

Case Study

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## Impact of circular economy on a sustainable future- documenting the product design process of handmade papers in Pune

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### Abstract

**Aim:** This study documents the rich history, production process, and contemporary interventions of the Pune Handmade Paper Institute, while recording its role in promoting sustainable product design within a circular-economy model.

**Methodology:** A qualitative research method was followed, involving semi-structured interviews with 10 artisans and two managers at the institute. Data was analysed using the grounded theory method to understand the environmental, economic, and social impacts of handmade paper production.

**Results:** This study finds that handmade paper production in Pune utilises cotton textile waste and traditional techniques, thereby reducing CO<sub>2</sub> emissions. Despite challenges such as obsolete machinery, technical failures, and financial neglect leading to a temporary shutdown in 2019, the institute was revived through private intervention. Innovations in product design and marketing strategies have contributed to the industry's resurgence.

**Interpretation:** The study undermines the importance of handmade paper as a sustainable alternative to wood-based industrial paper. By integrating traditional craftsmanship with modern design approaches, the industry is a testament to a successful circular economy model. Reviving such heritage crafts not only preserves cultural legacy but also addresses alarming environmental concerns, emphasizing the need for sustainable production practices in the future.

**Key words:** Circular economy, Environment-friendly, Handmade paper, Sustainable development goals



## Introduction

Paper, also known as *Papyrus*, is a Latin word for a grass from which paper was made in Egypt in 2700 BC. With the development of civilization and the need for various media of communication, writing was one of the most important forms of expression. Paper ought to be the most versatile material that can be used for writing, recording, packaging, and other utility purposes. (Jain and Gupta, 2021). The importance of paper in our lives is underestimated. Books, magazines, newspapers, letters, and posters are strong media of communication which require paper. Handmade paper is a manual process of papermaking that is one of the strongest and most niche cottage industries in India. Handmade papers are durable, pure, sustainable, and wood-free compared to industry-made wood-consuming paper. (Madhukar and Sun, 2023). The history of paper is rich, and it has been in constant evolution in terms of its raw materials, manufacturing, and usage. As handmade papers are recycled, revived and eco-friendly, it is the need of the hour to increase their usage for environmental concerns. Buddhist monks travelling widely to spread Buddhism, introduced the art of papermaking to Tibet and India in 1417 AD. (Bloom, 2017). The Chinese kept the papermaking process a secret to increase their trade with other countries. Khadi and Village Industries Corporations (KVIC) were established, and many cottage industries started producing paper. (Dwivedi and Dangayach, 2013).

Many researchers have worked on the manufacturing science and chemistry of handmade paper and various raw materials, such as plant fibres, seed hair fibres, leaf fibres, and wood-derived fibres, through pulp making (Hubbe and Bowden, 2009). Till 18<sup>th</sup> century, cotton had negligible usage in the papermaking process. As India produced cotton on a large scale, it exported it to Europe, and leftover cotton was used for papermaking (Bhodiwal *et al.*, 2022). With the growth of the garment industry in India, large amount of textile waste were generated. The cottage industry and the mechanized industry both produced papers, but of different quality. The handmade paper, produced from cotton rags and one sheet at a time, was durable, absorbent, and made from varied natural materials whereas the machine-made paper was thin, chemically produced, and occupied the market due to its mass production. With the influx of global development, many businesses prioritise profit goals; however, handmade products achieve more, such as fostering sustainable practices in society and the responsible use of natural resources. Their strategies focus on producing products from existing materials to reduce carbon footprints. (Mohanty and Arcot, 2024).

