

Sustainable Design Innovations Inspired by Bihar's Sujni, Khatwa, and Madhubani Traditions

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Abstract: This study, therefore, highlights the importance of traditional crafts in the context of contemporary global sustainability needs, while also providing support for rural artisans through responsive innovation, as informed by design principles. This specific study, as an analytical piece, focuses on the confluence of traditional textile and artistic forms of Bihar, with special reference to Sujni, Khatwa, and Madhubani, in the context of innovation in contemporary product and textile development, as informed by sustainable design. The objective of the study is to provide an alternative understanding of indigenous traditional crafts from a sustainability perspective. The main argument of the study is that traditional crafts can provide a potential framework for sustainable design and a circular economy. Contrary to other research studies, which primarily focused on the aesthetic and cultural dimensions of traditional crafts, the study attempts a unique integration of traditional heritage-based design methodology with sustainable material innovation. The study adopted a mixed-methods approach, which includes both qualitative and quantitative research approaches. The study conducted ethnographic research, where in-depth interviews were conducted with traditional artisans from Muzaffarpur, Darbhanga, and Madhubani districts. For the study, the researcher also adopted diverse sources of secondary research, which included traditional design, sustainable innovation, and material lifecycle research. The study also adopted a bibliometric approach as a methodology for understanding knowledge structures and research trends in sustainable craft-based design. Thematic content analysis identified the major sustainable attributes of traditional crafts, which were then recontextualized into experimental forms using biodegradable and recycled materials. The study findings show that an integration of indigenous aesthetics with contemporary eco-design methodologies can reduce waste, while also adding greater value and distinctiveness to the products. This study is a contribution to the existing knowledge in the area of design research, as it recontextualizes traditional crafts of Bihar as agents of sustainable development. The study also attempts a replicable design framework, which can connect traditional knowledge systems with contemporary sustainable product development.

Keywords: Artisanal Innovation; Bihar Crafts; Cultural Sustainability; Eco-Design; Heritage-Based Design; Sustainable Development.

1. INTRODUCTION

It is observed that the international design and manufacturing industry is witnessing a significant change, with sustainability representing a key focus in the backdrop of environmental degradation, depletion of resources, and climate change. The textile industry, in particular, is recognized as one of the most impactful sectors contributing to environmental pollution, resulting in the creation of carbon footprint, water footprint, and waste footprint (Muthu & Gardetti, 2021). The modern-day sustainability movement is witnessing an increased focus on the need for sustainability in design, with the objective of moving towards a more circular economy (Gardetti & Torres, 2013; Niinimäki, 2019). In the backdrop of the paradigm shift in the sustainability movement, the significance of traditional knowledge systems is increasingly recognized as a source of sustainability knowledge systems, with the potential for the development of innovative methods of sustainable design (Lin & Lin, 2022). It is observed that traditional knowledge systems are based on the ecological balance of the region, with the use of available natural resources, coupled with the focus on the sustainability of the final product, with the objective of promoting community-based production systems, which are in line with the modern-day sustainability movement (Fletcher & Grose, 2012; Niinimäki, 2019). The use of natural fibers, plant-based colors, and traditional manufacturing processes are the key characteristics of traditional knowledge systems, with the use of the same in the textile industry representing a significant step towards the development of sustainable design, with the objective of promoting environmental sustainability while allowing for the maintenance of the uniqueness of the traditional knowledge systems in the backdrop of the modern-day fast-fashion industry (Niinimäki et al., 2019). The usage of biodegradable materials and natural dyes in Madhubani art serves to reinforce the inherent sustainability of the art form. It is interesting to note that the usage of the above-mentioned art forms has been cited as an evidence of the potential of traditional art forms to function as conduits for the promotion of environmentalism while at the same time promoting the preservation of heritage (Kumar & Pallavi, 2025). A similar parallel may be drawn with the Sujni embroidery art form. This is a distinctive art form that is a result of the household craft of the women of rural Bihar. Traditionally, the art form is created through the usage of recycled fabrics and the sewing of the fabrics together to create a quilt. The fabrics have been cited as having the potential for the promotion of the story of daily life through the usage of embroidered motifs. The art form is based on the fundamental principles of material reuse and reduction of waste. These principles have since been cited as the foundation of contemporary sustainable design (Niinimäki et al., 2020). The social component of sustainability is highlighted in the art form through the usage of storytelling and the community component of the art. Another art form is the Khatwa appliqué art form, which is traditionally created in the state of Bihar. The art form is created through the usage of the sewing of opposite pieces of fabric to create a design. The usage of the art form highlights the potential of textile waste for the creation of aesthetically appealing designs through the usage of craftsmanship. The art form may thus be cited as an earlier manifestation of the concept of upcycling, in which waste is creatively used to create new products through the reconfiguration of the waste. This concept is a manifestation of the concept of sustainability (Pareek & Ojha, 2023). Despite the significance of the above-mentioned art forms, there are numerous challenges facing traditional art forms in the contemporary global economy. The decline of artisanal ways of living in various regions can be related to factors such as high levels of industrialization, changes in consumer behavior, and the availability of mass-produced products (Deshmukh et al., 2024). Furthermore, there is a general shift towards urban employment opportunities, especially among younger generations, which is gradually leading to a decline in traditional knowledge systems. Thus, there is a need to address these issues to ensure that these crafts do not turn out to be redundant, thus becoming less relevant to modern market scenarios. Therefore, there is a focus on design-driven innovation, which is essential to revitalize traditional crafts while making them relevant to modern scenarios (Mulchandani & Shaikh, 2025). This study is based on the idea that design-driven innovation could potentially address these issues. Thus, there is a need to reframe conventional techniques according to modern design trends, which could help researchers develop innovative products while ensuring their cultural integrity while meeting sustainability requirements set by modern scenarios (Aggarwal, 2024). Such approaches could potentially lead to innovative design solutions that could integrate indigenous visual styles with modern sustainability requirements, thus enhancing their cultural and environmental significance (Lin & Lin, 2022).

