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Review Article

Optimization of Hand Tools used in Handicrafts of Bihar for Improved Efficiency and Productivity: A Design Thinking- Led Review

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Abstract -*The handicrafts of Bihar, including Madhubani painting, Sikki grass work, Bhagalpuri silk weaving, stone work, and bamboo crafts, are an integral cultural heritage and a vital livelihood source for most craftsmen. Hand tools are the mainstay of these occupations, directly affecting artisans' production, product quality, and well-being. However, most tools are still based on orthodox designs that are not ergonomic in sophistication, lasting, and ineffective, causing physical strain, decreased productivity, and limited competitiveness in international markets. This paper analyzes the current status of hand tools empl oyed in Bihar's handicrafts, with critical issues like overloading, unsuitable grip design, and obsolete materials. This examines the use of Design Thinking methodology, an iterative human-centered process of enhancing tool design that involves ergonomics, material Design, and craft participation. The review, using national and international case studies, emphasizes that redesigning participatory tools has the potential to enhance production, facilitate safety, maintain cultural integrity, and enhance the socio-economic fabric of rural Bihar.*

Keywords - *Artisan productivity, Bihar handicrafts, Design thinking, Ergonomics, Hand tool optimization.*

1. Introduction

Bihar is famous for its centuries-long handicraft tradition, which not only provides it with a cultural identity but also sustains a livelihood for thousands of craftsmen. Madhubani painting, Sikki grass work, Bhagalpuri silk fabrics, stone carving, and bamboo crafts are only a few of the arts that have been passed through centuries. They keep the region's tradition and craftsmanship alive [1]. Hand tools are the most important part of making these handicrafts, and they directly impact the artisans' productivity, the quality of their work, and their health. The efficiency and ergonomics of these hand tools are important parameters. These parameters decide the competitiveness of the craft sector in the domestic or international market. Many tools are based on old Design and have not changed over time as per ergonomic requirements. These tools are valuable to culture but not necessarily adaptable to the needs of contemporary industry in terms of safety, comfort, and efficiency [2].

The most common issues are excessive weight, poor grip design, poor durability, and increased physical stress on artisans, particularly when they work for extended periods. All these constraints not only reduce productivity but also result in musculoskeletal diseases, fatigue, and occupational injuries. With global markets demanding better quality and quicker production, it is necessary to address all these tool-related issues so that Bihar's handicraft industry continues operating [3].

The Design Thinking approach, which is human-centered and repeatedly attempts things, is an effective approach to creating improved hand tools. Design thinking is based on empathy and integrates research, brainstorming, prototyping and testing. It promises that new ideas will work technically as well as be accepted culturally. Ideas developed through design thinking are simpler to use. Its application in handicraft industries balances traditional methods with modern ergonomics. It promotes the standard of living of the craft-persons, maintaining their authenticity [3].

This review attempts to assess the current scenario of tools used in the handicrafts sector in Bihar, study their shortcomings and find optimized designs through the design thinking process. Research will help in creating knowledge to enhance efficiency and productivity [4].

Research in states like Assam and Rajasthan and countries like Peru and Nepal has demonstrated the advantage of ergonomic interventions in the handicraft sector. A comprehensive study focusing on the case of Bihar's handicrafts is required, as artisans in Bihar still experience problems like musculoskeletal pain due to the use of unergonomic tools. These tools have a short lifespan and cause inefficient production. In this research, a unique evaluation by combining the design thinking process and ergonomic analysis to suggest tool optimization opportunities has been suggested. The research aims to fill the gap by focusing on Bihar's craft sector and providing practical recommendations to increase artisanal welfare, improve their productivity, and preserve cultural integrity.

The present review differs from previous research conducted in locations such as Assam and Rajasthan, Nepal and Peru, in that it focuses solely on Bihar's handicrafts. It is the first systematic attempt to suggest hand tool optimization by combining ergonomic assessment and design thinking framework in the craft sector.

2. Brief of Bihar's Handicrafts Sector

2.1. Historical and Cultural Importance

Prior studies in areas like Assam and Rajasthan have shown that making weaving shuttles and block-printing tools more comfortable can greatly reduce tiredness and boost production. Other such projects in Nepal and Peru have also shown the benefit of optimizing tools on the health of artisans. However, this research is limited to specific areas. In the case of Bihar, its handicraft traditional tools continue to be in wider use without a thorough assessment. This assessment is unique from the others as it applies a Design Thinking paradigm and ergonomic analysis to address the unique challenges in Bihar. This contributes to an important research and practice gap.

Bihar has a rich and long handicraft history that is of great significance to its culture and society. Archaeological evidence from sites such as Nalanda, Vaishali, and Vikramshila indicates that craft practice in the region dates back to the Mauryan and Gupta periods. Ancient literary accounts and travellers' descriptions mention skilled artists producing textiles, ceramics, metalwork, and decorative arts for local consumption and export. Bihar handicrafts are not just functional objects; they also tell, represent, and show who you are.

For example, female artisans in the Mithila region are responsible for making Madhubani paintings to highlight religious, mythological, and societal ideologies [5]. Sikki grass craft even employs unbridled golden-colored grass to create delicate household and decorative items that are greatly needed during celebrations and festivities. A number of studies have shown measurable improvements in artisan productivity and in their health parameters.

Bisht et al. (2019) showed that new chisel handles were easy to grasp for carpenters. It reduced pressure on their muscles and joints by 18%. Kone (2023) reported that lighter shuttles in Assam improved weaving speed by over 12%. Nakata (2020) also had comparable results, showing that block-printing tool cushion grips made muscles ache 30% less. Muthukumar et al. (2022) reported on ergonomic basket-weaving tools in Africa that maintained a neutral wrist position, allowing craftspeople to increase their working hours without added fatigue. These observations highlight the importance of holistic ergonomic treatments; however, such testimony is largely absent in Bihar's handicraft industry.

