P3 REPORT

Furniture Design with Banana Stem Fibers

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Approval

This is to certify that the Industrial Design Project entitled "Furniture design with Banana Fiber" by Infant Bibin is approved for fulfillment for Master of Design degree in Industrial Design.

Prof B K Chakravarthy

(Project guide)

Signature of Chair Person: 28th June 2023

Signature of the Internal Examiner: 28/6/23

Vinayak Nabar

Signature of the External Examiner: 28.06.2023

Declaration

I, declare that this written report represents my ideas in my own words, and where others' ideas or words have been included I have adequately cited and referenced the original sources.

I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea, data, facts or source in my submission.

I understand that any violation of the above will be caused for disciplinary action by the Institute and can also evoke penal action from the source, from which proper permission has not been taken or improperly been cited.

Signature: 

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Abstract

Banana is one of the most important fruit crops grown in India. After the harvest of fruits, huge quantity of waste biomass from Pseudo stem, burnt or left in situ causing detrimental impact on environment. This thesis presents a comprehensive exploration of product design for a furniture range made by utilising leftover banana stems as the primary raw material and primarily focuses on environmental sustainability and empowering rural women and promoting through the utilization of banana fiber, while also delving into craft and form exploration.

The research begins with an analysis of the social and environmental context, highlighting the impact of banana fiber made for a small group of rural women at Melakkal village. This model can be used throughout India's banana-growing regions, and it also highlights the need for sustainable alternatives in the furniture sector.

To ensure the viability and marketability of the designs, the report emphasizes material-specific testing. Mockups are created to evaluate the structural integrity, load-bearing capacity, and overall comfort of the furniture. To bring the final designs to life, prototypes were developed in collaboration with industrial manufacturing partners. Different treatment methods such as boiling and dyeing are explored to enhance the durability, color options, and customization potential of the banana fiber ropes

In conclusion, this report presents a holistic approach to product design for a furniture range made with banana fiber ropes. The integration of craft and form exploration, material-specific testing, and empowerment of rural women contributes to the overall sustainability and social impact of the project.

Acknowledgement

I want to sincerely thank my mentor, Prof. B K Chakravarthy, for his invaluable guidance and support throughout the research. I also like to express my gratitude to the members of my jury, Profs. Avinash Shende and Purba Joshi, for their insightful comments.

In addition, I want to thank Prof. Anil Gupta, GIAN, for introducing me to rural innovators and allowing me take the project. I want to express my gratitude to P Murugesan and OM Banana Crafts for their assistance, openness to share their experience, and provision of materials for my research.

I would also want to express my gratitude to the Instructors and staffs at the Industrial Design Centre (IDC) for their help. Mr. Kailash and Mr. Rudra Pal in particular deserve special mention for their support for making prototypes throughout the project.

Finally, I'd want to thank my family and friends for their continuous support during all unforeseen circumstances.

Contents

Special thanks to

GIAN (Gujarat Grassroots Innovation Augmentation Network) *the first incubator of grassroots innovations set up in 1997 by* ***Prof.Anil Gupta*** *in collaboration with the Gujarat government and supported by SRISTI and IIMA in addition to the Honey Bee Network. In 2003, It received the NSTEDB, DST, the best technology incubator award at the hands of then President Dr. A P J Abdul Kalam, sharing it with IIT Madras.*

P M Murugesan*, he has been recognized for Farmer scientist Award during the year 2012 . Who innovated a machine that turns banana waste into ropes and eco-friendly crafts.*

In 2008, he started thinking of ways to make products out of banana waste. He found the idea of making ropes interesting. He patented the machine by investing Rs 1.5 lakh and decided to make items like baskets, bags and mats using the ropes. He provides permanent employment for 15 rural women's in the village. Due to the intervention, banana farmers in and around Madurai District got additional income of Rs 5/Pseudo stem as well as protecting their environment through waste utilization of Pseudo stem.

1.Introduction

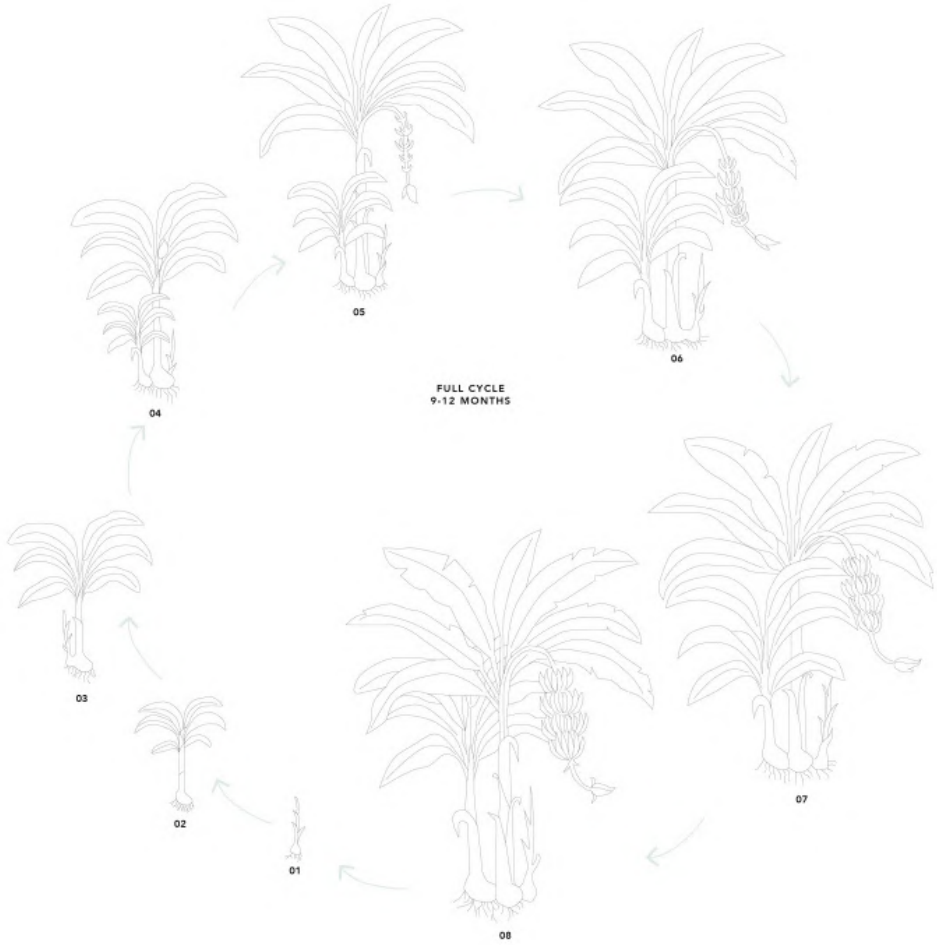
Banana trees (Musa spp.) have a rich history of cultivation in India, dating back thousands of years. India is one of the largest producers of bananas globally, with a diverse range of banana varieties grown across different regions. India is the world's largest banana producer with an annual output of 24.8 million tonnes followed by China,Philippines, Ecuador and Brazil. India accounts for 22 per cent of the global bananaproduction. Apart from the popular edible fruit, banana trees offer various valuable byproducts, one of which is banana fiber.

Banana fiber is derived from the stalks or stems of the banana plant, specifically from the outer layers known as sheaths. These sheaths are often discarded as agricultural waste after the fruit harvest, making banana fiber a sustainable and eco-friendly material with great potential.

Source: National Horticulture Board, India

1.1 Top banana producing states

The cultivation of banana trees in India is widespread due to the country's favorable climate and fertile soil. The major banana-growing states include Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh, Karnataka, and Kerala. India's diverse agro-climatic zones allow for the cultivation of different banana varieties, each with its distinct characteristics and uses.



GROWTH CYCLE

1-3 MONTHS OLD

01 Newly planted sucker chosen from previous mother plant.

02 Young banana plant.

4-6 MONTHS OLD

03 Young plant producing first suckers.

04 Fruit stem emerges from pseudotrunk.

7-9 MONTHS OLD

05 & 06 Female flowers start producing fruit.

07 Bananas are fully formed from fruit.

08 Fruit is ready to harvest.

1.2 Condition Post Harvest

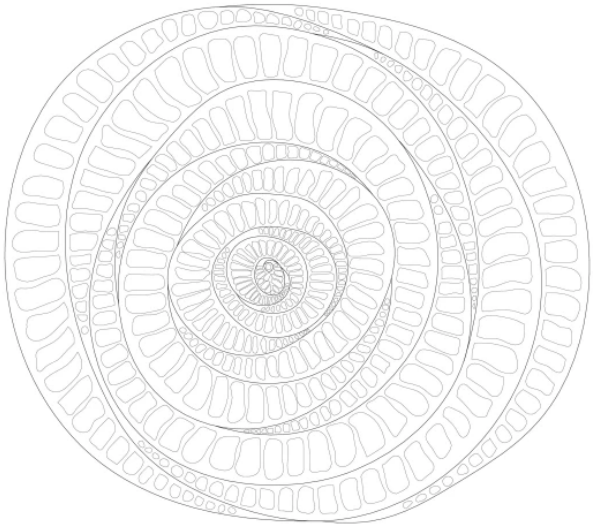
After the banana fruit is harvested, the remaining banana stem or pseudostem is often considered agricultural waste. If not properly utilized, the disposal of banana stem waste can have negative environmental impacts. Burning the leftover stems, which is a common practice in some areas, also contributes to environmental pollution and health hazards

- Burning banana stems releases harmful pollutants into the air, including particulate matter, carbon monoxide, and volatile organic compounds.
- Discarding banana stems as waste without proper management deprives the soil of valuable organic matter.
- Improper disposal of banana stem waste can contribute to waste accumulation in landfills or open areas.