Commercial paper mills use wood pulp, contributing to deforestation and the climate crisis over the years. The pulp and paper industry is one of the top five energy-intensive industries globally and the fourth-largest energy user in the industrial category. This industry accounts for approximately 6% of global industrial energy use and 2% of direct industrial CO<sub>2</sub> emissions. (Del Rio *et al.*, 2022). The circular economy model is a

transformative approach in contrast to the "take-make-dispose" model. It prioritizes minimizing waste by focusing on reducing, reusing, recycling, and recovering materials throughout the entire lifecycle of a product – from production and distribution to consumption and repeat (Kirchherr *et al.*, 2017). In view of the current state of man-made hazards to health and the environment, humankind has realised that natural materials like handmade paper are tree-free and completely eco-friendly. (Chauhan *et al.*, 2022). Globally, 75% of fabric waste is dumped in landfills, while only 25% is recycled or reused. (Juanga-Labayen *et al.*, 2022). Almost 100% of cotton textile waste can be reused through various methods, yet landfills are overloaded due to fast-fashion industry producing millions of pieces per minute, leading to faster consumption and disposal rates. Textile recycling prolongs the shelf life of the fibres (Sandin and Peters, 2018).

Textile waste segregation and converting it to useful product is a challenge in terms of skilled manpower and infrastructure. However, new product manufacturing can generate economic and social benefits while reducing environmental damage. (Bukhari *et al.*, 2018). Handmade paper making is one such industry that reuses textile waste without chemical processes, offering opportunities for small-scale businesses, providing sustainable livelihoods for artisans, preserving traditional skills, promoting socio-economic empowerment, and encouraging sustainability among consumers. The industry has the potential to grow further due to its use of functional products such as stationery, writing pads, degree certificates, drawing and painting sheets, documentation sheets, wrapping paper, and many decorative products. (Chummun and Rosunee, 2012).

Though the current trends and consumer behaviour have shifted towards industry-generated paper due to high demands and needs, the awareness of using sustainable products has been on the rise, considering climate change, health hazards and extreme urbanization. For many years, handmade paper was not readily available, and many factories closed due to machinery breakdowns, lack of maintenance, and a lack of investment. Handmade products faced closures due to financial losses, government subsidies, and workers shifting to well-paying jobs in the private sector. (Dwivedi and Dwivedi, 2009). The Pune Handmade Paper factory was established in 1940 under the Maharashtra State Khadi and Village Industries Board (KVIB). A breakthrough idea of Scientist K. B. Joshi and supported by Mahatma Gandhi, the factory produced handmade papers using traditional techniques. In 2019, the factory was closed due to problems with machinery, repair, and maintenance, thus leading to the extinction of a pure craft.

The design studio revived the factory and oversees the product design, development, innovation and marketing. The Pune Handmade Paper factory produces pure handmade paper sheets made manually by artisans and labourers. Made from cotton rags, the textile waste is prevented from going to landfills, reducing CO<sub>2</sub> emissions and making it biodegradable. Although

several studies have examined the history, chemistry, and environmental benefits of handmade paper, limited research in the last five years has focused on handmade paper production within a circular economy framework, minimal research combining product design principles with contemporary innovation, and impact assessment through the lens of environmental economics and alignment with sustainable development goals. The novelty of the study documents the history, process, and future scope of the handmade paper industry and serves as a reference for academicians, artists, students, and the community. Making contemporary products from handmade paper will sustain the rich tradition for future generations. The study aims to fill gaps and record data to address the problem statements, especially in environmental areas such as deforestation, high energy and chemical consumption, greenhouse gas emissions, and inefficient recycling.

### Materials and Methods

The research study employed a qualitative research design through primary and secondary data sources. The literature review was conducted by examining various publications on the process of making handmade paper and its sustainable characteristics. However, the data is limited. The qualitative approach was particularly appropriate for this study, as it enabled understanding of traditional production knowledge, artisanal systems, and sustainability practices, along with lived experiences, which are central to this analysis (Creswell and Poth, 2016). The primary data were collected through an intensive field study at the Pune Handmade Paper Institute, located in Pune. The study lasted 10 days. A case study approach was adopted, with an emphasis on the environment and sustainability to provide in-depth, rich insights and resource practices (Yin, 2018). Data were collected through semi-structured interviews with artisans working at the factory for more than 30 years to document the history, processes, and importance of handmade paper. Semi-structured interviews allowed consistency in probing experiential and process-based knowledge (Kvale and Brinkmann, 2009).