With regard to sustainable product development, there is a strong link between integrating craft traditions and the emerging paradigm of a circular economy. The circular design paradigm is based on improving resource productivity, increasing material durability, and minimizing waste generation using techniques such as reuse, recycling, and repair (Niinimäki et al., 2020). Various traditional artisanal techniques have already incorporated these aspects using techniques such as optimization of material use while minimizing environmental impact. For example,

techniques such as appliqué using fabric scraps and natural dyes used in folk art could potentially lead to circular material use. In conjunction with contemporary eco-design tools such as life cycle assessment and biocompatibility studies, artisanal techniques have the potential to lead to the formulation of novel solutions for sustainable manufacturing systems (Muthu, 2021). Recent studies have also highlighted the need for a multidisciplinary approach in understanding the relationship between artisanal traditions and sustainable design. A number of methodologies have been adopted in understanding the cultural context and knowledge system in artisanal traditions. Some of these include ethnography, participatory design, and bibliometrics (Bang et al., 2024). These approaches have enabled researchers to identify the intrinsic sustainability characteristics embedded in artisanal traditions that can be developed into design tools for contemporary applications. This has also been seen as an approach that leads to the formulation of novel design cognizance while promoting intangible cultural heritage. Although there is an increasing interest in the role of artisanal traditions in ensuring sustainability in Bihar's textile and art traditions, there is a need for further studies that focus exclusively on Bihar's textile and art traditions. Most studies have focused on cultural preservation and aesthetic analysis rather than the potential for the broader applications of these traditions in the formulation of sustainable design tools (Mulchandani & Shaikh, 2025; Singh & Munjal, 2025). This indicates a need for further research in the formulation of design thinking based on heritage and contemporary sustainable design tools. This is likely to demonstrate the potential for traditional knowledge in the formulation of sustainable products while supporting artisans in the region. The present research aims to fill this gap by assessing the role of Sujni, Khatwa, and Madhubani in sustainable design innovation in contemporary textile and product design. The current research utilizes a qualitative approach of close reading of the content, media, and narratives of the crafts under study. The research aims to explore the sustainable attributes of the respective domains of the crafts under study, which can be incorporated for use in contemporary design practice. An ethnographic approach is adopted for the research on the interface of indigenous knowledge and contemporary eco-design methodologies in the context of artisan communities and prototyping. The research focuses on the use of biodegradable and recycled media in the context of eco-design, with the objective of evaluating the efficacy of the methodology for the integration of indigenous knowledge into the domain of eco-design. The twin objectives of the research are: (i) to reposition the crafts of Bihar as a repository of cultural knowledge, and (ii) as a repository of sustainable creativity with the potential for global discourse.

2. REVIEW OF LITERATURE

2.1 Sustainable Design in the Textile and Craft Sector: Such an observed trend is a result of the increasing carbon footprint of the global textile and fashion industry. This has led scholars and practitioners alike to search for environmentally friendly solutions for addressing critical environmental issues. It has been well noted that the textile industry is among the most resource-intensive sectors and has been shown to exert considerable influence on the environment in terms of greenhouse gas emission, water pollution, and landfill waste. (Niinimäki et al., 2020; Muthu, 2021) In response to this, scholars have highlighted the importance of sustainable design approaches that are geared toward the integration of ecological considerations throughout the entire product lifecycle. (Santos & Silva, 2026) The approaches cited in the literature are varied and include several concepts such as eco-design, circular economy, slow fashion, and regeneration material systems. The objective of such approaches is the minimization of the impact on the environment while ensuring the viability of the social and economic system. (See: Fletcher & Grose, 2012; Gardetti & Torres, 2013) In this context, eco-design has been noted as a methodology of primary importance for the transformation of textile manufacturing practices. Eco-design has been noted for its focus on the use of environmentally friendly materials and the minimization of the use of resources and waste during the design stage. Inquiries have highlighted the importance of the integration of biomaterials and regeneration approaches in textile design for the facilitation of the transformation toward a bioeconomy-oriented textile manufacturing paradigm. (Santos & Silva, 2026) The circular economy methodology has also been noted for its focus on the design of products that promote reuse, recycling, and repair for the minimization of the impact on the environment. (Andersen et al., 2025) These methodologies have highlighted the importance of the paradigm shift in the conventional approaches toward design and the exploration of non-traditional knowledge systems. **2.2 Circular Economy and Textile Sustainability:** The concept of a circular economy has received considerable interest in the textile and fashion industries, as it offers an opportunity to achieve sustainable manufacturing practices. This is in contrast to a traditional linear economy, which is based on a 'take-make-dispose' concept, as presented in a circular economy model that focuses on efficient use of resources (Niinimäki et al., 2020). A recent systematic review identified a range of circular economy strategies that have been adopted in the textile industry, such as recycling, upcycling, repair, and biodegradable materials (Ramírez-Escamilla et al., 2024). Empirical studies suggest that the application of circular economy principles in textile manufacturing can help reduce environmental impact while also promoting innovation in product development. For instance, there has been a considerable increase in sustainable chemistry methodologies related to waste valorization, which transforms waste into valuable resources, thus facilitating the development of a circular economy in the industrial sector (Chopra et al., 2023). Additionally, various textile manufacturing practices have been evaluated through life cycle assessment frameworks to inform designers and manufacturers regarding the use of sustainable materials in product development (Shamsuzzaman et al., 2025). Another important aspect of a circular economy in the context of textile manufacturing is product longevity. Researchers have argued that product longevity is essential to addressing environmental challenges related to the repeated replacement of products (Andersen et al., 2025). Production practices such as craft have been identified as an important factor in product longevity, as demonstrated through high-quality craftsmanship in construction practices.