The visual sensibility behind these crafts is a combination of local traditions and external influences introduced to the region by traders, pilgrims, and royalty over time. Many forms of crafts have changed little in Design, methods, and themes; this has helped preserve the region in an authentic cultural state. People learn the skills within their families, generation by generation. This helps in the preservation of craft skills as well as strengthening the ties in the community. Handicrafts have also been economically important for Bihar for generations. They offer rural households means of earning and supplements to their livelihood. Handicrafts are also part of Bihar's intangible cultural heritage and are associated with the region's rituals, marriage and religious practices [6].

2.2. Types of Handicrafts

Bihar has a number of traditional art forms and crafts that have their own unique material use, techniques, and cultural significance. Some of these include:

2.2.1. Mithila Painting, also known as Madhubani Painting

Madhubani painting constitutes one of the most famous folk art forms in Bihar. It comes from the Mithila region. Paintings are generally based on mythology, natural elements and/or social events. These are known for detailed and fine line work, bright colours and symbolic motifs. In the past, people made them on walls and floors during festivals and ceremonies with natural dyes and brushes they prepared themselves. Madhubani paintings are made on paper, cloth, and canvas, and they are becoming known worldwide and can be sold [7].

Fig. 1 Traditional Mithila painting from Bihar depicting religious themes with natural colours and detailed line work.
(Source: https://cdn.rajasthanstudio.com/wp-content/uploads/2021/02/4-1-1024x576.png)

2.2.2. Sikki Grass Work

Sikki grass work makes baskets, boxes, toys, and decorative items out of wild grass that is golden in color. The craft is known for its unique coiling technique. It involves weaving grass strands together with coloured thread.

Fig. 2 Sikki grass artwork depicting Lord Krishna, highlighting the intricate coiling technique and traditional craftsmanship practiced by women artisans in Bihar.
(Source: https://5.imimg.com/data5/ECOM/Default/2025/5/512605060/VD/SC/EM/98960525/1-the-melodious-tunes-of-lord-krishna-in-sikki-grass-artwork-by-dhirendra-kumar-1000x1000.jpg)

Sikki work is mostly done by women in rural homes and is closely linked to marriage customs and holidays. Artisans are having difficulty as the wetlands are diminishing. To get good quality grass, they need to use sustainable farming methods [5].

2.2.3. Bhagalpuri Silk

People commonly call Bhagalpur the "Silk City of India" because it makes Tussar and mulberry silk fabrics. Bhagalpuri silk has a unique texture, natural colour and long lifespan. Weaving in sarees, scarves, and upholstery materials is done by local weavers, some of whom utilize traditional production looms, while others use newer weaving machines. This industry employs a lot of people, but it has to compete with synthetic alternatives and less expensive imports [8].

Fig. 3 Bhagalpuri silk fabric showcases natural colour, durability, and cultural importance in the weaving tradition of Bihar.
(Source: https://www.ssethnics.com/cdn/shop/products/fs2600202a1_grande.jpg?v=1679172705)

2.2.4. Stone Craft

People know that Bihar, especially the Gaya and Patna districts, is recognized for its stone carving. Artisans produce idols, architectural elements, and other practical items from black, gray, and pink stones obtained from local sites. The craft is closely associated with religious tourism, particularly at sites where Buddhists and Hindus embark on pilgrimages, where stone idols and other souvenirs are extremely popular. As the work is difficult, tool efficiency becomes important for ease of work [9].

2.2.5. Bamboo and Cane Work

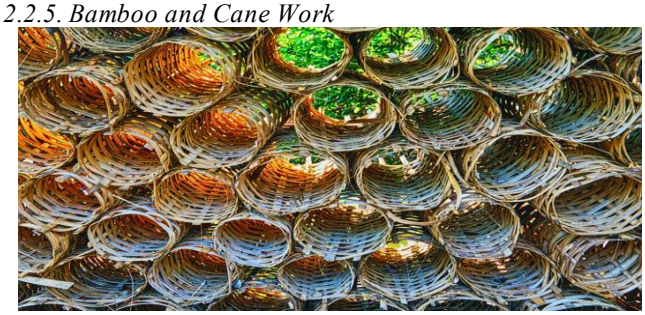

Fig. 4 Classic cane and bamboo craft from Bihar, illustrating handwoven baskets that reflect bamboo crafts' eco-friendly, sustainable, and versatile attributes in rural livelihoods.
(Source: https://images.pexels.com/photos/3290183/pexels-photo-3290183.jpeg?auto=compress&cs=tinysrgb&dpr=1&w=500)

In Bihar, people make furniture, baskets and decorative products using bamboo and cane. The craft is good for the environment and makes money, and it makes things that people in cities and towns want. Bamboo is useful for traditional and modern patterns; however, artists frequently use simple hand tools that limit their designs' complexity [10].

2.2.6. Lac and Metal Crafts

People in Muzaffarpur and Vaishali districts of Bihar make lac-based products like bangles, toys, and decorative pieces. Metal craft, such as brass and copperware, has been practiced in the region for several centuries [11]. These crafts are time-consuming and require precise tools. Tool optimization is thus essential to maintain high-quality products and ensure a comfortable workplace.

Fig. 5 Bihar's traditional crafts of lacquerware, such as painted wooden shrines, decorative bangles, and ornamented boxes, highlight the rich colors, delicate detailing, and cultural imagery of the region's artisanal heritage.
(Source: https://pbs.twimg.com/media/EetI4gwVAAAbb2i.jpg)

These crafts use different materials and methods, but they all face the same problems: old tools, hard-to-reach markets, and the need to come up with new ideas without losing the look of the old ones. Design thinking and technological intervention could help solve these problems and greatly improve artisans' productivity, quality, and lives [12].

2.3. Economic Aspects and Employment Opportunities

Bihar's handicraft industry is significant to rural economic welfare. It offers employment and also maintains cultural heritage in a sustainable manner. Reports indicate that the handicraft sector facilitates employment opportunities for thousands of families. There is a lot of demand for Bihar's handicrafts in India, and they could also do well on the international market. Madhubani paintings, Bhagalpuri silk and sikki grass products are often exhibited in trade fairs across the country and around the world. It also helps in generating foreign trade opportunities. Over the past ten years, the export of Bhagalpuri silk fabrics has developed significantly. The main markets are Europe, the USA, and Southeast Asia [13].