1.3 Possible Utilisation of this Agricultral waste

To mitigate these harmful effects, it is important to promote the utilization of banana stem waste through alternative methods

- Recycling and Upcycling: Banana stems can be recycled or upcycled into useful products such as crafts, furniture, paper, or organic fertilizers. By transforming the waste into valuable items, it reduces the need for burning or improper disposal.
- Composting: Banana stems can be composted to produce nutrient-rich organic matter that can be used as fertilizer for plants. Composting not only helps in recycling the waste but also improves soil health and fertility.
- Biomass Energy Generation: Instead of burning banana stems, they can be used as a feedstock for biomass energy generation. This can involve processes such as anaerobic digestion or combustion to produce renewable energy, reducing reliance on fossil fuels.
- Awareness and Education: Raising awareness among farmers, communities, and local authorities about the negative impacts of burning banana stem waste is crucial. Education programs can promote alternative waste management methods and highlight the economic and environmental benefits of utilizing the waste.



2.Pseudo stem

The pseudo-stem is a part of the banana plant that looks like a trunk, which consists of a soft central core and tightly wrapped up to 25 leaf sheaths. These leaf sheaths unwrap from the stem and transform to recognizable banana leaves when they have matured. The height of banana plant can reach approximately 7.5 m and since the leaf sheaths grow from the base of the plant, some of the leaves, on the inner side, have approximately the same length of the tree. Whereas the outer side leaves, which grow later, are shorter.

2.1 Banana Sheaths:

The sheaths of the banana plant refer to the outer layers of the pseudostem, which are formed by the tightly overlapping leaf bases. These sheaths protect the inner layers of the pseudostem and are typically discarded as waste after the fruit harvest.

- Fibrous Texture: Banana sheaths have a fibrous texture, composed of long, tough fibers that run parallel to the length of the sheath. These fibers provide strength and resilience.
- Natural Color: Banana sheaths typically have a pale green or yellowish color, depending on the maturity of the plant.
- Length and Width: The length and width of banana sheaths can vary, with longer sheaths being more desirable for fiber extraction and utilization.

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THE NEW INDIAN EXPRESS

Home › Good News

Mann Ki Baat: Madurai farmer wins PM Modi's praises for making 'wealth out of waste'

Ridicule was the only income that PM Murugesan received when he decided to tread a different path and came up with an idea to make ropes from banana fibre.

Published: 01st March 2021 04:01 AM | Last Updated: 01st March 2021 04:14 PM

Murugesan with the household handicraft products he made using banana fibre. (Photo | EPS)

3. Visiting the crafts facility

During my visit to PM Murugesan in Madurai, I had the opportunity to study and understand the intricate craft of banana fiber. PM Murugesan is a renowned artisan and expert in working with banana fiber, and his workshop provided valuable insights into the traditional techniques and skills involved in this craft.

Upon arrival, I was greeted by the bustling activity in the workshop, with artisans engaged in various stages of the banana fiber crafting process. The workshop was filled with the earthy scent of banana fiber, creating a unique atmosphere.

He shared his knowledge and expertise, explaining the step-by-step process of working with banana fiber. He showcased the raw materials, including banana pseudostems and sheaths, which were collected from local banana plantations. It was fascinating to learn how these seemingly insignificant byproducts could be transformed into beautiful and useful items.

1

Preparing the waste banana stem on the harvest site. And allowed for drying.

2

Collection of processed fibres to the craft workshop

3

Wetting Process before fibre seperation

3.1 Process of working with Banana fiber

Sourcing Banana Stems: Local banana farmers or cooperatives provide the raw material by harvesting mature banana plants. The stems are then transported to the rope-making facility.

Wetting Process: These dried sheaths are then made wet in a small concrete tank which is outside the workshop. This process reduces the stiffness of the sheath for better workability and also removes impurities.

Stripping and Cleaning:The outer layers of the banana stem, known as sheaths, are carefully stripped to expose the inner fiber. These sheaths are cut into man-ageable lengths and cleaned to remove any dirt, debris, or residual sap.

4

Tools to separate fibres
Fiber separation as per width needed

5

Fibres collected after seperation

6

Machinery used to make fibre ropes

7

Rope spinning for storage

Rope Making: The spun fibers are twisted together to form ropes. This process is done manually or with the help of simple tools such as a spinning wheel or a rope-making machine. The fibers are tightly twisted and wound onto a spindle or reel to create the desired thickness and length of the rope.

Spinning and Quality Control: After rope making, the finished ropes are inspected for any defects, inconsistencies, or weak points. Any necessary adjustments or repairs are made to ensure the quality and strength of the ropes and stoered

8

9

Spun ropes made from banana fiber can be stored for various purposes, depending on the artisan or the specific requirements of the craft making process. mainly for

I. Craft Making: They themselves could use these ropes to create a variety of products such as baskets, mats, bags, and decorative items. By having a stock of spun ropes readily available, artisans can efficiently produce their crafts and meet customer demands.

II. Selling to Other Rope Buyers: In some cases, banana fiber ropes are sold as their products to other rope buyers. These buyers could be individuals or businesses that utilize the ropes for different applications. By selling their spun ropes to other buyers, artisans can diversify their customer base and generate additional income.

Making the product

Using galvanized iron molds as a guide or frame for weaving the products. This process allows them to create consistent shapes and patterns in their crafts.

The craftswomen start by selecting the appropriate length of banana fiber rope and securing it to the mold. They use their skilled hands to intricately weave and wrap the rope around the mold, following specific patterns or designs. This technique enables them to create baskets, mats, bags, or other items with desired shapes and sizes.

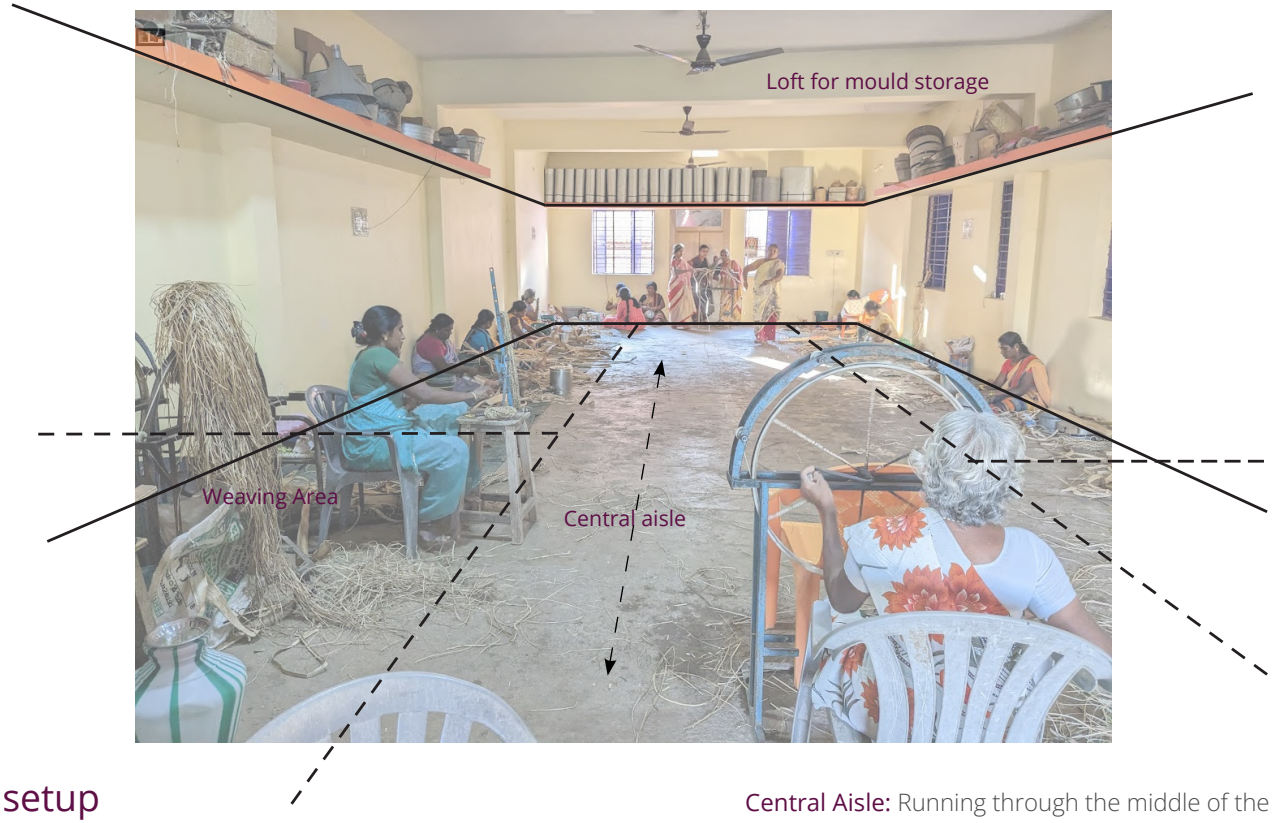
Sitting on the floor allows the craftswomen to have a stable and comfortable working position, allowing them to concentrate on the intricate details of their craft.

