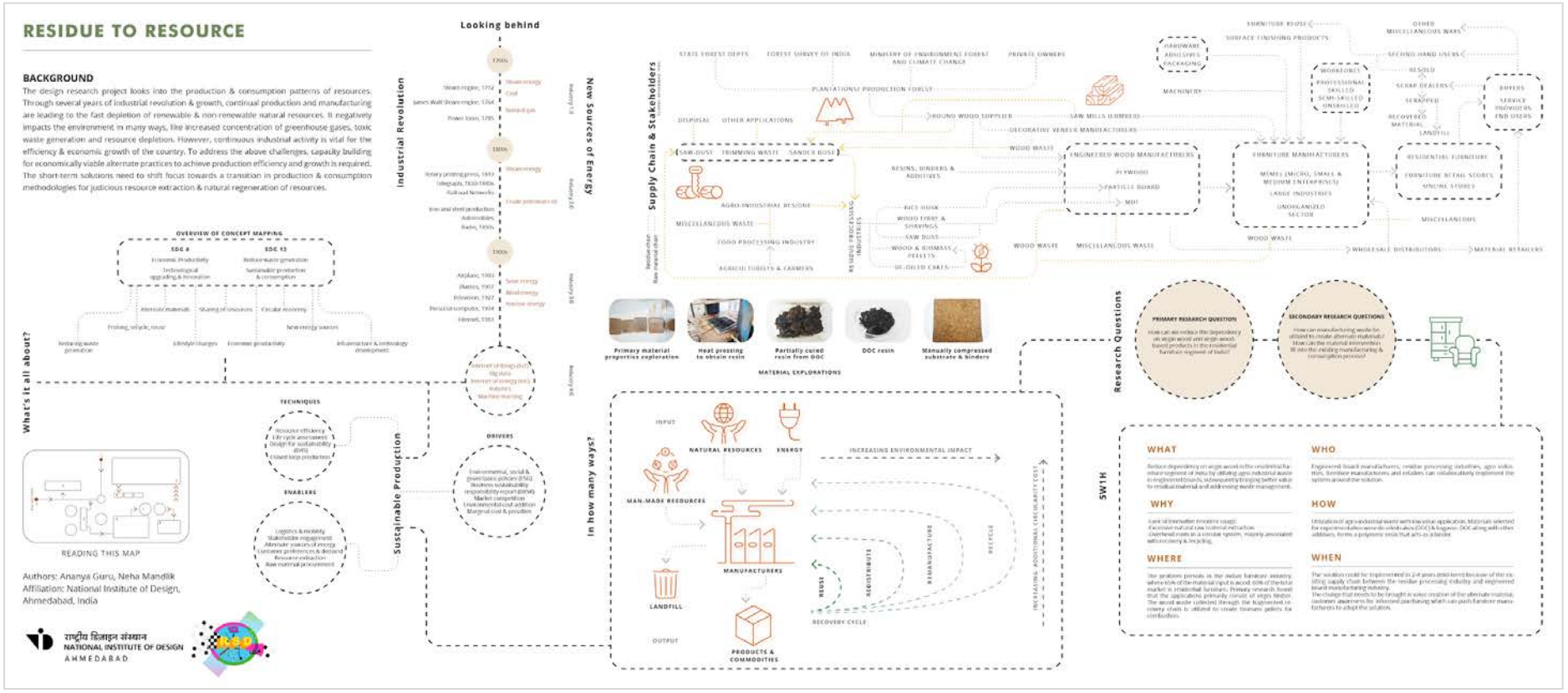

Figure 1: Systemic design mapping was used to identify the production and consumption patterns of resources and supply chains.