The sector also has a special ability to create jobs for everyone. Handicrafts usually take much work and do not cost much to start, thus they are easy for poor and marginalized populations to get into. Women make up a large share of the artisan labor, especially in crafts like Sikki work, Madhubani painting, and embroidery. This helps women become more economically independent and self-sufficient in rural areas.

Artisans can work on their crafts and farm at different times of the year, which means they can make money all year long. The sector also supports a number of other jobs, such as those that supply raw materials, create tools, trade, and transport goods. Although the industry supports the economy, it experiences problems such as a lack of access to the latest tools, unfavorable connections to markets, and difficulty accessing raw materials, that does not allow it to reach its full economic potential. With new designs, assistance from the government, and individuals being trained in new skills, we would be able to do a lot to enhance productivity and employment opportunities in Bihar's handicraft industry.

3. Existing Hand Tools in Bihar's Handicrafts

Hand tools are the most important part of handicraft production in Bihar. They affect the quality, productivity, and ergonomics of artisan work. The tools are very different depending on the craft, the raw material, and the stage of production. Most of them are operated by hand and are based on traditional knowledge that has been passed down through the years with few changes to the Design [14].

3.1. Classification of Tools based on Craft Type

3.1.1. Madhubani Painting

One of Bihar's most famous art styles is Madhubani painting, which uses a variety of simple yet very specific tools. In the past, people made bamboo nib pens by cutting the tip of a bamboo twig to make a tiny point for intricate line work. When it comes to filling large areas with color, people use either cotton tips or brushes made from natural fibers. Artisans grind natural pigments such as ground-up turmeric, soot, and indigo to create the colours in a mortar and pestle. The use of only manual tools means that it is the skill of the artist to ensure the precise Design and use of color [14].

3.1.2. Sikki Grass Craft

Sikki grasswork is the method of coiling and sewing golden-hued grass into beautiful and practical products. Blades of knives are the most important tools that are used when cutting the grass into equal lengths. Long, fine needles or awls are used to sew the coils together with brightly colored yarns. Craftsmen employ wooden molds or frames. It helps in making baskets, vessels, and figures. These tools are suited for domestic small-scale production because of their lightness and compactness [12].

3.1.3. Bhagalpuri Silk Weaving

Bhagalpuri silk weaving requires big hand-operated looms (such as pit looms and frame looms), which demand physical effort and coordination. Wooden or bamboo shuttles are used to create weft and warp. Reeds and heddles ensure the weave patterns are intact. Manually powered warping drums help to condition the warp threads for mounting on the loom. Each of the tools used is required to ensure the quality and the unique texture that Bhagalpuri silk is renowned for [15].

3.1.4. Stone Craft

In Bihar, especially in areas like Gaya with Nalanda, Bihar's stone craft utilizes heavy tools like chisels of various shapes and sizes to carve, cut, and fashion the stone. Wood and iron hammers are used to hit the chisels, and pointing tools and punches help in forming fine details. Rasps and files are utilized in the latter stage to smooth surfaces and sharpen edges. These tools demand physical strength and accuracy [16].

3.1.5. Bamboo and Cane Work

The bamboo and cane craftsman utilizes a mixture of cutting and shaping tools. The most frequent is the dao, a big, heavy knife used to split and shape bamboo poles. Hand planers are used to level surfaces. Measuring tools like scales or wooden jigs are used for proper sizing. There is a risk of cuts when splinters of bamboo are cut. Thus, it is very important to make tools safe and comfortable to handle [17].

3.1.6. Metal Craft and Lacquerware

Metal craftsmen use casting molds to melt metal and cast it in the desired forms, and then they employ chisels and burins (lithic flake) to put fine decorations on the surface. To obtain a bright, smooth finish, people usually make use of hand-cranked polishing wheels. The same type of engraving tools is

used in lacquerware, with sticks or brushes used to apply the lacquer. The tools used in such arts should be able to resist excessive heat and sustained use [16].

3.2. Materials used and Manufacturing Process

The hand tools used in Bihar's handicrafts are mostly made from cheap, locally available materials. This reflects the manner in which manufacturing within the area is dependent on the material. The artisan's having money to spare, the practical uses of the tool, and raw material availability in the rural and semi-urban marketplace all play a role in choosing the material. Bamboo and wood are two of the most common materials used to make hand tools for Bihar handicrafts. Wood is used by individuals, especially from sal, sheesham, and teak trees, because it is strong and resilient. This makes it good for tool handles, loom frames, and other structural parts. On the other hand, bamboo is preferred because it is light, flexible, and easy to shape. This is thus great for producing pen nibs for Madhubani painting, shuttle frames for weaving, and measuring templates for craft work using bamboo. Iron and mild steel are used greatly in an effort to make blades, chisels, engraving tools, and cutting knives because they are hard, lasting, and can maintain their sharp edges. Brass and copper are used in crafts because they do not rust easily and look aesthetically good. Granite and sandstone are used to make pigments in Madhubani paintings. These are also used for making mortar, pastels, and base surfaces for cutting and engraving. Cotton and natural fibres

Table 1. Classification of hand tools used in Bihar's handicrafts

Craft type	Primary tool	Function	Material used
Madhubani Painting	Bamboo nib pens, natural fibre brushes, mortar & pestle	Outlining, coloring, pigment preparation	Bamboo, cotton, stone
Sikki Grass Craft	Cutting knives, needles/awls, wooden frames	Cutting grass, stitching coils, shaping products	Steel, wood
Bhagalpuri Silk Weaving	Pit loom, shuttle, reeds, heddles, warping drum	Weaving silk fabric, maintaining the weave pattern	Wood, bamboo, steel
Stone Craft	Chisels, hammers, pointing tools, rasps/files	Cutting, engraving, and finishing stone	Steel, iron, wood
Bamboo & Cane Work	Dao knife, hand planer, measuring tools	Splitting, shaping, and smoothing bamboo/cane	Steel, wood
Metal Craft & Lacquerware	Casting moulds, engraving chisels/burins, polishing wheel	Shaping, detailing, finishing metal/lacquer items	Steel, brass, wood

They are used to make brushes. Leather or cloth wraps are commonly used around tool handles to make them easier to hold and grip when used for a long time [18]. Local blacksmiths, carpenters, and craftspeople use ancient methods to make these tools mostly by hand. To create metal tools, metal rods and/or sheet metal are first heated in a small furnace. Then forging and shaping are done with hammers and files, followed by sharpening. Wooden parts are curved and smoothed using hand planers, and bamboo portions can be cut, trimmed, and shaped using basic blades. Most tools will be made to work with the way artists work and what they enjoy. The absence of mechanization in manufacturing guarantees cultural authenticity, although it frequently leads to discrepancies in ergonomics, weight distribution, and finish quality [19].