Treatment

After the woven products made by the craftswomen are completed, they undergo an organic anti-fungal treatment using a combination of moringa gum and maida (refined wheat flour). This treatment helps protect the products from fungal growth and ensures their longevity.

Sun Drying

After applying the mixture, the woven products are left to dry under the sun. The sunlight helps to activate the anti-fungal properties of the treatment and facilitates the drying process. It also imparts a natural freshness and enhances the durability of the products.



3.2 Work area setup

The work area for banana craft weaving women accommodate their specific needs and facilitate the various stages of the crafting process. It is typically a spacious hall with a layout that maximizes efficiency and ease of movement.

Weaving Area: The majority of the space in the hall is dedicated to the weaving area, where the craftswomen sit on the floor to work on their crafts. They are positioned in rows or clusters, each with their own designated workspace. This setup allows for easy communication, collaboration, and a sense of community among the craftswomen.

Central Aisle: Running through the middle of the hall is a central aisle, which serves as the primary workspace for making banana fiber ropes. This is where the crafts-women spin the fibers into ropes using spinning wheels or other traditional equip-ment. The central aisle provides a clear and accessible area for this specific task, ensuring efficient rope production.

Mould Storage: The top loft of the work area is utilized for storing the galvanized iron molds used in the weaving process. The loft provides a space-saving solution, keeping the molds organized and easily accessible. Craftswomen can retrieve the specific molds they need for their projects without cluttering the main working area.

Fiber seperator

Manually operated machine

Motorised machine

3.3 Machineries used by them

Manually Operated Cord and Rope Making Machines: These machines feature a cycle wheel rim design and are operated by hand. Craftswomen can manually spin the fibers or yarns using the machine, which helps in the creation of cords or ropes. The machine's cycle wheel rim provides the necessary traction and tension to produce consistent and tightly spun cords or ropes. Craftswomen stand near the machine and control the spinning process manually, often using a rhythmic walking motion.

Motorised Machines: This machine is same as that of manual machine but here the spinning wheel is motorised for rope making

The choice of using manually operated machines or a motorized machine depends on factors such as the scale of production, the availability of resources, and the preferences of the craftswomen.

In both cases, the craftswomen may walk to and fro while spinning or adjusting the fibers to ensure uniformity and proper tension. This motion allows them to maintain a steady rhythm and control the spinning process effectively.

Crochet inspired weaving with banana fibre rope

Braided sheaths of various widths are stiched over a mould

3.4 Various techniques they are familiar with

It is wonderful to learn that these talented craftswomen possess skills in crochet as well, adding another dimension to their creative repertoire. Crochet offers a versatile and intricate technique that complements the traditional weaving craft. By incorporating banana stem-based ropes of 2mm or 3mm, they can produce unique and sustainable lamp shades and bags with a beautiful blend of natural materials and artisanal craftsmanship.

The craftswomen's technique of braiding with banana stem sheaths is truly remarkable and adds yet another dimension of creativity to their craft. This traditional braiding method, where 5 to 7 banana fiber sheaths are skillfully woven together, results in a band of impressive length – 7 meters. This band is then carefully wound around the Mould and skillfully stitched along the edges to form exquisite and unique lamp shades.

3.5 Weaving over the GI Moulds

The use of locally made Galvanized iron (GI) sheet Moulds in the weaving process has been a foundational aspect of various products. Currently, the craftswomen work with Moulds that take basic forms such as cylindrical, conical, and hemispherical shapes, which dictate the final form of their woven products.

The craftswomen's forms are somewhat restricted by the available Moulds, limiting their ability to explore more diverse and contemporary shapes for their woven products. This constraint can hinder the evolution of their craft and its potential adaptation to modern design trends and market demands. One approach could be to introduce a broader range of Mould designs that cater to a more diverse set of forms.

Additionally, the integration of technology, such as 3D printing or CNC machining, could offer new possibilities for creating custom Moulds with greater precision and complexity. These advanced manufacturing techniques would enable the craftswomen to experiment with unique designs and achieve greater flexibility in their craft.

GI moulds stacked on loft

3.6 Weaving over the Metal Frames

(This is an interesting technique for better workflow)

Utilization of Banana Stem Sheaths:

Dried banana stem sheaths provide an excellent material for weaving. The craftswomen carefully select and prepare these sheaths to ensure their suitability for the weaving process.

Metal Frames for Standardization:

Incorprating metal frames of 5 mm thickness allows the craftswomen to achieve consistent and standardized forms for their creations. The frames provide structural support and help maintain the desired shape and dimensions of the woven products.

Simultaneous Work by Multiple Women:

Weaving with metal frames enables multiple craftswomen to work on different parts simultaneously.

Assembly for Final Product:

Once the weaving process is complete, the individual woven components/parts are assembled to form the final product. This step involves combining various parts and securing them in place, ensuring that the product is sturdy and well-structured.

Weaving over the metal frame with ropes or narrow sheaths

3.7 Hand Weaving the narrow sheaths without mould

Hand weaving with just the Narrow sheaths of banana fiber stems, without the use of any moulds, is a remarkable technique that showcases the craftswomen's exceptional skills and creativity. This method allows them to create sturdy and unique coasters and mats of various sizes and shapes.

Skillful Hand Weaving: Hand weaving without moulds requires a high level of craftsmanship and precision. The craftswomen skillfully manipulate the banana fiber sheaths to create intricate patterns and textures, resulting in coasters with exceptional artistic value.

Sturdiness and Durability: Hand weaving directly with the sheaths of banana fiber stems produces coasters that are remarkably sturdy and durable. The natural strength of the banana fibers ensures that the coasters can withstand regular use and last for a long time.

Coasters and mats made without mould

Cat Tail grass

Cotton

Woven shade mat with grass and cotton

3.8 Other Regional Material influence in their craft

It was wonderful to witness these craftswomen have been exploring new materials like cat tail grass and cotton to create innovative products like shade blinds and mats. Regional availability of these materials makes them an excellent choice for sustainable and locally-sourced crafting.

Cat Tail Grass: Cat tail grass, also known as bulrush or cattail, is a common wetland plant found in many regions. Since cat tail grass is regionally available, it supports the local economy and reduces transportation costs. This grass is a renewable resource, and harvesting it does not harm the environment.

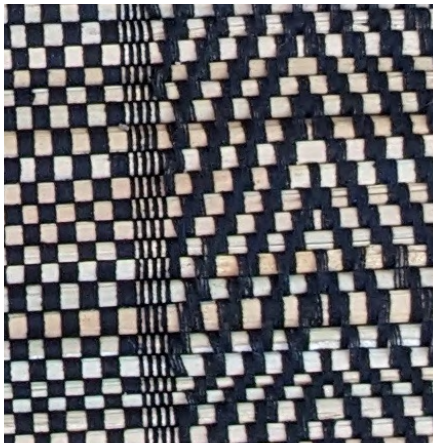
Cotton: Cotton is a versatile material widely available in many regions. Its softness and absorbent properties make it suitable for various applications