2.3 Craft Traditions and Sustainable Innovation: It has recently been recognised that traditional craft practices represent a valuable source of sustainable innovation within the field of design research. The production of crafts is frequently distinguished by localised methods and the utilisation of natural or reused materials, characteristics that are closely aligned with current sustainability objectives (Zhang et al., 2023). Furthermore, the practice of craftsmanship is characterised by the embodiment of knowledge systems, which have undergone a process of evolution across generations. These systems are imbued with ecological awareness and a commitment to efficiency in the utilisation of resources, elements that have been intricately integrated into the quotidian production processes. A body of research has been conducted on the correlation between craft and sustainability, with the findings suggesting that craft-based design methodologies can function as efficient models for the development of environmentally conscious products. In a comprehensive review of relevant literature, Zhang et al. (2023) demonstrate the contribution of sustainable craft practices to the principles of the 'circular economy' through the promotion of reuse, repair and community-based production systems. In a similar vein, Saxena and Pandey (2024) posit that craft-based design methodologies facilitate human-centric innovation by promoting interaction between designers, artisans, and end-users. Such initiatives have been shown to promote knowledge transfer and to foster inclusive design methodologies that blend established practices with current design philosophies. The practice of traditional crafts has been demonstrated to have a substantial role in the reduction of textile waste. This is achieved by means of creative reuse and upcycling (Jones, 2022). To illustrate this point, consider the transformative process of repurposing scrap fabrics into new products within the context of craft-based fashion systems. This practice has been demonstrated to yield both financial benefits and environmental advantages (Chopra et al., 2023). It is evident that designers can create innovative products that combine cultural authenticity with ecological responsibility, by reinterpreting traditional craft techniques within modern design frameworks. Moreover, craft-based sustainability programmes frequently accentuate the social and cultural aspects of sustainable growth. In a multitude of regions, the practice of craft manufacturing provides a means of subsistence for rural populations and serves to empower individuals who are marginalised within their communities. Initiatives of this nature are conducive to the realisation of sustainable development objectives, given their capacity to encourage inclusive economic growth, gender equality and cultural preservation.

2.4 Traditional Embroidery and Textile Crafts as Sustainable Systems

The domain of sustainable design encompasses a broad spectrum of research inquiries, in which traditional embroidery and textile crafts form an important constituent part. Historical records demonstrate that a number of embroidery styles have emerged in domestic settings focused on conserving resources and practicing material reuse. Kantha embroidery is an important textile recycling method practiced in eastern India, in which second-hand fabric is carefully combined to create quilts and textile patterns (Singh, 2013). Recent scholarly research indicates a high degree of association with sustainable fashion concepts in the context of reducing waste, minimizing carbon footprint in the production process, and promoting community-based artisanal practices.

In addition, an increasing number of research studies in the field of sustainable textile design focus on the revival of traditional embroidery styles. Singh and Singh's (2025) bibliometric analysis of over four thousand publications on embroidery and sustainable design identified important

research streams in the context of heritage conservation, sustainable use of resources, and artisan emancipation. The research analysis indicates that traditional embroidery styles have the potential to generate important insights for sustainable manufacturing methods. It is evident that traditional textile crafts have significant cultural and symbolic value beyond their association with sustainable design concepts. Craft artifacts often have an important role in representing cultural narratives that reflect community values and historical experiences. These cultural aspects of traditional textile crafts highlight the need for preserving traditional knowledge while making it relevant in contemporary contexts.

2.5 Indigenous Craft Traditions in India: It is evident that India boasts a substantial and multifarious craft heritage, which has historically exerted a pivotal role in the nation's cultural and economic evolution. The intricacy of Indian textile crafts is well-documented, as is their regional diversity and deep cultural symbolism. A significant proportion of these crafts depend on natural materials, manual production methods, and conventional design patterns, thereby rendering them inherently congruent with principles of sustainable production (Muthu, 2021). There has been a marked increase in the exploration of Indian crafts in the context of their potential contribution to sustainable design innovation among scholars. In India, craft-based design endeavours frequently entail collaborative endeavours between designers, artisan cooperatives, and local populations with a view to the development of modern products grounded in time-honoured techniques. It has been demonstrated that these initiatives contribute to sustainable production whilst concomitantly aiding in the preservation of intangible cultural heritage, in addition to engendering new economic opportunities for artisans operating in rural areas (Bang et al., 2024).

Furthermore, the practice of reuse and recycling is a fundamental aspect of many craft traditions in India. The utilisation of remnant textile fragments in techniques such as patchwork, appliqué, and embroidery is a method of reducing material wastage, with the creation of new designs being a key benefit of this approach. This phenomenon serves to demonstrate the capacity of indigenous knowledge systems to inform contemporary sustainable design methodologies.