3.3. Typical Design Features

The shape of hand tools used in Bihar's handicrafts greatly depends on each craft's needs, material availability in the locality, and traditional artisan practices that have evolved over the years. Most of the handles are in sal or sheesham type hardwoods and are shaped to fit the hand, though they do not always display good ergonomic shaping. Lightness and evenness are essential while designing weaving tools like shuttle frames or heddles. These are assembled with bamboo and wood to make them slender and balanced. Chisels and engraving tools have either single-bevel or double-bevel blades, depending on the degree of accuracy in work [20]. Blade sizes vary as per requirement. Some tools have a simple tang-and-handle Design in which a metal blade goes into a wooden handle and is held in place with glue or nails. By and large, surface finishing is unpretentious, and jagged edges are eschewed by buffing with sandpaper or natural oil. For pans employed for repetitive operations such as pounding or scraping, weight is typically slightly top-centered to give force to the blow. Cosmetic features are rarely added except when the pan is employed in a cultural exhibit, in which simple carvings or colored bands may be added. Design is otherwise functional, concerned with durability, repairability, and accommodation to the craftsman's workplace environment rather than of aesthetic sensibility [21].

4. Design Thinking Approach to Optimize Tools

Ergonomic examination of four main points is considered here: (i) comfort and ease of handling of the handle, (ii) weight and balance of the tool, (iii) ruggedness of the tool and suitability of material for the task, and (iv) minimizing muscle and joint stress with repetitive use. These points were chosen largely because they directly affect the health, productivity, and viability of handicraft activity in Bihar in the long run.

Table 2. Mapping of materials to tools used in Bihar's handicrafts

Material	Example tool	Crafts Where Used	Key Properties
Wood (Sal, Sheesham, Teak)	Loom frames, shuttle handles, and engraving tool handles	Bhagalpuri silk weaving, stone craft, and metal craft	Durable, easy to shape, good grip
Bamboo	Bamboo nib pens, shuttle frames, measuring templates	Madhubani painting, bamboo & cane work, weaving	Lightweight, flexible, eco-friendly
Mild Steel/Iron	Chisels, cutting knives, engraving burins, and a dao knife	Stone craft, sikki craft, metal craft	Strong, sharp edge retention
Brass/Copper	Decorative moulds, fine engraving tools	Metal craft, lacquerware	Corrosion-resistant, aesthetic appeal
Stone (Granite, Sandstone)	Mortar & pestle, grinding base	Madhubani painting pigment prep, stone craft	Hard, abrasion-resistant
Cotton/Natural Fibre	Brush tips, thread for binding handles	Madhubani painting, Sikki craft	Soft, absorbent, pliable
Leather/Cloth Wrap	Grip covers for tool handles	Multiple crafts	Improves grip, reduces slippage

4.1. Stages of the Design Thinking Process

Design thinking is a way to come up with new ideas that put people's needs first and focus on practical solutions. It is "a non-linear, iterative process that teams use to understand users, question their assumptions, redefine problems, and generate new ideas." It is widely used in product design, commercial innovation, teaching, and increasingly in the documentation and development of local practices, arts, and crafts. Design thinking is different from purely technical or top-down development procedures in that it places emphasis on understanding the needs and experiences of those for whom solutions are under development, in the case of the project, craftsmen and craft worlds [22]. It has been successful everywhere, for instance, in rural localization. Design Thinking is human-centric and iterative problem-solving. Using Design Thinking for better hand tools in India's interior handicraft sector establishes systematic ways to address chronic ergonomics, productivity, and safety issues. Generally, there are five steps in this process. Empathize: visit the artisan's workshop to learn about their needs, issues, daily work habits, and impacts through site visits, interviews, and direct observations. It means understanding pain points like the weights of tools, grip pain, and repetitive strain injuries [23]. Clarify: translate all ideas into clear problem statements, such as "Artisans experience pain in their wrist after using a chisel when they use it for an extended period of time because the tool is poorly designed," to ensure solutions respond to the most urgent needs. Ideate: to create as many different ideas as possible by brainstorming, co-creation sessions with artisans, or collaborating across fields. The more diverse the ideas are, the better. They can be anything, from lightweight composites to new geometries of handles. Prototype: creating real or mock models/mock-ups of promising concepts that are inexpensive and simple to experiment with, such as 3D-printed grips, re-balanced heads of tools, or interchangeable parts. Test: Place prototypes into the craftsman's everyday work to receive feedback on how comfortable, productive, and durable they are, and refine the designs incrementally over time to isolate the top-performing ones [24].

4.2. Examples of its use in Craft or Informal Sectors

Design Thinking has had a successful application in many rural and crafts-based industries to improve productivity, ergonomics, and sustainability, above and beyond conventional Design. In India, organizations like the National Institute of Design (NID), along with the Indian Institute of Technology (IIT), have used Design Thinking to make traditional weaving tools better in Assam and Gujarat. This has led to lighter shuttle looms, making the work easier and faster [24]. In Rajasthan, the method has been utilized to redesign block printing tables to adjust to different heights and have a firmer surface. This makes it easier for artisans to work and reduces pressure on their muscles and joints. Similar interventions have been reported globally [25], including in rural Kenya, where Design Thinking guided the creation of modular beekeeping tools to make them easier to use and increase honey production; in Indonesia, where bamboo weaving tools were redesigned to improve accuracy while

keeping traditional methods; in Nepal, where ergonomic pottery tools have lessened back strain among women potters; and in Peru, where hybrid knitting needles that combine traditional wood with modern polymer grips have made knitting more comfortable [26]. Those cases show that the focus of the approach on the user, combined with its iterative approach, is particularly suitable for rural and crafts-based environments, wherein innovation of novel concepts is finding the right balance between upholding traditional customs and handling limited resources.