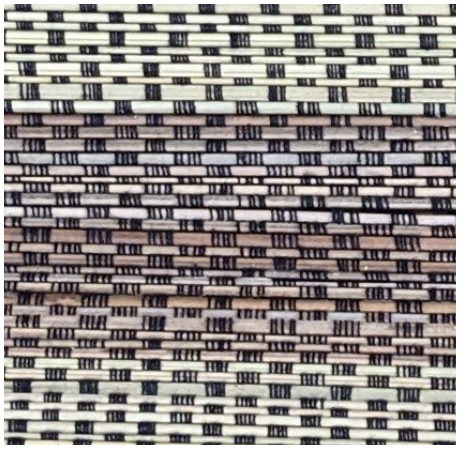

Cat tail grass + cotton


Cat tail grass + cotton


Banana stem ropes


Cat tail grass + cotton





3.9 Few samples of other weaving (with and without handloom loom)

PRODUCT VARIETIES

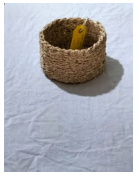

BASKETS

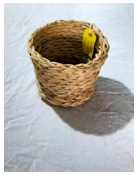


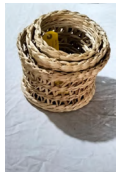
BAGS




MINI OBJECTS FOR DAILY USE




LAMP SHADES



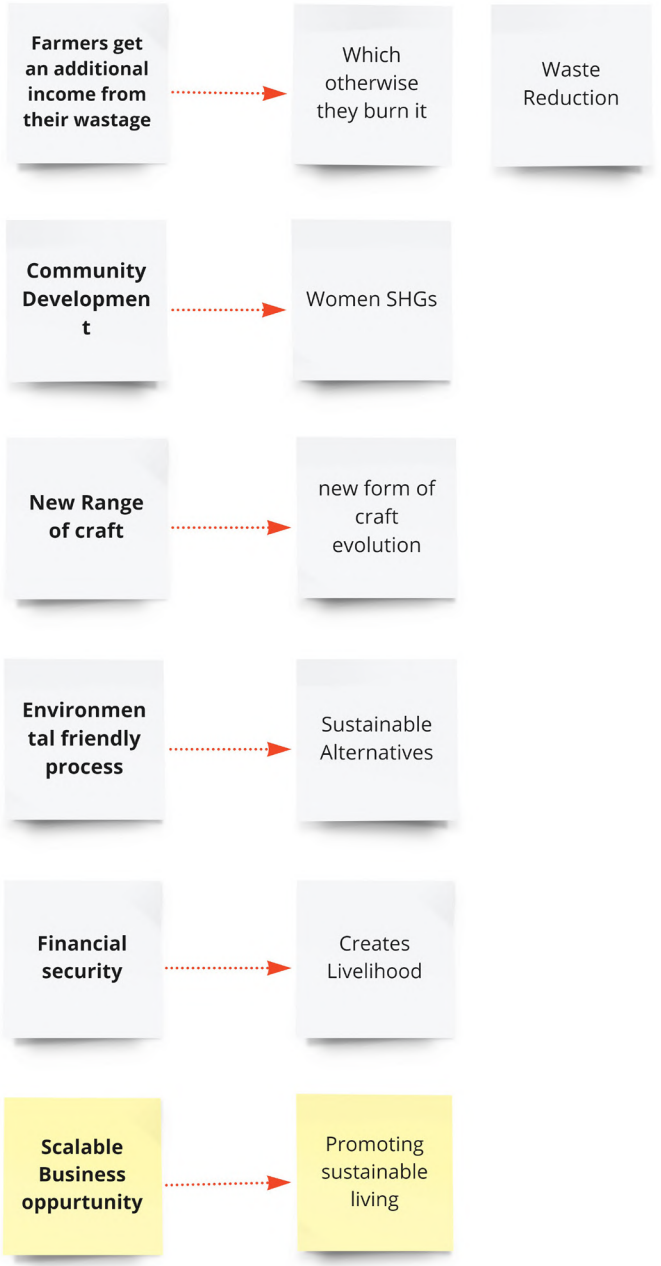


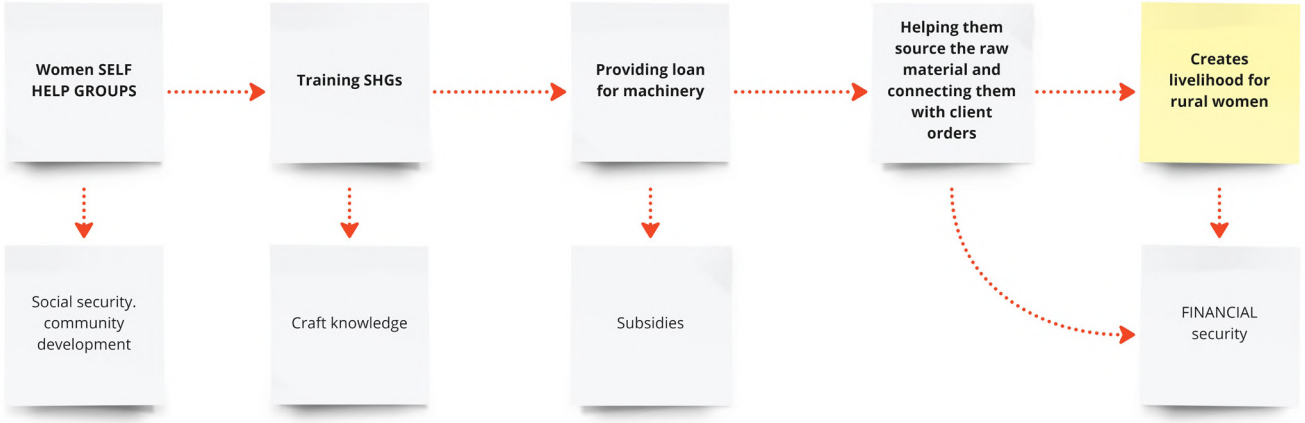

SHADE MAT


4. Range of Products they make

5. Impact of banana fibre products

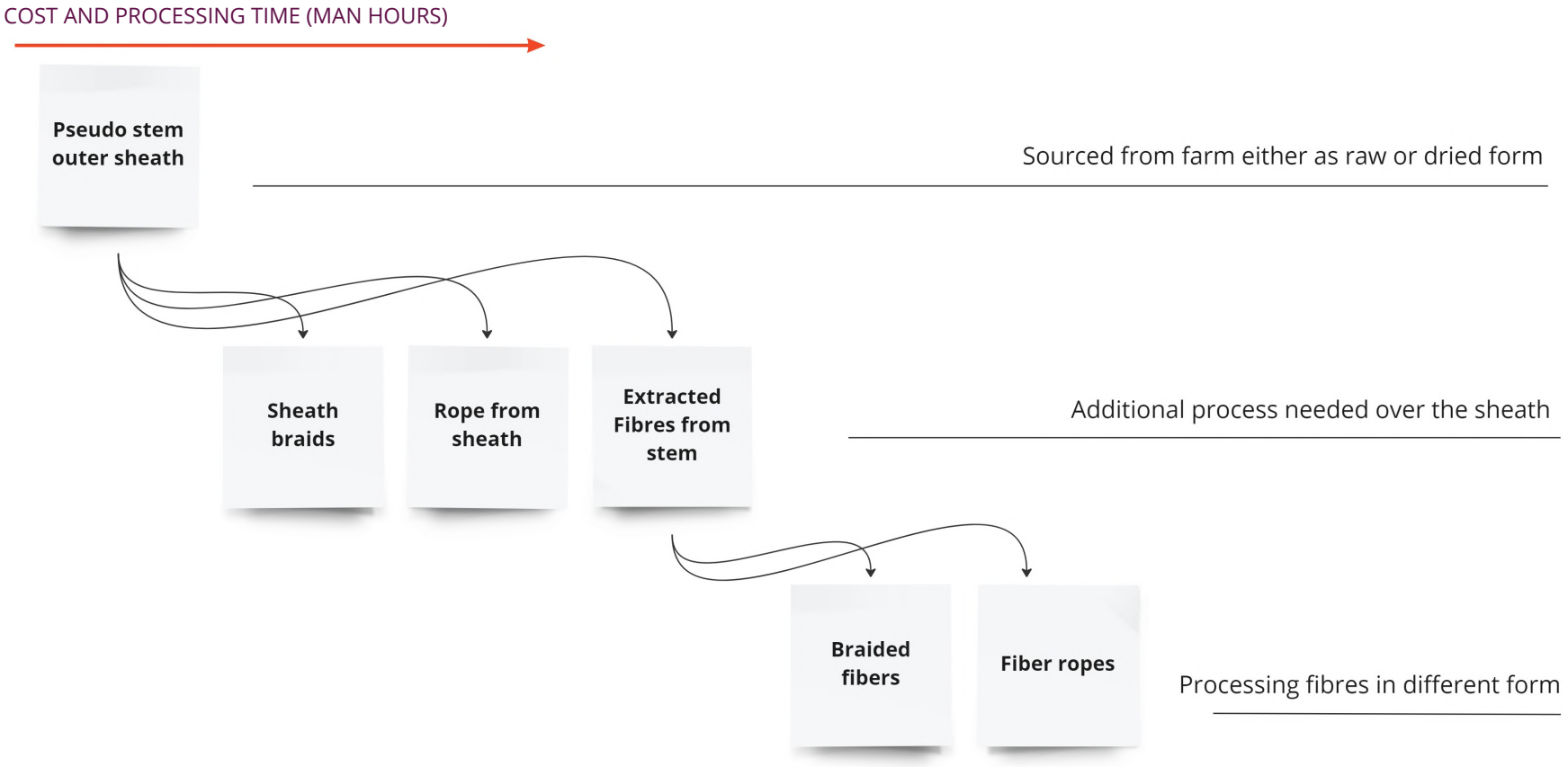
- Banana plants are fast-growing and require minimal water and pesticide usage compared to other crops. By using banana fibers, the craft reduces the dependence on synthetic materials and contributes to sustainable production.
- The craft makes use of banana plant residues, such as the pseudostems and sheaths, that would otherwise go to waste after banana harvesting. By repurposing these agricultural by-products, the craft contributes to waste reduction and resource optimization.
- Banana fiber craft often involves the participation of rural women and artisans, providing them with income-generating opportunities and economic empowerment. The craft helps preserve traditional skills and knowledge, passing them on to future generations.As the demand for banana fiber products grows, more job opportunities are created for craftswomen and artisans in rural areas. This leads to better livelihoods and a positive impact on the local economy.
- The unique and eco-friendly nature of banana fiber craft appeals to environmentally conscious consumers, creating niche markets for sustainable and handcrafted products.
- Exploring new materials and design techniques for banana fiber craft encourages innovation and collaboration between artisans, designers, and researchers, leading to continuous improvement and growth in the craft.