The one-to-one interactions with artisans conducting operations at various stages of paper production yielded in-depth data through follow-up questions and answers. Qualitative data were collected at each stage of the pre- and post-production processes and analysed using grounded theory. (Corbin and Strauss, 2014). Some of the processes were recorded through empirical study, and follow-up questions were asked from the artisans. A sample of 10 artisans and 2 senior managers was interviewed, who performed all the key operations of handmade papermaking. Only 24 workers in total work at the institute, with the others being helpers and cleaners. The respondents are from Pune and adjoining rural areas, have mastered the art of papermaking, and have been working at the institute for 15 to 30 years. The male gender dominated the workforce, with women working primarily as helpers on small jobs such as segregation of raw materials, drying, and packing paper sheets. The

respondents' age group was 35-50 years. They spoke Marathi and were not formally educated. The average income of the artisans and other support staff ranged from INR 8,000 to INR 20,000, depending on seniority and the nature of the job. Artisans were recruited through a government process administered by the Khadi and Village Industries Corporation. The data recorded at the factory provided insights into the rich history, traditional knowledge, and current status of sustainable papermaking. Observational and interview data enhance validity, accuracy and qualitative standards. (Kalu and Bwalya, 2017). The livelihood of artisans and supporting workers is entirely dependent on the factory and the projects they receive. The entire papermaking process is handmade with minimal machinery, yet the outcome and products are highly aesthetic and durable. This initiative is now advancing towards commercialization due to development of new product and high demand by consumers.

### Results and Discussion

**Process of papermaking:** The present handmade papermaking process follows the traditional methods and uses minimal machinery and technology. The papermaking entirely depends on the skills and efficiency of the labourers. By using waste materials and recycling old paper and cloth, handmade papermaking is a perfect synergy of art and science. Textile waste can primarily be recycled through reuse and conversion into low-value or value-added products. (Chavan, 2014). The circular method is highly sustainable and eco-friendly. Though the process is labour-intensive and slow compared to machine-made paper, the results are aesthetically pleasing and cost-effective, and they continue the trend of age-old sustainable practices. These findings have implications for various factors identified by the United Nations for achieving the Sustainable Development Goals by 2030. The stages of papermaking are documented to meet the research objectives and to promote sustainable product design and development.

**Procurement of raw materials:** The primary raw material required for making handmade paper is cotton cloth. Cotton and hosiery textile waste, as shown in Fig. 1 (a), is procured from the industrial waste generated in the textile industry belts of Andhra Pradesh, Karnataka, Mumbai, Gujarat and Haryana. Synthetic textiles are not used in papermaking. Coloured textile, as shown in Fig. 1 (b), is used to make coloured papers with natural dyes. Natural resin extracted from the trees is available in liquid form and is also used in the process.

**Sorting:** Manual sorting of the textile waste received from industries is done as shown in Fig. 2. Synthetic fabrics or any foreign particles are removed. All textile waste is thoroughly checked, and big pieces are cut into smaller ones for further processing. Coloured and white fabrics are separated, and any threads or buttons are removed.

**Shredding:** The fabric and paper procured for recycling are checked and fed into the shredder machine, as shown in Fig. 3, to



Fig. 1: Textile waste is used as a raw material, especially cotton and hosiery.



Fig. 2: The sorting of raw material is done manually.



Fig. 3: The shredder machine shreds the fabric and paper waste into a finer form.

produce fine material for further processing. Shredding reduces the size of the material and converts it into a finer form, as shown in Fig. 4 (a). Paper waste from old government documents, official records, factory waste, and files is also shredded in the machine for use in papermaking, as shown in Fig. 4 (b). As files and some papers contain wood pulp, smaller quantities of shredded paper are used in recycling. The shredded fabric is washed in alum water to remove all dirt and dust for further processing.