4.3. Potential Benefits for Artisans in Bihar

Applying the Design Thinking approach to improve hand tools in Bihar's handicraft sector could provide local artisans with multiple opportunities for transformation. Improvements in tool design reduce physical stress, allowing artisans to work longer hours. Material innovation through the use of lightweight composites or eco-friendly bamboo allows for higher portability and handleability of tools, at the same time minimizing the costs of production. Improved tools can profoundly impact productivity by making blades sharper and longer-lasting, as well as sleeker operation mechanisms. In this way, artisans will be able to fulfil an increased demand while producing the same quality (National Handicrafts Development Corporation). Also, the participative approach of Design Thinking instils a sense of possession in craftspeople, as they themselves become part of ideation and testing. This makes it more likely that they will use the improved tools for a long time [27]. Better-designed tools will lead to high-quality and valuable products made by craftsmen. This will improve marketability. Economically, increased productivity linked to enhanced quality can translate into higher profits and increased market share both internationally and domestically. These benefits will promote local crafts, create interest in crafts among the younger generation, and help to bring socio-economic upliftment to rural Bihar [28].

For this study, the chosen case study followed three criteria: (i) relevance to tool ergonomics in the craft sector, (ii) presence of measurable outcomes, and (iii) contextual similarity to Bihar and its social-economic and artisanal practices. Consequently, studies conducted in Assam, Rajasthan, Nepal, Peru, and Kenya were included for comparison. The synthesis was achieved through consideration of the ergonomic aspects (e.g., weight, grip, durability and strain relief) from disparate studies and merging those aspects with Design Thinking. Therefore, knowledge from disparate fields can be safely applied to advance Bihar's handicraft industry.

5. A Detailed Analysis and Comparison

Quantitative findings concerning previous studies strongly support ergonomic intervention. Bisht et al. (2019) found that adjusted chisels reduced grip force by 18%, thus lessening musculoskeletal stress. Kone (2023) showed that lightweight shuttles increased weaving efficacy by 12%, while Nakata (2020) found that cushion blocks for block-printing reduced muscle stiffness by 30%. Ahmed et al. (2020) also found that Madhubani artists who used hybrid bamboo-polymer brushes were more accurate and did not get cramps in their fingers as often. Muthukumar et al. (2022) showed that using ergonomic basket-weaving tools led to working long hours without extra fatigue. Thus, we can conclude that tool optimization can improve ergonomics and productivity in the handicraft sector in Bihar.

5.1. Ergonomic Improvement Studies

Previous research on ergonomic improvements of hand tools employed in traditional crafts consistently showed that design modifications can significantly increase the comfort of craftsmen, reduce fatigue, and improve production. Bisht et al. (2019) made an anthropometric analysis of chisel handles used for woodcarvings at Saharanpur and found that by modifying handle diameters to conform to the mean width of the palms of local artisans, they reduced grip force by up to 18%, thus minimizing the likelihood of repetitive strain injuries. Kone, V. S. (2023) studied weaving shuttles from Assam and found that lightweight, ergonomic shuttles not only reduced wrist flexion strain but also contributed to speeding up weaving performance by up to almost 12%. C. Nakata (2020) upgraded block-printing tools in Rajasthan by adding padded grips and weight distribution modifications. Craftspersons indicated that changes enhanced muscle comfort by 30% during extended hours of work. W. Ahmed et al. (2020) reviewed hybrid bamboo–polymer paintbrushes used by painters from the Madhubani tradition. Their results showed that the brushes offered enhanced control over fine details of paintings and finger cramping reduction during hours of continuous use. International studies corroborate these findings; for instance, K. Muthukumar et al. (2022) reengineered African basket-weaving tools to preserve a neutral wrist angle, allowing craftspeople to extend their working duration without heightened tiredness. The studies collectively indicate that ergonomically optimized tools will improve the health and well-being of craftsmen, improving productivity.

5.2. Material Innovation Studies

Development of materials utilized to manufacture hand tools has taken remarkable prominence to increase tool durability to be used in handicraft industries, enhance user-friendliness, and ensure environmental sustainability. An array of research-based studies has investigated replacing standard materials with superior or composite materials to meet universal problems such as wear, corrosion, and unnecessary weight. G. Ramakrishnan et al investigated substituting mild steel blades of woodcarving chisels with high-carbon steel, achieving a 40% increase in edge retention and less frequent sharpening. P. Micheli et al researched the application of bamboo–epoxy composite to tool handles for weaving looms and reported that they provided improved shock absorption and were 25% lighter compared to conventional hardwood handles, thus decreasing artisan

fatigue. K. Muthukumar et al substituted iron with stainless steel scrapers for pottery tools. This leads to higher corrosion resistance and better use life in a humid environment. Maneiah et al. (2020) researched green polymer bamboo composite to use in the handle of Madhubani painting brushes. It displayed adequate stiffness and was aligned with green sustainable manufacturing. K. Muthukumar et al. proved the effective use of recycled aluminum in the frame of Scandinavian cloth-based textile tools, obtaining lightweight without sacrificing strength. These studies demonstrate that novel materials can transform challenges to traditional tools into opportunities for environmental sustainability. It is of particular value to the handicraft industry of Bihar, for which the twin goals of productivity and cultural preservation hold topmost centrality [39].