5.1 Empowering Women SHGs


Kissan Care
Black Diamond



Studying and understanding the raw materials used in the craft is essential for achieving quality and creativity in the final products. The process starts with the dried banana stem and involves various steps to create different components for the craft.

6. Raw Material Hierarchy

6.1 Raw Material Samples

Rope made of just extracted fibers

Intervention in machinerys

- Already existing market
- Trained artisans to old existing methods
- Remove employment oppurtunity

New products lineup to improve their portfolio

- Not aware of design trends and practices
- Can incorporate design tools
- No packaging or proper branding of the product
- Always dependent on retailers
- Generic forms and patterns

- Should be Easily trainable.
- Low cost mouldmaking
- Better opportunities / reachability
- Should not take their jobs away
- Should consider Product specific tools

Low cost Packaging.

- Engineered product
- Large scale
- Packaging design can't be standardised
- Material exploration

7. Design Intervention Areas

PRODUCT VARIETIES

BASKETS

BAGS

MINI OBJECTS FOR DAILY USE

LAMP SHADES

SHADE MAT

INTERIOR decoratives

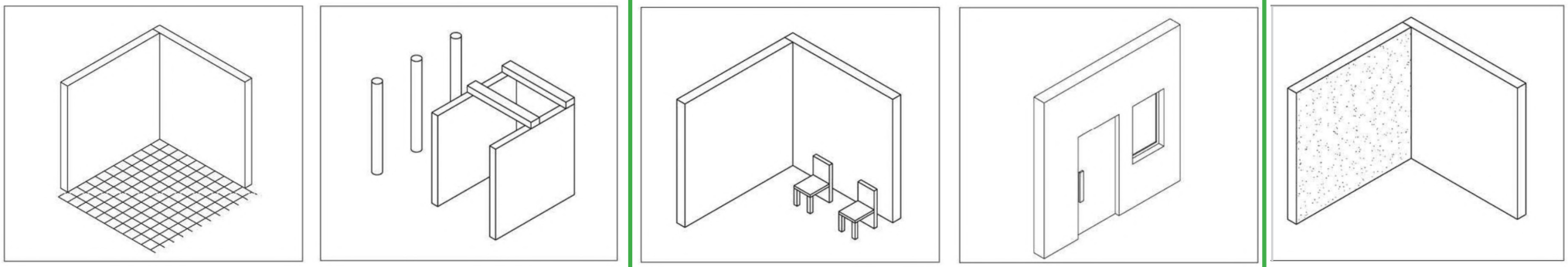
INTERIORS Furniture

INTERIORS Ceiling fixtures

Blinds and shades for OPENINGS

7.1 Clustering their existing range based on focus area

Potential Scope Areas



Floor based intervention | Ceiling based intervention | SPACE objects intervention | Intervention on openings | Wall surface based

Both Space Objects and opening-based interventions offer exciting opportunities for showcasing the craft's artistry, sustainability, and versatility. These applications cater to indoor spaces, where the longevity and anti-fungal properties of the craft are best utilized. Moreover, focusing on furniture and openings aligns with current design trends that emphasize the use of natural materials and handcrafted elements to create inviting and eco-friendly interiors.

7.2 Space making products using crafts

- Bachelors
- Single people not living at home
- Newly married couples
- Families with the youngest child under six
- No children families
- Students
- Professionals

Mono segment positioning

+

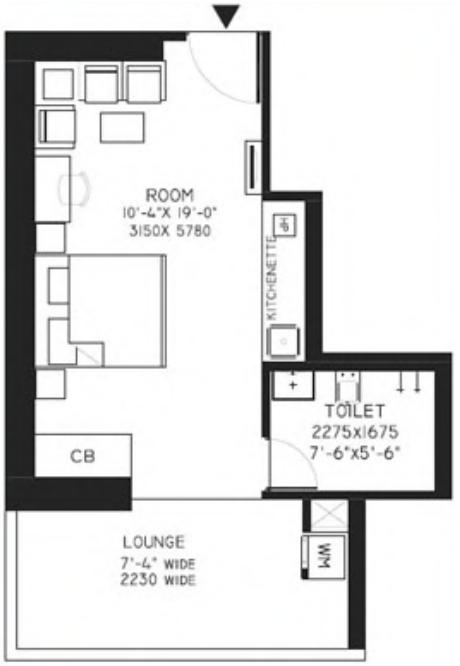
Adaptive positioning

" The goal of positioning is to present your product as attractively as possible for Multiple market segment. If the product appeals to several demographics, then a new range can be developed based on interest"

7.3 Product Positioning

7.4 Monosegment Target Audience

- Special attention to 16-34 year old adults who are living away from home.
- (Tier 1 and 2 cities)
- Living in a studio apartment trying to set a lounge area for themselves.
- Who likes to decorate homes
- Sustainability interest



organic textures and warm colors create a soothing and inviting atmosphere

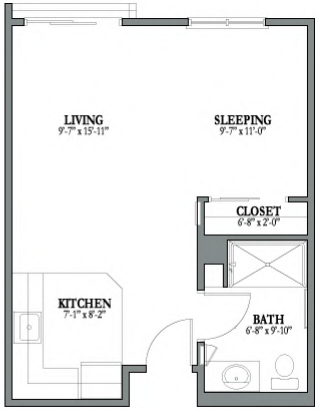
comfortable seating experience with good ventilation

supports sustainable practices

contribute to reducing carbon footprint

natural element to your decor

sense of authenticity and craftsmanship



User 1_he/him

Lives in Pune city, sets his own lobby space in his 1hbk appartment. His lounge area is decorated with Plants and furniture selected by him- placed over the space to go with harmony.

User 2_he/him

Lives in Noida, sets his own lobby space in his Studio appartment.

Plant and a stool Placed near the natural light and ventilated area in the room.

7.5 Similar current users

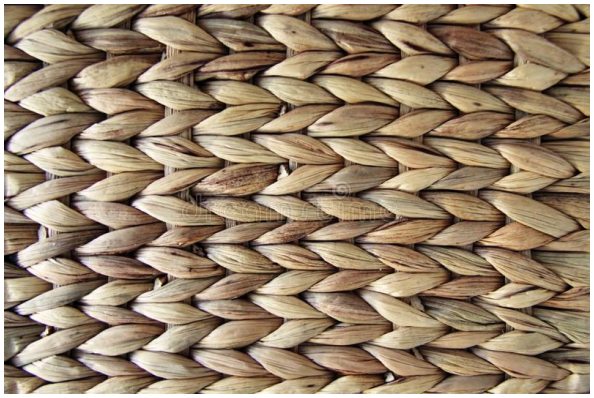
8. Revised Design Brief

" Designing lounge furniture (Easy chair, movable partition wall, etc.) for studio apartments, using banana fiber as a material to diversify the portfolio of Rural Banana fiber craft "

Aim:

Promoting sustainability and rural women empowerment by crafting a livelihood system using product design

9. Benchmarking Banana fibre products



Material

Basematerial:
Banana leaves, Clear acrylic lacquer

Frame:
Steel, Epoxy/polyester powder coating

Binding:
Rattan, Clear acrylic lacquer

Care

Wipe clean with a cloth dampened in a mild cleaner.

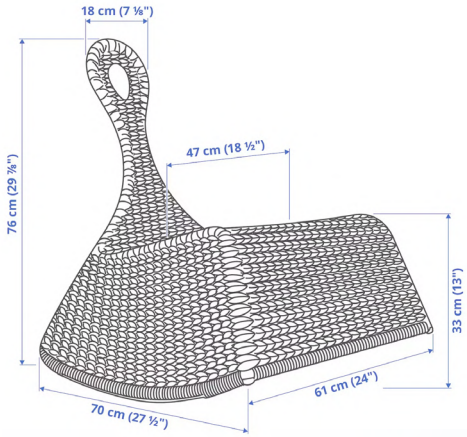
Wipe dry with a clean cloth.