2.6 Sujni, Khatwa, and Madhubani Crafts of Bihar: Among the varied crafts of India, the textile and art tradition of Bihar may be regarded as an exemplary manifestation of culturally embedded sustainable design. Sujni embroidery, Khatwa, and Madhubani (Mithila) painting may be regarded as a manifestation of artistic expression and domestic crafts of the people of the region. Sujni embroidery is associated with the concept of textile reuse, an integral part of the sustainable design of the craft. In conformity with the tradition of the craft, the female artisans of the region reuse old and antique saris and fabric pieces by sewing them together with the aid of the running stitch to create quilts and other domestic crafts. The recent academic literature suggests that the Sujni artisans may be regarded as the guardians of cultural heritage, thus highlighting the significance of the craft in the context of the preservation of traditional knowledge systems (Muthu, 2021). The Khatwa technique of art may be regarded as a manifestation of the innovative reuse of fabric pieces to create intricate and visually attractive designs. In the context of sustainability, the Khatwa technique may be regarded as a pioneering manifestation of the concept of upcycling, in which waste materials are used to create new and artistic compositions. Madhubani painting, also known as Mithila art, is a prominent manifestation of the art tradition of the region. Madhubani paintings may be regarded as a manifestation of the vibrant colors and symbolic content of the paintings, depicting a range of themes and ideas derived from the realm of nature, mythology, and everyday life. This art tradition may be regarded as a manifestation of the commitment of the artisans of the region to tradition and the use of eco-friendly artistic techniques in the execution of the art. The academic literature suggests that Madhubani painting is a manifestation of the deep connection between the people of the region and the natural world. The cultural importance of these craftworks cannot be limited to environmental issues; instead, it has significant social and gender aspects as well. The role of women in craftwork and its propagation is central to this aspect, thereby making them important agents in women's empowerment and construction of community identity (Saxena & Pandey, 2024). The economic benefits that come with craftwork have made women economically independent and have helped in maintaining cultural values and social networking.

2.7 Design-Led Craft Innovation: Recent studies highlight the significance of design-led regeneration in traditional craft practices. It is evident that design interventions help in the reinterpretation of traditional craft practices in the context of modern product design, thus promoting the continued significance of crafts in the modern market. The design-led focus on innovation in crafts has been observed as the experimental use of new materials, new categories of products, and new processes of manufacturing. However, this focus on modernization is simultaneously linked with the need for the preservation of traditional crafts in terms of their cultural significance. For example, the use of eco-friendly materials, design software, and eco-friendly colors in the manufacturing process of crafts could be linked with the promotion of ecological sustainability while adhering to traditional notions of aesthetics. The use of hybrid approaches in design interventions highlights the capacity of traditional knowledge systems in crafts to accommodate modern technological advancements, thus promoting new forms of design interventions. The focus of design research on the use of participatory approaches, wherein artisans are actively involved in the process, is acknowledged as a practice that recognizes the significance of traditional knowledge systems in the promotion of ecological sustainability in the modern world. The integration of the expertise of traditional knowledge systems in crafts with modern design approaches could be linked with the promotion of new forms of sustainability in the modern world.

RESEARCH OBJECTIVES

- 1) To examine current research trends in sustainable design and indigenous crafts through bibliometric analysis.
- 2) To explore how Bihar's Sujni, Khatwa, and Madhubani craft practices can inform sustainable product and textile design through field insights and material experimentation.

3. RESEARCH METHODOLOGY

This study uses a combined qualitative–bibliometric approach, an ethnographic study of artisans in Bihar being complemented by a comprehensive bibliometric study of global sustainability and craft innovation literature for analytical work. The two-tier approach enables investigation of both experiential and scholarly knowledge systems.

3.1 Research Design: Methodological articulation unfolds in three sequential phases:

1. On-site investigation: The Sujni, Khatwa, and Madhubani arts were documented because of their embedded know-how, material use, and environmentally conscious practices.
2. Bibliometric Analysis: The study involved an in-depth analysis to find the prevailing global scholarly trends, influential publications, recurring themes, and conceptual relationships related to eco-friendly artisanal design.
3. Design Synthesis and Prototyping: The integration of insights from the two data streams allowed the development of guidelines and prototypes for sustainability-oriented design integrating bio-friendly and upcycled resources.

The study adopts a three-phase methodological framework integrating ethnographic fieldwork, bibliometric analysis, and design synthesis, as illustrated in Figure 1.

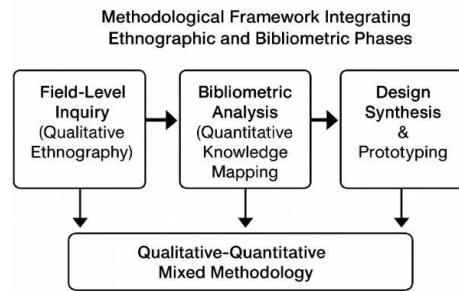


Figure 1. Three-Phase Methodological Framework Integrating Ethnographic Study, Bibliometric Analysis, and Design Synthesis.

3.2 Data Sources and Sampling Strategy

3.2.1 Primary Data (Ethnographic Fieldwork)

Primary data were collected through the following means:

- Interviews with 38 artisans were conducted in Muzaffarpur, Darbhanga, and Madhubani districts through semi-structured formats.
- Observation of stitching, dyeing, painting, and appliqué processes
- Photo documentation of evidence, with recording of manufacturing steps

Purposive sampling ensured inclusion of seasoned artisans versed in ancestral methodologies and ecological principles, such as organic dyes and waste reduction.