5.3. Technology as an Enabler in Hand Tools

With hand tools, technology can enable precision, productivity, and user comfort without substituting manual labour. Research in this area often focuses on cheap, locally adaptable technologies to achieve acceptability by craftsmen. A semi-mechanized spinning wheel created by Kone, V. S. 2023 increased thread production rates by 35% in weaving clusters. Yadav et al. (2023) designed an LED-based magnifying device for fine stitching. Craftsmen were able to achieve precision even in low-light environments. Choubey, A. S. 2003 tested rotary tool holders powered by replaceable batteries in woodcarving. The holders enable craftsmen to perform detailed tasks twice as quickly as they could with mere hands. For crafts like Madhubani painting, research has focused on the micro-heating elements in pigment-mixing devices to render them more reliable and reduce drying times. It was especially useful when it was humid. Yadav et al. (2023 successfully integrated sensor-based feedback mechanisms into leather-cutting machines. It helped artisans manage the pressure of the cuts. All of these new ideas show that using the right technology can connect old ways of doing things with new and efficient ways.

Table 3. Comparison of different studies on hand tool optimization

Study	Tool study	Methodology	Key findings
(Bisht et al., 2019)	Wooden chisel handles	Handloom weaving (incl. flying-shuttle operation)	Contoured handles of the chisel minimize muscle load and enhance comfort and precision.
(Yota et al., 2025)	Cloth-pulling device for the silk weaving process	Ergonomic Design and lab testing (F1000Research, open access PDF)	Ergonomic tool minimized effort and improved efficiency - documentation of productivity through weaving-tool redesign
(Meena et al., 2015)	Block printing tools	Ergonomic handle redesign, risk assessment (open PDF)	Redesigned, contoured grips reduced fatigue and improved control in block printing operations
(Ichim et al., 2014)	Bamboo–polymer brushes for Madhubani painting	Materials study with performance criteria (MDPI Polymers)	NFRCs (e.g., bamboo fiber composites) offer lighter and stiffer handles, and support improved grip for craft tools/brushes.
(Srivani et al., 2024)	Hand block-printing (Kalamkari) workstation/tools	Ergonomic assessment & intervention in the Indian craft cluster	Ergonomic improvements to tools/work surfaces cut musculoskeletal risk and improve task efficiency
(Pandit et al., 2013)	Handloom weaving (incl. flying-shuttle operation)	Field ergonomics + design-issues mapping (open PDFs)	Identified high strain at shuttle operations; recommends lighter/better-balanced shuttle & handle redesign to reduce MSDs and improve throughput.

This makes Bihar's handicrafts more competitive in both domestic and international markets.

5.4. Comparative Study

Comparative studies show consistent ergonomic advantages. Redesigned tools reduce musculoskeletal strain by 20 to 30%. It increases productivity by 10 to 15% on average. Bisht et al. (2019) showed an 18% reduction in grip force from the optimized chisels. Kone (2023) showed a 12% improvement in weaving productivity through the use of lightweight shuttles. Nakata (2020) showed a 30% reduction in muscle fatigue from cushion-gripped block-prints.

Collectively, these outcomes indicate that ergonomic changes deliver quantifiable gains in artisans' well-being as well as productivity, yet similar data for the handicraft sector of Bihar is still lacking. This underscores the necessity for systematic ergonomic validation tailored to the region.

5.4.1. Bihar vs. Other States

Bihar's handicraft industry has a lot of cultural history, but has a harder time designing tools than states like Gujarat, Rajasthan, and Assam. Most of the tools in Bihar have not changed much. For instance, weaving shuttles have been reinvented in Assam using lightweight bamboo-composite mixes [37]. In Bihar, however, the use of bulky wooden shuttles is still prevalent. Similarly, even though the block-printing equipment in use in Rajasthan is modernized by replacing cushion grips, brushes employed to deliver paintings of the Madhubani genre in Bihar are yet to be modernized through ergonomic design modifications in bamboo grips.

5.4.2. Traditional vs. Optimized Tools

Most of the traditional tools in Bihar are created from materials that are easily available. But they are not so heavy, easy to hold, or precise. Optimized tools, on the other hand, have ergonomically shaped handles, long-lasting material, and even mechanized elements at some point.

This makes them more productive and less tiring. An example would be replacing the handle of a hardwood chisel with a polymer-wood composite designed to fit the hand better to make it much easier to hold without altering the integrity of the craft.

5.4.3. Manual vs. Semi-Mechanized Tools

With manual tools, artists have full control of their products, yet it consumes a lot of physical effort and time. Semi-mechanized tools, such as battery-powered rotating attachments for carving [21], or foot-operated spinning wheels with motors, help make work easier and increase productivity. But semi-mechanized tools need an initial

Table 4. Comparison of Bihar's Hand Tools vs. Other Categories

Aspect	Bihar (traditional)	Optimized within Bihar	Other States (Optimized)	Semi-mechanized
Material	Local wood, bamboo, mild steel	Hybrid bamboo–polymer, stainless steel	Composite materials, treated hardwoods	Mixed metals, composites
Ergonomics	Basic handles, no cushioning	Anthropometric grips	Cushioned/contoured grips	Adjustable, powered mechanisms
Durability	Moderate, prone to wear	Improved via material innovation	High durability with treated or composite materials	High, but requires maintenance
Productivity	Low to moderate	Moderate to high	High	Very high
Cost	Low	Moderate	Moderate to high	High
Training requirement	None (traditional skills)	Minimal adaptation needed	Minimal to moderate	Moderate to high

Investment, technical training, and upkeep might not be possible for all groups of artisans.

6. Discussion

The research shows that the tools in the handicraft sector in Bihar need upgradation on ergonomic parameters. In places like Assam and Rajasthan, lightweight shuttles and cushioned block-prints have increased productivity by about 10% to 30%. Ergonomic basket-weaving tools in Africa and hybrid bamboo-polymer brushes in Peru have made it easier on the muscles and bones of workers around the world while allowing them to work longer hours. On the other hand, Bihar still uses heavy, unmodified wooden tools, which is why its artisans are still tired and have health problems at work. This apparent difference shows how much Bihar needs systematic ergonomic intervention.

This review makes a new contribution by explicitly merging Design Thinking ideas with ergonomic assessment. Previous publications have only looked at certain crafts or locations. This comprehensive framework makes it easier to find artisan pain spots, rank tool redesign features, and adjust to Bihar's socio-economic situation. The study puts Bihar's handicraft sector in a good position to take advantage of proven global advances while keeping its cultural identity by aligning its methods with the latest ergonomic strategies.