If placed close to a radiator or other source of heat, the material can dry out and deteriorate.

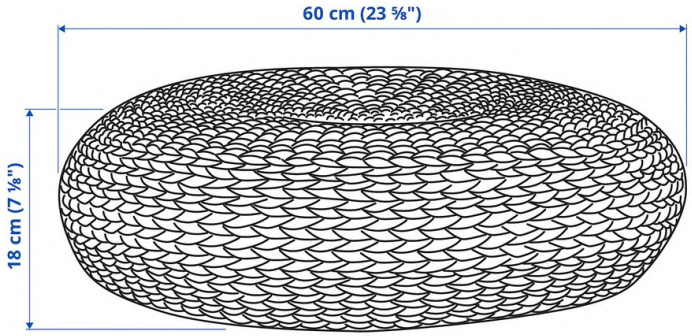
Good to know

Banana fibres may have dark spots; these have no effect on the strength of the material.

Possible to separate for recycling or energy recovery if available in your community.



9.1 IKEA Gullholmen Chair

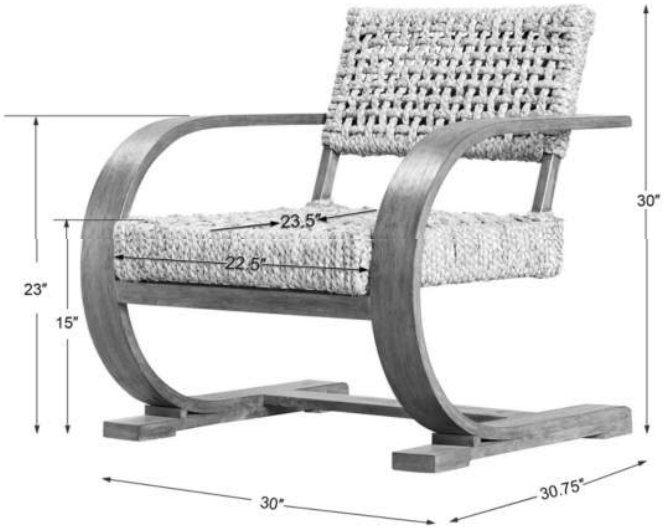


Product details

Hand-woven by experienced craftspeople, which makes each stool unique.

Lightweight; easy to lift and move.

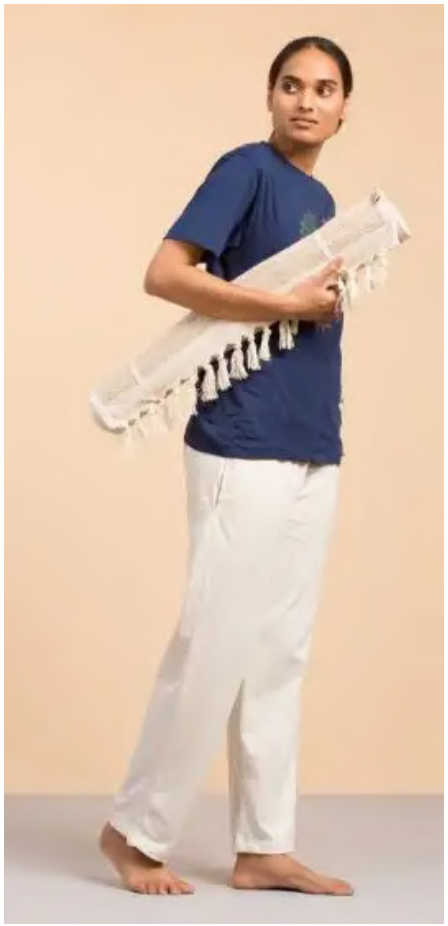
9.2 IKEA Alseda Stool



Dramatically curved arms of the weathered pecan finish solid wood frame create an eye-catching display. Made by Uttermost, this accent chair's natural banana fiber seat and back in a woven pattern provides plenty of comfort for watching the world go by.

9.3 Uttermost Rehema Natural Woven Banana Fiber Modern Accent Chair

UTTERMOST



The fibres are woven together with cotton yarns, which provide this mat with a softer and more comfortable feel. Banana fibre is known to be supple and is a known hypoallergenic (which means, it is relatively unlikely to cause an allergic reaction).

9.4 Banana Fibre Yoga Mat

By using banana ropes as a building facade material, the final outcome took what is considered a very 'vernacular' material and inserted it into a contemporary building context – the renovation of a townhouse for a typical suburban residential development.

https://www.architectkidd.com/index.php/2010/07/hand-made-facades/

9.5 Facade design with banana ropes

10. Design Approach Ideations

Achieving furniture forms based on banana fiber sheath weaving over a mesh frame (Either cane, bamboo or steel frame mesh). The malleability and strength of banana sheaths allow for intricate and artistic designs to be woven over the frames.

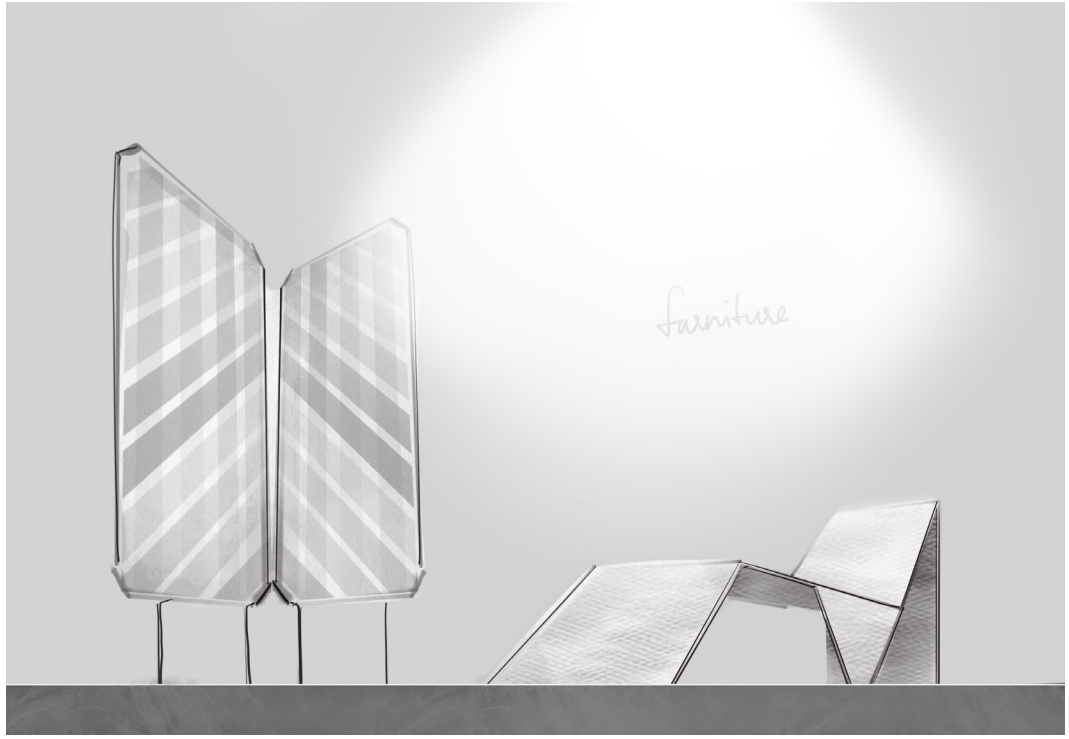
10.1. Design Approach 1

banana fiber sheath woven over bamboo sticks

Rope dyed with stainer to check how colour variation

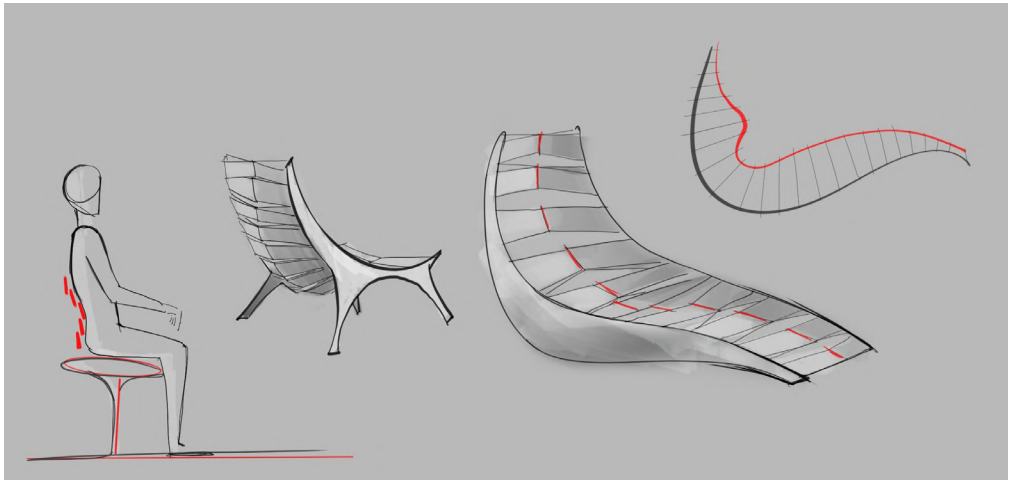
Using standardized ropes made from banana fiber that can be dyed in various colors opens up opportunities for creating visually striking and vibrant products. The ropes can be woven over frames or mesh to construct furniture pieces like chairs, tables, or loungers, adding a pop of color and uniqueness to the market. This concept would cater to customers who appreciate both sustainability and personalized design elements.