Table 1 lists the participants.

Table 1. Profile of Artisans Participating in the Study

District	Craft Forms Represented	No. of Artisans	Gender Distribution	Experience Range
Muzaffarpur	Sujni, Khatwa	12	10F, 2M	8–35 years
Darbhanga	Sujni, Madhubani	15	14F, 1M	5–40 years
Madhubani	Madhubani Painting, Khatwa	11	10F, 1M	7–50 years

3.3 Secondary Data (Bibliometric Dataset)

The bibliometric data were retrieved from Scopus and WoS using specific targeted search terms: "sustainable design," "craft-based innovation," "textile legacy," "Indigenous Crafts + Sustainability," and "circular design + crafts."

Inclusion Criteria:

- Peer-reviewed scholarly articles that undergo a critical review by experts in the field
- English-language periodicals
- Publication window: 2000–2024
- Indexed in Scopus or WoS

Exclusion Criteria:

- Editorials and reviews that are without empirical grounding
- Duplicate records
- Incompletely cited documents

Of these, 423 publications were identified to be suitable for analysis after screening. An overview of the dataset is given in Table 2.

Table 2. Bibliometric Dataset Description

Database	Initial Records	After Screening	Time Span	Document Types
Scopus	621	389	2000–2024	Articles, Reviews
WoS	248	182	2000–2024	Articles, Reviews
Total	869	423	—	—

3.4 Bibliometric Analysis Protocols

3.4.1 Methodological Framework: A set of standard bibliometric techniques was used to analyze co-authorship networks, co-citation structures, and bibliographic coupling. These procedures allowed the detection of clusters of collaborating researchers, influential authors, and the interrelationships among ideas within sustainability-focused craft research.

3.4.2 Data Pre-processing: Duplicates were removed from the Scopus and WoS records. Author names were standardized, and keyword terms were harmonized, aggregating such terms as "crafts," "traditional craft," and "handicraft." Exports in RIS and CSV format were subjected to a completeness check prior to analysis.

3.4.3 Network Construction and Thresholds: Bibliometric networks were constructed using minimum thresholds set (Table 3).

Table 3. Thresholds Applied for Bibliometric Network Construction

Analysis Type	Minimum Threshold	Purpose
Keyword co-occurrence	8 occurrences	Identify dominant themes
Author co-citation	20 citations	Identify influential authors
Source co-citation	25 citations	Identify foundational journals
Bibliographic coupling	10 shared references	Map intellectual connectivity

Network visualizations were created to show patterns of collaboration among people, document clustering by topic, citation rates, and document-to-document connections.

3.5 Qualitative Data Analysis

3.5.1 Thematic Coding

Interview data and field notes were analyzed using Braun and Clarke's 2006 thematic analysis method. Codes were organized into theme groups related to sustainability, including:

- Waste minimization
- Resource recycling
- Thematic, restorative storytelling
- Energy-efficient methods of production

3.5.2 Cross-Integration with Bibliometric Findings

Data triangulation was conducted to:

- Identify commonalities of globally well-researched sustainability themes with locally rooted artisan practices
- Verify field-level insights against wider academic discourse
- Formulate a concept of craft-based sustainability for design

4. RESULTS

The findings combine insights from the bibliometric review and ethnographic case studies to provide a comprehensive understanding of sustainability-oriented developments within Bihar's Sujni, Khatwa, and Madhubani handicraft traditions. The findings are organized into two major sections: bibliometric mapping and thematic analysis.

4.1 Bibliometric Analysis Results

This dataset consisted of 423 records from Scopus and WoS. Network visualizations along with the conceptual and collaborative dimensions within global research in eco-friendly craft-based design.

4.1.1 Co-authorship Network

Among the four dominant regions represented in Table 4, India is the country with the highest share of publications, which represents patterns of international collaboration. The largest shares of publications are contributed by India, the United Kingdom, and the United States, which says a lot about the wide global interest in crafts-based environmental applications.

Table 4. Summary of Co-authorship Patterns in Sustainability and Craft-Innovation Research

Region / Country	Key Contributing Authors (Examples)	Collaboration Characteristics	Approx. Publication Share
India	Multiple authors across sustainability–craft domain	Strong domestic collaborations, moderate global links	High
United Kingdom	Authors in eco-design and heritage studies	Cross-continental collaborations with EU/Asia	Medium
United States	Authors with sustainability and cultural studies focus	Limited cross-country connections	Medium
Asia–Europe Clusters	Distributed authors across design, sustainability	Regionalised cluster formation	Medium–Low

Key Observations

- The largest cluster is formed by the sustainability-design cohort.
- Asian and European research developments exhibit different sub-network formations, showing regionalization.
- Limited links between clusters indicate fairly restricted global integration within the field.

4.1.2 Keyword Co-occurrence Analysis

The keyword clusters through content-based analysis of co-occurrence are shown in Table 5. Fieldwork themes strongly correspond with these groupings.