**Pulp making:** After the shredding process is complete and the fabric is thoroughly washed with alum water, the raw material is fed into the pulper machine to make the paste. The pulper machine is like a mixer grinder, processing shredded fabric or paper with a mixture of resin and paper waste. The paste or sludge is produced by continuous movement and rotation in the tank to achieve the desired consistency and texture, as shown in Fig. 5 (a). It takes 8 hours to prepare the correct formulation, with water as the primary ingredient. The pulper machine's capacity is 150 kilograms. The tank is made of concrete, and a mechanical device rotates the mixer within, as shown in Fig. 5 (b). White

paper, white fabric, and paper are used whereas chemical or natural dyes, along with paper waste, are added to coloured papers. The pulp is further stored in smaller tanks and can be used for 2-3 days in paper manufacturing, as shown in Fig. 6 (a;b).

**Papermaking:** The paper sheets are created using paste and a mechanism operated by an experienced artisan. The paste is poured into the designated wooden frame with mesh, according to specific measurements based on the paper's grams per square meter (GSM). Specific measurement buckets are used to pour the paste into the moulds, as shown in Fig. 7 (a). The standard mould is 25 inches by 35 inches. There is a water tank below the mesh and bamboo frame that helps distribute the paste evenly using the pouring technique. Once the paste is mixed, the artisan lifts the wooden frame through a mechanism operated by his leg and hand movements. The mesh frame is lifted from the water tank, and a rectangular layer of paste is formed, leaving water behind.

The pulp take over the shape and size of the frame, as

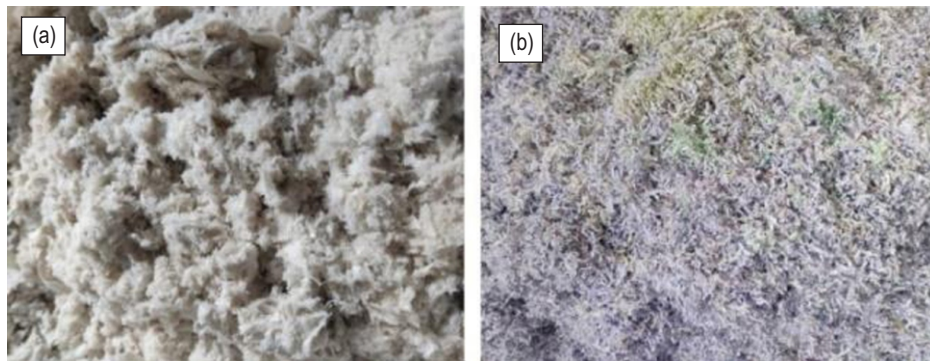


Fig. 4: Shredded fabric and paper waste.



Fig. 5: Pulper machine makes a paste from shredded fabric, along with a combination of paper waste, resin, and dyes.



Fig. 6: Paper pulp stored in the tank (a) is used to manufacture paper as shown in (b).

shown in Fig. 7 (b). The formation on the metal frame is transferred for drying. For decorative paper, petals, flowers, leaves, colourful threads, and silk threads are used, which are poured into the paste bucket during the making of the paper sheets. Around 1,500-2,000 sheets of paper are made in one day. The papers are made from 100 GSM to 700 GSM, and there is a higher demand for 300 GSM paper. The standard size is 22

inches by 30 inches. The price of the paper varies as per GSM and approximately ranges from INR100 to INR 120 per sheet.