An important limitation of such analysis is that it lacks primary field evidence from Bihar craftsmen. Compiling secondary research adds fruitful direction, but valid verification requires experimental tests and participatory design trials by local crafts groups. Therefore, future research must focus on pilot treatments that involve craftsmen in co-design protocols and the physical outcomes of ergonomic improvements. Such activity will render scientific and practical grounds for raising the welfare of craftsmen and maintaining Bihar's handicraft industry.

7. Limitations and Research Gaps

Interest in making the hand tools of the handicraft industry more productive and efficient is present, yet issues remain with the research that has already been conducted. One significant issue is that ergonomic issues specific to the populations of artisans are nevertheless not adequately addressed. Some studies emphasize material strength or mechanical effectiveness while omitting detailed ergonomic analyses conducive to specific work postures, tool handling, and environmental conditions [10].

A notable deficiency exists due to the lack of extensive anthropometric data for artisans in Bihar. Without accurate hand size, grip strength, and body position measurements, tool design generally uses general or borrowed data sets, which can lead to tools that do not fit the intended users well [5].

Besides, minimal co-design or participatory Design includes craftspeople being involved in the ideation and prototyping stages. Most interventions are top-down, with engineers or designers leading development without close collaboration with end users over the long term. This could result in tools that do not align with cultural values, skill sets, or user preferences [8].

Finally, field testing and taking in user feedback are still not going that well. Prototypes are usually tested in controlled environments, but ongoing testing on-site with feedback loops occurring repeatedly is rare. This makes it more difficult to refine tools for hard use, comfort, and performance in real life, which leads to many new ideas going unused or abandoned by the artisan community.

8. Conclusion

This analysis points out that upgrading hand tools in Bihar's handicraft industry can profoundly improve artisans' comfort, efficiency, and precision. Technological upgrades in ergonomics, innovations in materials, and judicious use of technology have been demonstrated to simplify work procedures, reduce fatigue, and enhance safety while remaining loyal to traditional techniques. Comparative case studies indicate that those localities employing optimized tools and participative design methods possess higher production volumes as well as higher satisfaction levels amongst artisans. It points to the possibility of Bihar gaining by adopting analogous techniques. Also, application of Design Thinking principles, including empathy, ideation, prototyping, and testing, ensures that changes in tools are user-friendly, culturally appropriate, and durable. Such changes maintain customary techniques while rendering handicrafts lucrative, thus enabling artisans to meet the requirements of modern markets. By fostering co-design processes, ergonomic training, and increased access to better quality material and tools, policymakers and concerned organizations can ensure retention of culture in addition to socio-economic development.

References

[1] Serkan Bayraktaroğlu, *Actors of Rural Innovation: Bamboo Craft Initiatives from Northeast India*, Rural Areas: An Overview, pp. 145-190. [Google Scholar] [Publisher Link]

[2] Time Brown, *Design Thinking*, Harvard Business Review, vol. 86, no. 6, pp. 1-11, 2008. [Google Scholar] [Publisher Link]

[3] Jaya Jaitly et al., "Craft Designs and Development: A Search for Values," *Journal of Design History*, vol. 2, no. 2/3, pp. 169-174, 1989. [CrossRef] [Google Scholar] [Publisher Link]

[4] Manika Walia, Sachin Datt, and Tejwant Brar, "Comparative Analysis of Design Thinking Process And Traditional Craft Practices Of Rajasthan," *ShodhKosh: Journal of Visual and Performing Arts*, vol. 5, no. 1, pp. 1262-1275, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[5] Archi Banerjee, and Francesco Mazzarella, "Designing Innovative Craft Enterprises in India: A Framework for Change Makers," *She Ji: The Journal of Design, Economics, and Innovation*, vol. 8, no. 2, pp. 192-216, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[6] Uma Shankar Yadav et al., "Digital and Innovative Entrepreneurship in the Indian Handicraft Sector after the COVID-19 Pandemic: Challenges and Opportunities," *Journal of Innovation and Entrepreneurship*, vol. 12, pp. 1-40, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[7] Priti Suresh Rao, *Connecting the Dots: A Design Approach to Services for the Poor*, Northumbria University, pp. 1-245, 2012. [Google Scholar] [Publisher Link]

[8] Harita Kapur, and Suruchi Mittar, "Design Intervention & Craft Revival," *International Journal of Scientific and Research Publications*, vol. 4, no. 10, pp. 1-5, 2014. [Google Scholar] [Publisher Link]

[9] Jahangir Ahmad Bhat, and Pushpender Yadav, "The Sector of Handicrafts and its Share in Indian Economy," *Arabian Journal of Business and Management Review*, vol. 5, no. 5, pp. 1-6, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[10] John Harris, "Meeting the Challenges of the Handicraft Industry in Africa: Evidence from Nairobi," *Development in Practice*, vol. 24, no. 1, pp. 105-117, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[11] Tirthankar Roy, "De-Industrialisation: Alternative View," *Economic and Political Weekly*, vol. 35, no. 17, pp. 1442-1447, 2000. [Google Scholar] [Publisher Link]

[12] Syed Khalid Hashmi, "Market for Indian Handicrafts," *Excel Journal of Engineering Technology and Management Science*, vol. 1, no. 1, pp. 1-7, 2012. [Google Scholar] [Publisher Link]

[13] Dhananjay Singh Bisht, and Mohammed Rajik Khan, "A Novel Anatomical Woodworking Chisel Handle," *Applied Ergonomics*, vol. 76, pp. 38-47, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[14] Wuttichai Yota, Manida Swangnetr Neubert, and Teeraphun Kaewdok, "Ergonomic Design and Evaluation of Cloth-Pulling Devices for Praewa Silk Weavers," *F1000Research*, vol. 14, no. 144, pp. 1-32, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[15] A. Santana et al., "Costing Models for Capacity Optimization in Industry 4.0: Trade-Off between Used Capacity and Operational Efficiency," *Procedia Manufacturing*, vol. 13, pp. 1183-1190, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[16] Zihao Cao, and Muhizam Bin Mustafa, "A Study of Ornamental Craftsmanship in Doors and Windows of Hui-Style Architecture: The Huizhou Three Carvings (Brick, Stone, and Wood Carvings)," *Buildings*, vol. 13, no. 2, pp. 1-17, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[17] A.G. Rao, Tools, Small Technologies and Design for Bamboo Craft: Indian Experience, World Bamboo Congress, pp. 1-14, 2004. [Online]. Available: https://agrao.in/images/Articles/OnBambooToolsDesignEtc-IndianExperience.pdf