Table 5. Keyword Co-occurrence Clusters in Global Sustainable Craft Research

Cluster	Thematic Label	Core Keywords	Interpretation
Cluster 1: Red	Sustainable Design & Circularity	sustainable design, circular economy, eco-innovation, material reuse	Emphasises material circularity and environmental design priorities
Cluster 2: Green	Indigenous Knowledge & Craft Traditions	traditional crafts, heritage textiles, indigenous knowledge, artisanal production	Reflects cultural preservation and knowledge-based sustainability
Cluster 3: Blue	Textile Design & Materiality	textile innovation, biodegradable materials, upcycling, slow fashion	Focuses on eco-materials and low-impact fashion systems
Cluster 4: Yellow	Community Empowerment & Livelihood	women artisans, livelihood, rural development, skill preservation	Highlights crafts as a socio-economic sustainability mechanism

Additional Insights

- The two most frequent keywords are "sustainable design" and "traditional crafts," underscoring relevance.
- Overlay visualization shows the paradigm shift from a "craft preservation" paradigm during 2000–2010 to a "sustainable innovation" paradigm during 2016–2024.

4.1.3 Co-citation Analysis

Table 6 provides a succinct overview of the leading authors and the journals that form the core of the co-citation framework.

Table 6. Frequently Co-cited Authors and Journals in Craft-Based Sustainability Research

Author / Journal	Citation Influence	Contribution to the Field
Manzini	High	Eco-design theory, sustainable systems thinking
Papanek	High	Ethical and human-centred design frameworks
Fletcher	High	Sustainable fashion and ecological textile innovation
Journal of Cleaner Production	High	Foundational research in sustainability and circularity
Sustainability (MDPI)	High	Broad coverage of eco-design, social sustainability
Design Studies	Medium–High	Cultural and design methodology scholarship

Findings

- Frequently cited authors include sustainability theorists such as Manzini, Fletcher, and Papanek
- Journals such as the Journal of Cleaner Production, Sustainability, and Design Studies form tightly linked clusters.
- The co-citation structure represents a mature but constantly developing research domain.

4.1.4 Bibliographic Coupling of Documents

The principal bibliographic-coupling subjects and their shared reference sections are defined by Table 7.

Table 7. Bibliographic Coupling Themes and Shared Research Areas

Coupling Theme	Shared Reference Basis	Insight Derived
Material Circularity	Studies on eco-materials, recycling, circular design	Strong global trend toward circular resource application
Artisan Innovation	Craft revitalisation, hybrid techniques, adaptive design	Reinforces emerging interest in innovation within traditional craft systems
Cultural Sustainability	Heritage preservation, narrative design, intangible culture	Links ecological design to cultural identity and storytelling
Eco-Design Methodologies	Sustainable product frameworks, low-carbon practices	Represents the methodological backbone of sustainable craft design research

Key Insights

- Considerable overlap of references among the core documents, showing the relations among design papers from 2018 to 2023 and
- hotspots on "material circularity" and "artisan innovation," which goes to reinforce growing interest in the circularity of craft design.
- This supports integrating global sustainability theory with Bihar's traditional craft systems.

4.2 Qualitative Results from Artisanal Fieldwork

Observations from 38 artisans across Muzaffarpur, Darbhanga, and Madhubani show that sustainability is a constituent element of their practice.

4.2.1 Waste-Minimising Material Practices

A number of common resource-efficient practices include:

- Reuse of leftover yarns from Sujni embroidery Fabric scraps are used in Khatwa appliqué.
- Application of natural pigments in Madhubani painting

These practices have continuously been improved and are in line with international eco-design standards (Table 8).

Table 8. Waste-minimising Practices Observed Across Craft Clusters

Craft Form	Identified Sustainable Practice	Description
Sujni	Thread reuse	Leftover threads used for filler stitches, reducing wastage
Khatwa	Scrap appliqué	Small fabric remnants repurposed into motifs
Madhubani	Natural dyes	Plant-based pigments and cow-dung treated surfaces

4.2.2 Low-Energy, Handcrafted Production Systems

Artisans predominantly employ traditional techniques of hand stitching, manual appliqué, and brush-based painting that minimize electricity use. These findings correspond to the association of Cluster 3 with “slow fashion” and “low-carbon production.

4.2.3 Motif-Based Regenerative Storytelling

Field observations identify motifs that deliver environmental information: fish and peepal in Madhubani symbolize regeneration; sun motifs represent energy cycles; Sujni weaving is a form of communal reminiscence that matches the connections made between traditional crafts and “cultural sustainability” discussed in Cluster 2.

4.2.4 Skill Transmission and Women’s Economic Empowerment

Interviews reveal that 90% of artisans are women, and craft practice is a source of financial autonomy. Daughters are informally trained by mothers at home. The above finding consolidates Bibliometric Cluster 4 on crafts as drivers of rural empowerment.

4.3 Integration of Bibliometric and Field Findings

A striking correspondence arises between global research themes and the artisanal practices of Bihar.

- Thematic bibliometrics → Field insights
- Circularity: use of residual and eco-friendly materials
- Ancestral knowledge passed down through generations
- New materials appeared: organic dyes, manually processed surfaces
- Community development: women-led artisan groups

This convergence indicates that the traditional crafts of Bihar can be shaped well within the contemporary eco-design framework.

5. Discussion

The present study illustrates that Bihar's traditional arts of Sujni, Khatwa, and Madhubani embody sophisticated and sustainable design. The findings are in line with those from other studies on eco-friendly design, circular approaches to material usage, and design with cultural heritage at its base. In this chapter, the concepts, materials, and economics relevant to integrating traditional handicrafts into modern sustainable-design frameworks are explained.