**Drying:** After the primary paper is formed, it is transferred to woollen cloth for drying, as shown in Fig. 8. A bunch of 150-200 sheets of paper is placed between woollen cloth sheets and pressed under a hydraulic machine to remove around 60-70% of

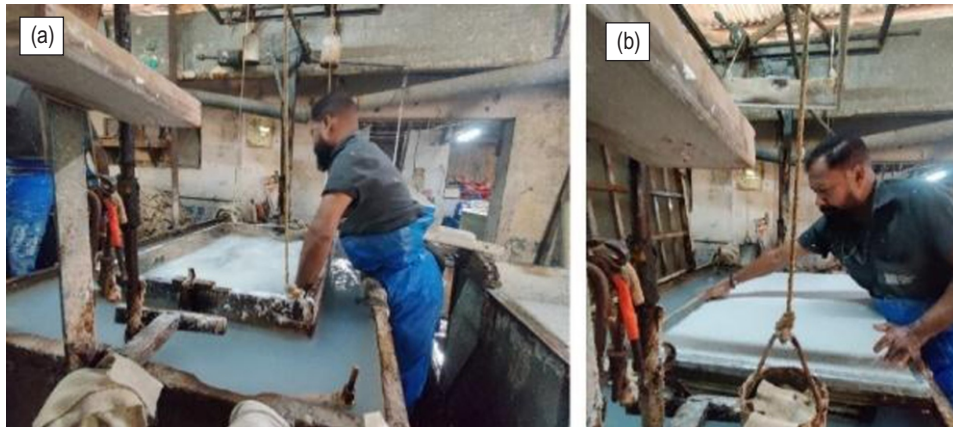


Fig. 7: The making of handmade paper sheets.



Fig. 8: Water absorption and sheet transfer.



Fig. 9: Drying process.

water. Once done, it is further dried in the shade on metal rods for 2-3 days, as shown in Fig. 9. If the paper is thin, it dries within 1-2 days. Proper drying of paper is crucial during the entire process, as sheets are cold pressed between metal sheets to make them crease free as shown in Fig. 10 (a, b). The cutting and edge finishing of the sheets are done with the help of paper cutting machine as shown in Fig. 11 (a, b). With reference to Fig.12 (a, b), the difference is visible between the finishing of the paper post the paper cutting process. Before dispatch, the finished paper sheets are thoroughly checked and counted as per order. The paper stacks are carefully packed as shown in Fig. 13.

**Implications of study on various factors:** The documentation and promotion of handmade paper practices have significant environmental, socio-economic, cultural, economic, and academic implications. From an environmental preservation perspective, reliance on waste materials rather than wood lowers the carbon footprint. There is a significant reduction in landfill use, combating deforestation, and a decrease in overall energy utilisation and CO<sub>2</sub> emissions. Handmade paper

industries are eco-friendly due to the use of vegetable dyes that are safe and non-toxic. (Kulshreshtha *et al.*, 2011). Socio-economically, there is strong support for sustainable livelihoods, with a focus on generating employment opportunities for skilled artisans and women. This sector strengthens cottage industries and aligns with broader rural development goals. (Mahajan and Singh, 2022). From an economic point of view, handmade paper and its products create market differentiation from conventional wood-based papers and scope for higher investments, business participation, and expansion of production capacity. The financial authority of the producers and separate collecting and recycling organizations contributed significantly to the success of the extended producer responsibility-based environmental policies. (Gupt and Sahay, 2015). Such initiatives help preserve cultural factors such as India's craft heritage and historical knowledge that would otherwise be lost to industrial standardisation. Systematic documentation creates a policy and advocacy stance by informing policymakers to support subsidies, tax incentives, sustainable practices, skill development programs, and legal structures that support circular-economy frameworks