10.2. Design Approach 2 Using Rope as a primary material for furniture



Design Approach 2 - Using Rope as a primary material for furniture

Woven with banana fiber rope



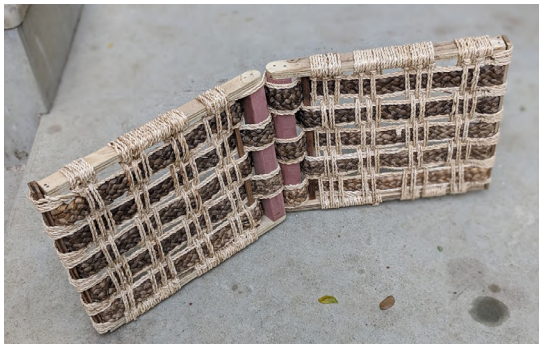
Weaving a criss-cross pattern along a frame with variable side widths is an ergonomic approach to craft making. This technique allows the crafted products to adapt to the human ergonomics, especially targeting the lumbar areas, providing enhanced comfort and support.

10.3 Design Approach 3 - Using ropes and frames to achieve uni directional crossweave/winding to achieve ergonomic forms

Creating braided bands of different widths using banana sheaths allows for a modular approach to crafting. These bands can be stitched or woven over a mold or frame to achieve various forms, enabling craftswomen to work easily.

10.4 Design Approach 4 Using both Braided sheath and rope

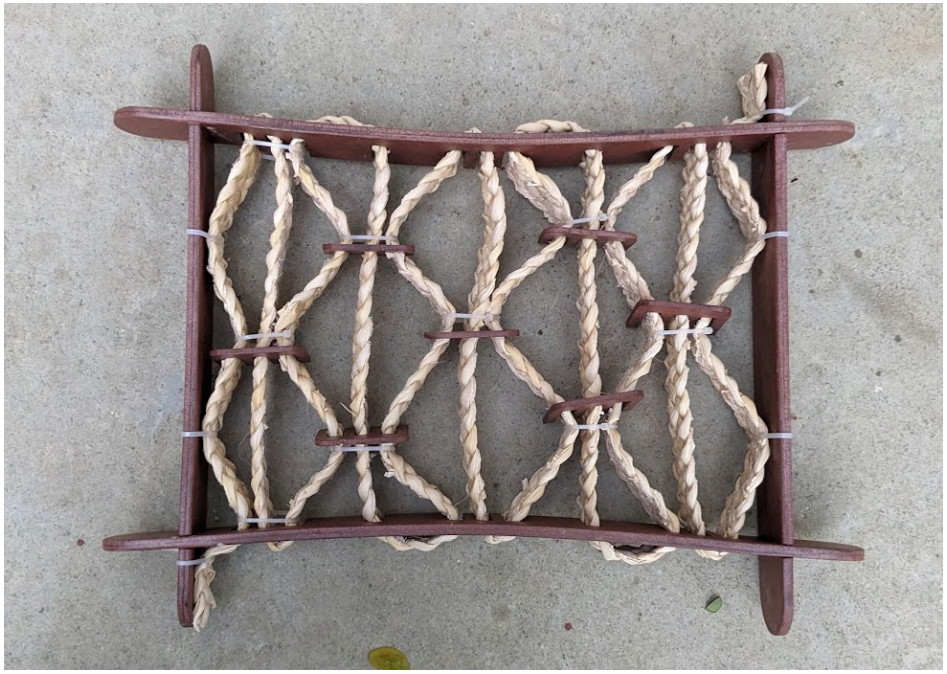


Achieving collapsibilty through weaving

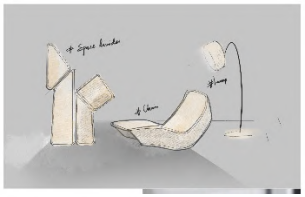
This open up lot of possibilites to achieve foldable/collapsible products with banana stem ropes/braides.

Design Approach 4 Using both Braided sheath and rope

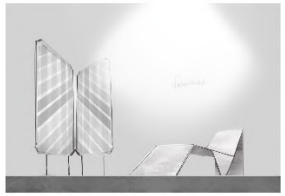


10.4.1 Design Approach 4.1 -

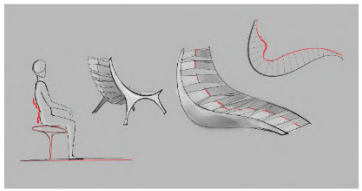
Using Braided sheath as a primary material to wind over a frame to from a furniture



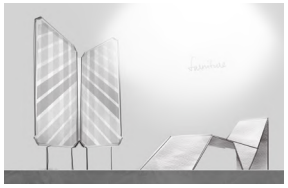
Concept 1



Concept 2



Concept 3



Concept 4

All the 4 Approaches(concepts) are evaluated critically using following criterias to select C2,C3 to take it forward for application.

1. Workability of craftswomen (All the concepts are easily workable by rural women with some training)
2. Novelty of idea (As of this C1 is a common practise in banana fiber. C2,C3,C3 are new ideas in banana fiber craft)
3. Spatial harmony (From analysing the form potential C2,C3 can arrive a spatially harmonius form well)
4. Longevity of product (C2 and C3 are completely made with ropes which are more durable than sheath based weaving)
5. Aesthetics (Contemporary possibilities can be achieved with C3 since its adaptabilty to curved forms are better than C1)
6. Manufacture standardization (C2 can be standardised better comparing C1 and C4)
7. Ergonomic preferences (C3 gives the freedom to make forms to adapt ergonomics and canbe made without bottom reinforcement)
8. Time consumption for making (C2 has more man hour consumption for the product and it is appreciable since it generates employment)
9. Transportability (C4 ideas can be transported better because of its collapsibility, other concepts can also be transported easily if designed well)
10. Renewable sources (Since C2,C3 uses ropes which are stronger, dependability for other material can be reduced for stregth)
11. Post processing treatment(Dyeability) (C2,C3,C4 allows them to dye which can be an added advantage)

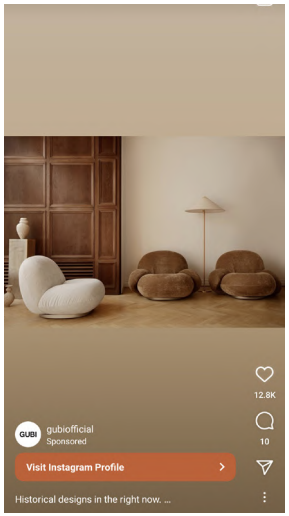
10.5. Concept Evaluation

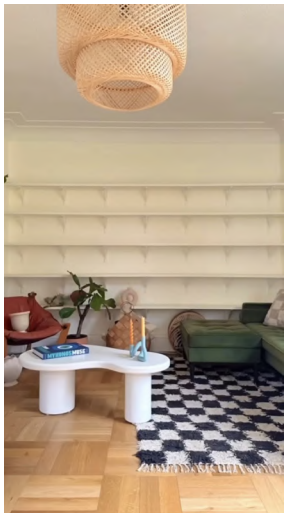
Exceptional Instore Experience + SMM (Social Media Marketing)

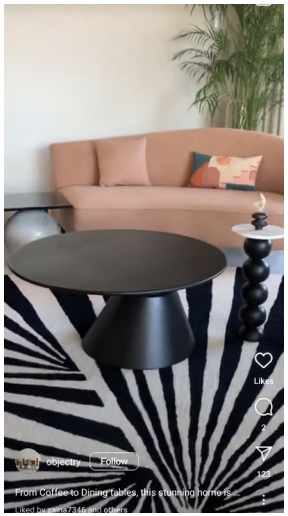
" Asking the user to dream about how the space looks and making them experience the product"

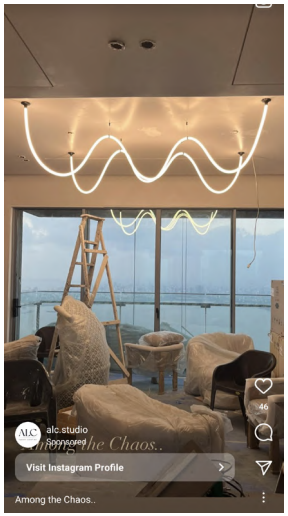
#Connectiontowardstheproduct

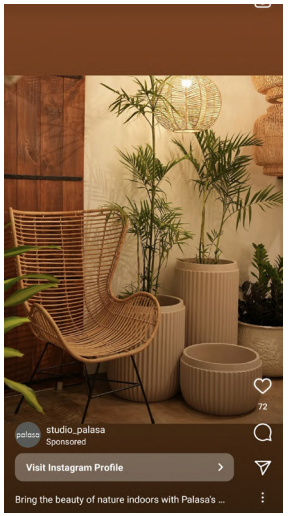
11. Additional Design consideration and Strategies