5.1 Traditional Craft Practices as Embedded Sustainability Systems: The keyword clustering analysis reveals distinct thematic groupings within the literature, demonstrating a strong convergence around sustainability, traditional craftsmanship, and design innovation as central research domains. These concepts are more than abstract ideas; they reflect concrete practices identified within each of the three craft traditions researched. Field observations show that Sujni, Khatwa, and Madhubani artisans already practice resource-efficient principles such as:

- Reuse of leftover threads
- Remaking textile remnants
- Production with organic pigments and manual techniques

These practices reflect globally recognized eco-friendly strategies that have been highlighted in the literature, particularly those associated with ecological design and perpetual-use paradigms. In this sense, Bihar's handicrafts represent indigenous manifestations of a local design paradigm predating contemporary sustainability discourses.

This corroborates an earlier debate challenging craft traditions as inconsequential and adds nuanced insights within an Indian context (Fletcher, 2016; Manzini, 2015).

5.2 Convergence Between Global Research Networks and Local Knowledge: The temporal distribution of publications suggests a significant growth in research interest in sustainable fashion and craft-based practices, especially from 2018 onwards. Cross-cultural comparisons highlight that many of the drivers for craft sustainability are indeed inherent within the artisanal practices of Bihar.

Key convergences include:

- The emphasis on biodegradable materials can be seen globally in natural dyes and natural-fiber textiles.
- Sujni and Khatwa are forms of upcycling through which waste materials have been innovatively transformed into motifs.
- Ecological narratives undergird regenerative design in the use of Madhubani motifs.

These findings indicate that traditional crafts are not simply remnants of the past, but rather active manifestations of enduring and emergent ideas. This challenges the prevailing assumption in the global design discourse that sustainable innovation is predominantly created in technologically advanced contexts.

5.3 Craft as a Socio-Economic Catalyst for Sustainable Development: The bibliometric cluster related to community empowerment most closely corresponds to the field observations that indicate how craft practice:

- Promotes economic independence for women
- Supports rural livelihoods
- Promotes intergenerational knowledge transmission in ecology

The fact that the majority of artisans are women, at about 90%, underlines the gender-sensitive character of these sustainable practices. This is in line with broader discussions in global scholarship, though more detailed examinations are comparatively rare.

The study thus contributes empirical evidence to theoretical models of sustainable design rooted in social relationships.

5.4 Motifs and Materiality as Vessels of Regenerative Knowledge

Deployment of ecological motifs such as fish, peepal, and the sun in Madhubani painting represents ways in which local environmental ethics become imbued in material culture. Bibliometric analyses identified “cultural sustainability” as an important yet fragmented theme, a finding reinforced by field data showing:

- Articulation of environmental metaphors through motifs
- Documentation of Sujni community memory by narrative stitching
- Appliqué layering in Khatwa, depicting human–nature interlinkages

These observations suggest that craft systems in Bihar have a function beyond aesthetic expression: they are repositories of knowledge with respect to regenerative design principles.

5.5 Toward a Craft-Based Sustainable Design Framework

Synthesis of findings from the two data sources reveals a number of principles pertinent to modern eco-design:

1. Incorporate design logics that prioritize material circularity, including reuse, repair, and repurposing.
2. Lower carbon footprints with handcrafted, low-energy production processes.
3. Apply narrative materiality using story-driven motifs that reinforce emotional resilience and are in service to cultural sustainability.
4. Embed innovations and designs within local knowledge rather than relying on external ideas.

These design principles serve as guidelines to create sustainable products that respect ancient history and do less harm to the environment.

The proposed design framework integrates sustainability objectives with the indigenous knowledge systems of Bihar craft communities, emphasizing the relevance of traditional practices in environmentally responsible product development.

6. Limitations and Scope of the Study

6.1 Limitations: Even though the study offers significant contributions to the domain of knowledge, it is necessary to recognize the limitations of the study to effectively position the findings within the realms of the domain. Firstly, the ethnographic study is geographically limited to the districts of Muzaffarpur, Darbhanga, and Madhubani. Even though these districts are significant hubs of the selected forms of artisanal crafts, the study does not recognize the complete gamut of crafting techniques that are employed across the state of Bihar or India as a whole. The usage of varied techniques and the employment of varied materials could provide varied insights regarding the sustainability parameters. Furthermore, the study focuses on the sample group of 38 artisans, which are selected using the purposive sampling technique. This is another limitation of the study from the domain of knowledge. Even though the sampling strategy was employed to select the sample group consisting of experienced artisans with high levels of traditional knowledge, the strategy could also be biased towards the selection of the artisans. The inherently subjective nature of ethnographic data is also significant from the domain of knowledge, as the data collected is qualitative in nature. Even though the thematic analysis employed in the study is consistent with the established frameworks (Braun and Clarke, 2006), the analysis and presentation of the data regarding the themes such as "cultural sustainability" or "regenerative storytelling" could be biased towards the factors such as researcher bias and understanding of the context. From the bibliometric point of view, the study is limited by the databases used, which are Scopus and Web of Science, as well as the focus on English-language publications only. These databases are well known for their comprehensive coverage of the field, though the lack of representation of regional journals, non-indexed publications, and vernacular publications is a major limitation of the study, as these may provide valuable insights into the sustainability of indigenous communities, an aspect of the overall field that is often neglected. Furthermore, the study has not extensively discussed some of the key aspects that are crucial for the successful implementation of the concept of sustainability, as discussed in the study, though not in detail, as they are not the main focus of the study, including the market forces that may act as a constraint, as well as the intellectual property rights of the artisans, which is an important aspect that may influence the sustainability of the system.