[18] S. Venkataramanaiah, and Ganesh Kumar Nidugala, "Approaches for Enhancing Competitiveness of Moradabad Handicrafts Manufacturing Units," *International Journal of Technology Management & Sustainable Development*, vol. 15, no. 3, pp. 253-273, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[19] Avinash Sahu, and Sangeeta Pandit, "Development of a New Wax Thread Extruder Machine to Enhance Productivity and Reduce Muscular Strain in the Dhokra Handicraft Process: An Unorganised Sector in Indian Handicraft Industry," *Ergonomics*, pp. 1-23, 2025. [CrossRef] [Google Scholar] [Publisher Link]

[20] Meenal Pachory Pandey, and Uzma Hasan, *Empowering Indian Traditional Handicrafts through Digitalization*, *Digital Cultural Heritage*, pp. 40-56, CRC Press, 2024. [Google Scholar] [Publisher Link]

[21] Asha Shukla Choubey, "Technology and Culture among the Iron Workers of Bihar during the Seventeenth and Eighteenth Centuries," *The Medieval History Journal*, vol. 6, no. 1, pp. 75-109, 2003. [CrossRef] [Google Scholar] [Publisher Link]

[22] R. Wolniak, "The Design Thinking Method and its Stages," *Production Engineering Support Systems*, vol. 6, no. 6, pp. 247-255, 2017. [Google Scholar] [Publisher Link]

[23] Lukas Waidelich et al., "Design Thinking Process Model Review," *2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)*, Stuttgart, Germany, pp. 1-9, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[24] Uma Shankar Yadav et al., "Entrepreneurship in India's Handicraft Industry with the Support of Digital Technology and Innovation during Natural Calamities," *International Journal of Sustainable Development & Planning*, vol. 18, no. 6, pp. 1777-1791, 2023. [Google Scholar] [Publisher Link]

[25] Katja Thoring, and Roland M. Müller, "Understanding Design Thinking: A Process Model based on Method Engineering," *DS 69: Proceedings of E&PDE 2011, the 13th International Conference on Engineering and Product Design Education*, London, UK, pp. 493-498, 2011. [Google Scholar] [Publisher Link]

[26] Neha Singh et al., "Finding a Digital Silver Line During COVID-19 Pandemic: A Case of Madhubani Paints," *Emerald Emerging Markets Case Studies*, pp. 1-26, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[27] Chanakya Mehta, and Khanjan Mehta, "A Design Space and Business Strategy Exploration Tool for Infrastructure-based Ventures in Developing Communities," *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, vol. 6, no. 2, pp. 1-28, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[28] Zyad El Jebbari, "*State of the Art of Supply Chains and Network Design Optimization in Emerging Economies: An Indian Case Study*, Master's Thesis, Massachusetts Institute of Technology, pp. 1-67, 2016. [Google Scholar] [Publisher Link]

[29] Souleymane Kone, "Energy and Environmental Impact of the Future Mega-Data Center on Ivorian Territory," *Research Management*, In Press, pp. 1-21, 2023. [Google Scholar] [Publisher Link]

[30] Cheryl Nakata, "Design Thinking For Innovation: Considering Distinctions, Fit, And Use In Firms," *Business Horizons*, vol. 63, no. 6, pp. 763-772, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[31] Waqar Ahmed, Arsalan Najmi, and Minhaj Ikram, "Steering Firm Performance through Innovative Capabilities: A Contingency Approach to Innovation Management," *Technology in Society*, vol. 63, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[32] Krishnamoorthy Muthukumar et al., "Ergonomic Assessment of Handloom Silk Saree Workers," *Materials Today Proceedings*, vol. 64, no. 1, pp. 771-780, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[33] G. Ramakrishnan et al., "A Critical Access on Improving Productivity and Livelihood of Handloom Weavers," *International Journal of Engineering and Advanced Technology*, vol. 8, no. 6s, pp. 403-405, 2019. [CrossRef] [Publisher Link]

[34] Pietro Micheli et al., "Doing Design Thinking: Conceptual Review, Synthesis, and Research Agenda," *Journal of Product Innovation Management*, vol. 36, no. 2, pp. 124-148, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[35] D. Maneiah et al., "Process Parameters Optimization of Friction Stir Welding for Optimum Tensile Strength in Al 6061-T6 Alloy Butt Welded Joints," *Materials Today: Proceedings*, vol. 27, no. 2, pp. 904-908, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[36] M.L. Meena, G.S. Dangaych, and A. Bhardwaj, "An Ergonomic Approach To Design Hand Block Tool for Textile Printing Handicraft Industry," *International Journal of Recent Advances in Mechanical Engineering*, vol. 4, no. 4, pp. 19-30, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[37] Mariana Ichim, Emil Ioan Muresan, and Elena Codau, "Natural-Fiber-Reinforced Polymer Composites for Furniture Applications," *Polymers*, vol. 16, no. 2, pp. 1-35, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[38] Thadepalli Srivani, and Sundarvel Amsamani, "Ergonomic Interventions in Kalamkari Block Printing: Addressing Challenges and Preserving Tradition," *Ergonomics*, vol. 68, no. 10, pp. 1583-1605, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[39] Sangeeta Pandit, Prakash Kumar, and Debkumar Chakrabarti, "Ergonomic Problems Prevalent in Handloom Units of North East India," *International Journal of Scientific and Research Publications*, vol. 3, no. 1, pp. 1-7, 2013. [Google Scholar] [Publisher Link]

[40] Jeanne Liedtka, "Why Design Thinking Works," *Harvard Business Review*, vol. 96, no. 5, pp. 72-79. 2018. [Google Scholar] [Publisher Link]