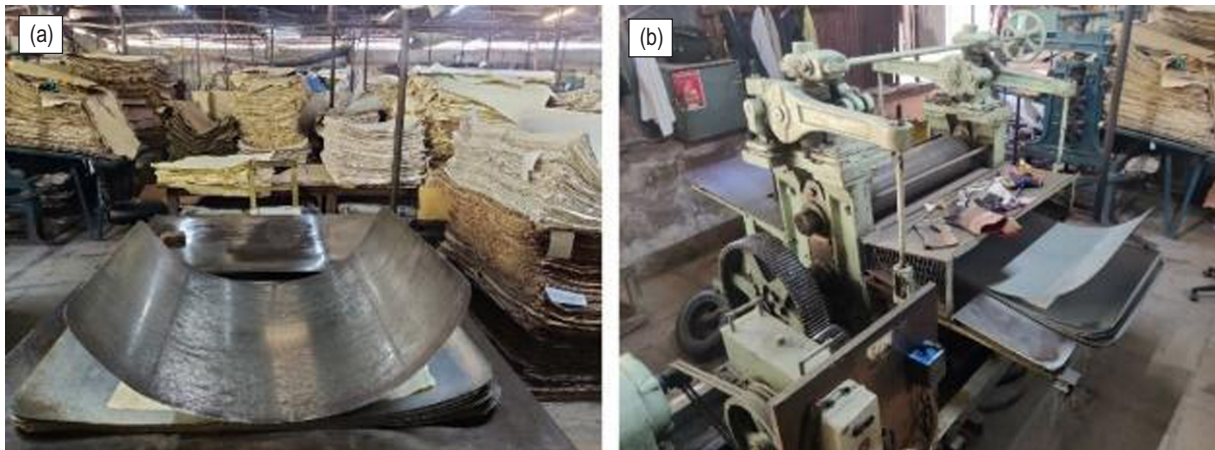


Fig. 10: Dried papers are cold-pressed under the metal sheets to make it crease-free.

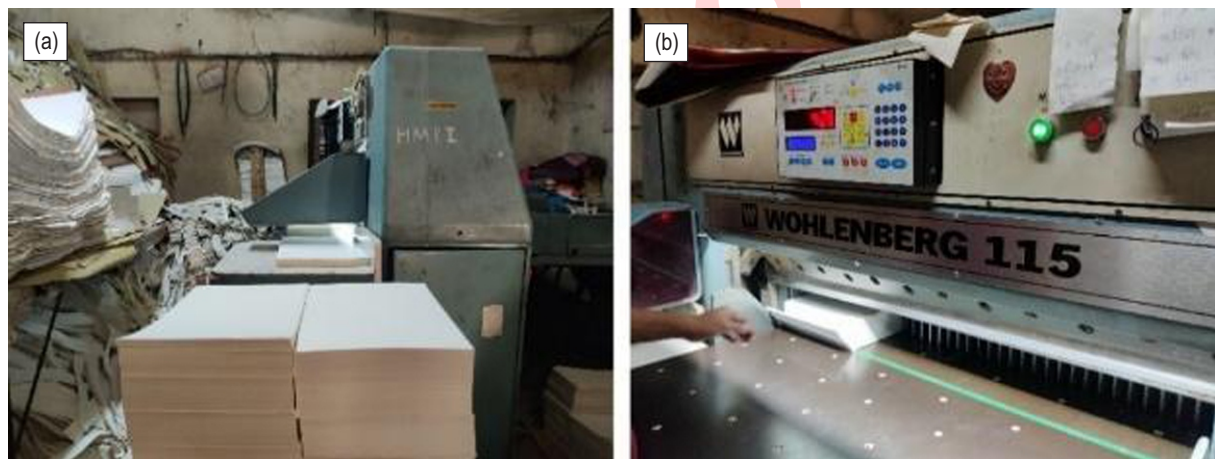


Fig. 11: (a) Cutting and (b) edge finishing of paper sheets.

at national and global levels. (Yadav *et al.*, 2022). The art and science of papermaking encourage academic research and valuable insights for researchers investigating sustainable practices, as they can integrate eco-materials into craft and art education.