6.2 Scope for Future Research: Despite the aforementioned limitations, the present study opens up new avenues of future research and contributes to the ever-expanding literature on sustainable crafts and design innovations. Firstly, one of the major areas of future research is the expansion of the geographic scope of the study. It is suggested that the future study could be conducted on the basis of comparative inquiry over more than one Indian state or across the globe with respect to craft-based sustainability. This would enable the researcher to conduct cross-cultural replication and comparison of the sustainability strategies adopted by artisans across the globe. Another area of future research could be the inclusion of more diversified specimens of artisans with respect to different age groups, gender identities, and proficiency levels. This would enable the researcher to conduct a comparative analysis of the evolution of sustainability strategies over the course of the artisans' life span and the integration of traditional knowledge with modern design innovations and market requirements by the younger generation of artisans. It is also suggested that the future researcher could consider the longitudinal framework of inquiry to monitor the evolution of sustainability strategies over the course of time. This would be highly advantageous in understanding the effect of extrinsic factors such as climate change, digitalization, governmental regulations, and global market fluctuations on sustainable crafts. From the scientific viewpoint as well, there is immense scope to incorporate analytical tools such as life cycle analysis, carbon footprint analysis, and material flow analysis in the future study. These tools could provide the researcher with quantified evidence of the sustainable advantages of conventional artisanal techniques. It is also suggested that the bibliometric analysis could be extended to incorporate more databases such as Google Scholar, regional indexing services, and publications in languages other than English. The inclusion of diversified linguistic datasets could facilitate the researcher with the exchange of ideas with more individuals across the globe and provide deeper insights into the concept of sustainability.

7. Conclusion

The present study attempts to examine the possibility of sustainable design innovation in the current global scenario with specific reference to the traditional craft practices of Sujni, Khatwa, and Madhubani. By using a unique blend of ethnographic and bibliometric approaches, the study has managed to bring together different knowledge domains with the broader academic discussion on sustainability and design. The study reveals that the traditional craft practices of Sujni, Khatwa, and Madhubani are not mere cultural and aesthetic expressions but are in fact dynamic systems that embody deeply ingrained ecological, social, and material philosophies. What is most significant and seminal in the study is that it reveals that sustainability is not an extrinsic factor that is imposed on traditional craft practices but is in fact an intrinsic part of them. Observations made during the field study reveal that the traditional craft practitioners are already using many practices that are aimed at reducing waste, using recycled resources, and using low-intensity manufacturing technology. In Khatwa, the use of recycled fabric is an example of sustainability in practice, while in Sujni embroidery, the use of recycled threads is an example of sustainable practice. Similarly, in Madhubani painting, the use of eco-friendly dyes is an example of sustainability in practice. What is significant in this regard is that sustainability is an intrinsic part of the traditional practices and not an extrinsic factor that is imposed on them. Moreover, the bibliometric analysis that is part of the study reveals that there is a growing academic consensus on the importance of certain thematic clusters such as material circularity, indigenous knowledge systems, textile innovation, and community empowerment in assessing the value of traditional craft practices in addressing environmental issues. This is evident from the analysis of the existing literature on the subject. It is important to note that there is considerable similarity between such broad research paradigms and the prevailing practices in the state of Bihar, which emphasizes the importance and applicability of indigenous knowledge systems in the context of sustainability. This understanding transforms the prevailing perceptions of technology and industrialization as the driving forces behind sustainability and innovation. Instead, traditional arts are recognized as important contributors in the creation of a sustainable future. Another significant aspect of the study is related to the socio-economic aspects of sustainability. From the study, it is evident that the significance of women artisans emphasizes the importance of such practices in the creation of an independent economy. The significance of traditional arts lies in their ability to provide livelihood and sustenance as social systems, in addition to their role as modes of production. This understanding is significant in the context of sustainability, where such factors as environmental, socio-cultural, and economic sustainability are important. The present study is significant in the context of sustainability and traditional arts, as it provides empirical evidence in support of the holistic understanding of sustainability. This is evident in the manner in which environmental and socio-cultural sustainability are addressed in the context of traditional arts. The narrative and emblematic aspects of sustainability are emphasized in the context of traditional arts. These aspects are intricately linked with traditional arts. Motifs in Madhubani painting, stories in Sujni embroidery, and compositions in Khatwa are important in the context of sustainability. These factors extend the understanding of sustainability beyond environmental sustainability and encompass factors such as emotional sustainability and sustainability in narratives. Intangible aspects of sustainability are important in the context of traditional arts and sustainable design. These factors influence the manner in which sustainability is addressed in the context of product design. This study is important in the context of traditional arts such as Sujni, Khatwa, and Madhubani, as it emphasizes their potential in sustainable design innovation, which is yet to be fully exploited. This integration of the experiential fieldwork, along with the global scholarly perspectives, seems to be crucial in substantiating the importance of these methodologies. Additionally, it offers a framework for the integration of these practices into the contemporary design discourses. This paradigm shift in the understanding of crafts seems to be a crucial step in moving from the traditional crafts, which are associated with artefacts of the past, towards understanding them as living knowledge systems that have the potential for sustainability. The present study seems to hold importance in the sense that it adds another dimension to the

existing literature on sustainability, particularly in terms of the importance of adopting an interdisciplinary and culturally rooted approach towards the issue. The paper seems to propose a paradigm shift in terms of moving from technologically focused approaches towards the integration of various knowledge systems, which have in the past demonstrated the potential for sustainability in unique ways associated with their contexts. While dealing with the critical global environmental concerns, the lessons learned in these craft traditions hold significant importance in terms of developing sustainable, innovative, equitable, and sustainable systems.

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