**Environmental economics in relation to handmade paper industry:** Economic factors, policies, external costs/benefits, market structure, and incentives play significant roles in the handmade paper sector. The costs versus benefits in industrial paper mills often do not internalise environmental externalities, such as pollution, deforestation, emissions, and wastewater treatment, which cause significant environmental harm. Handmade paper production has a lower impact as it avoids many external costs. There are environmental regulations, forest certifications such as the Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest

Certification (PEFC) in the industrial sector, and sometimes subsidies or incentives for sustainable forestry, recycling, or alternative fibres, which can be a greater benefit for the handmade paper industry. Globally, about 13% of forest area is certified under these two certification schemes. (Yadav and Dugaya, 2025). The handmade paper industry may benefit from policies that promote the circular economy, utilise waste, or support small craft industries.

The trade-offs between volume and sustainability in handmade paper cannot match the volumes of industrial production. In many applications, such as packaging, tissue paper making, or other consumer goods, high volume and speed are required. In the case of handmade, there may be trade-offs in durability, uniformity, and cost. Also, the supply of raw materials for non-wood fibres or waste materials needs to be stable. The economic externalities and ecosystem services



Fig. 12: Paper cutting process (a) before and (b) after.



Fig. 13: Checking and packing of paper.

of handmade paper support carbon sequestration (by preserving trees or using plants like hemp), biodiversity preservation, and soil improvement (especially when using agricultural waste or sustainably grown fibre crops). These are often not included in market costs but represent social and environmental value.

**Limitations of handmade papermaking:** As it is a labour-intensive, handmade process, the scalability of bulk production is limited. The manual labour and limited use of machinery lead to higher costs. Industrially produced paper is consistent, available at lower prices for bulk orders, and readily accessible to a mass audience, thereby creating a perception of luxury around handmade paper. Training and development of artisans is crucial as papermaking depends on skilled workers and their efficiency. Dependence on traditional tools and techniques restricts the use of latest technologies and efficiency, and causes fatigue among artisans.

**Recommendations/Observations for the handmade paper preservation:** From an environmental sustainability perspective, continued training programs or capacity-building ensure low-energy, low-emission systems that rely on manual processes rather than fossil fuels. Adopting hybrid techniques will support scalability while maintaining environmental benefits, such as reduced carbon footprint, minimal chemical dependency, and no material waste. Promoting ecological integrity among consumers is crucial to driving sustainable consumption patterns. Scientific studies highlight that such initiatives are effective in achieving multiple sustainable development goals. Partnerships, design interventions, and the functional life span of handmade paper can help reduce overall environmental impact. Handmade papermaking is compatible with circular economy models, thereby encouraging repeated use and multi-cycle applications and mitigating plastic waste. Integration with climate-responsive policies for the paper and packaging sector can further validate its role in the sustainable material ecosystems.

**Future scope:** Increasing awareness of sustainability and the adoption of eco-friendly products. Economic impact on the artisans making the paper and employment opportunities. Innovation in designs, new product development, and creation of a variety of day-to-day products to increase usability and functionality by encouraging handmade paper as a “sustainable necessity” rather than a “luxury.” Marketing and awareness programs for future generations and current consumers worldwide, leveraging social media campaigns to showcase handmade paper’s eco-friendliness and aesthetic appeal.

The socio-economic impact on artisans’ livelihoods will lead to more artisans joining the unit. The use of handmade paper for packaging utility products such as medicines, skincare, dry food, and clothing can reduce the use of single-use plastic and the hazardous fumes it generates. The handmade paper from fabric waste is more than just art; it is a testament to human skill, science, and environmental responsibility. By recycling waste fabric into aesthetic, functional paper, this process exemplifies the principles of sustainability, creativity, and cultural preservation. In an era of mass-produced, industry-generated products that cause environmental degradation, handmade paper is a tangible solution to reduce waste, conserve resources, and support local artisans. With rising consumer awareness of eco-friendly products, the reduction of textile waste in landfills, sustainable livelihoods in urban areas, the producing utility and gifting products, design interventions, and environmental policies, the handmade paper has a bright future for a greener tomorrow.

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