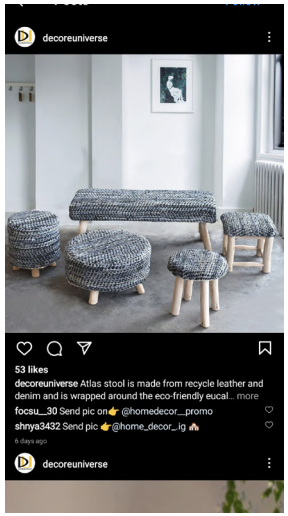








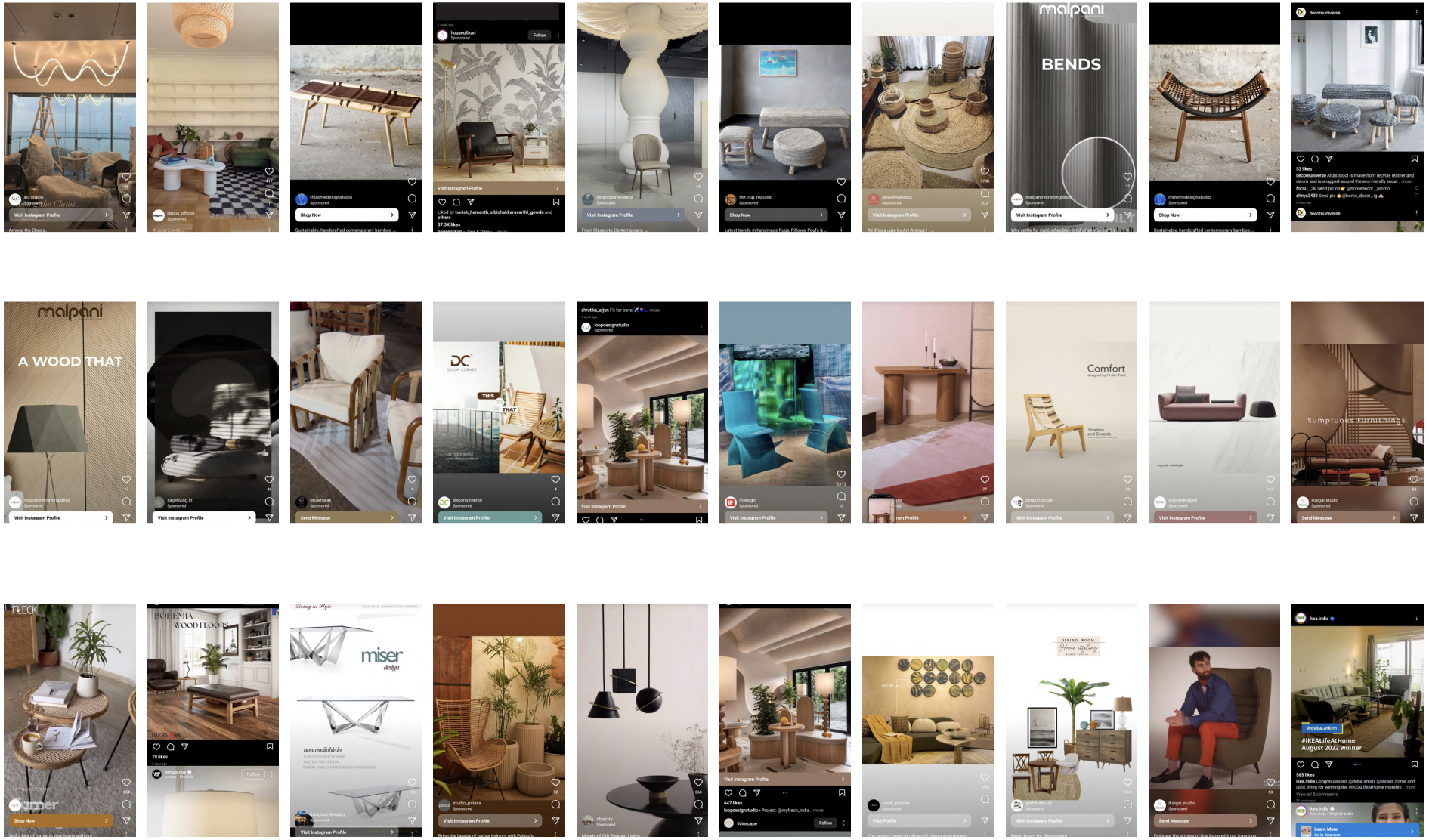




Designing banana fiber furniture for social media marketing is important because it allows to effectively showcase our products, connect with a larger audience, build brand awareness, and drive sales. By leveraging the power of visually-driven platforms and implementing strategic design and marketing techniques, you can create a strong and engaging social media presence that attracts and engages customers interested in sustainable and eco-friendly furniture.

but how?

Visual Appeal	Lifestyle Context	Storytelling
Showcasing the unique texture, colors, and craftsmanship of banana fiber	Appealing and relatable setting that resonate with the target audience	Journey of the artisans, the sustainable production process, the cultural significance of banana fiber



11.1 Documenting the social media ads

targeted me as i started leaving digital footprint during this p3 project researching on natural fibers. This helped to get an analogy of how each brands create visually appealing ranges they made it to fit lifestyle context to convey a story to sell.

RIG 1

Rig made to test ergonomics

Backrest- Banana stem Ropes

Backrest width - 36 cm

Seat height -38 cm

RIG 2

Rig made to test ergonomics

Backrest- Banana stem Ropes

Backrest width - 36 cm

Seat height -50 cm

RIG 3

Rig made to test Material Strength

Panel made with Banana stem Ropes

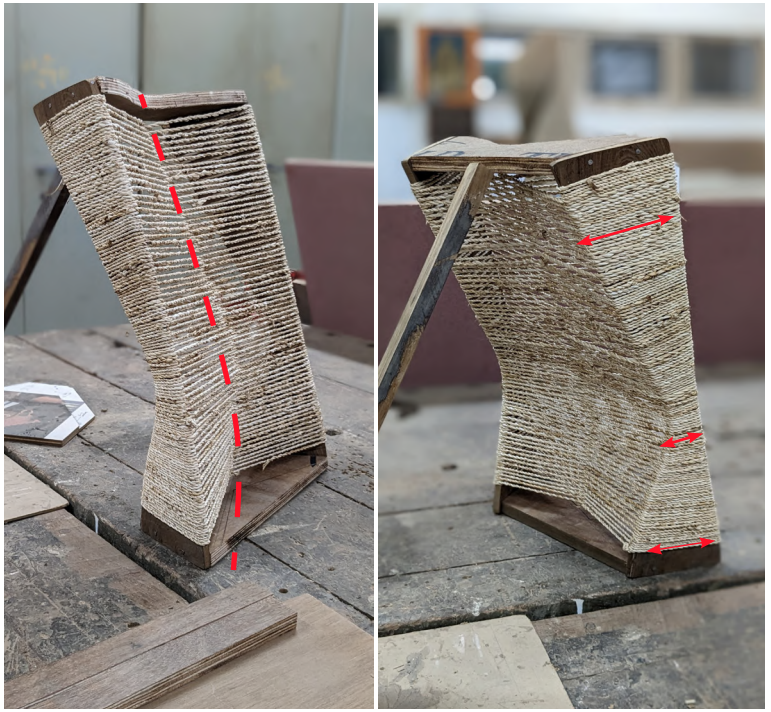
RIG 4

Rig made to test Material Strength

Panel made with Manila Ropes

12. Testing (Ergonomics / Strength)

Backrest module made with plywood frame having the variable side widths to adapt the ergonomic form



The design of this backrest is based on the Concept 3 of the Ideation where the ropes are winded criss cross along the frame to form a central intersection line which adapts the human lumbar support.

The development of testing rigs represents a significant step in our journey to harness the full potential of banana fiber ropes and banana stem-based ropes in furniture design. These testing rigs serve a dual purpose of evaluating the properties of the materials and understanding the ergonomics of the furniture.

12.1 Testing rig making

Testing with First Rig

Testing with second Rig

Around 15 users were made to experience these set up, of that the male and female user mentioned in that photos above are from the extreme per-centile of the ergonomic. The male is 183cm tall and the female is 153cm tall.

Over the study , considered factors such as comfort, posture support, and usability to ensure that our furniture pieces meet ergonomic standards and provide enhanced user satisfaction.

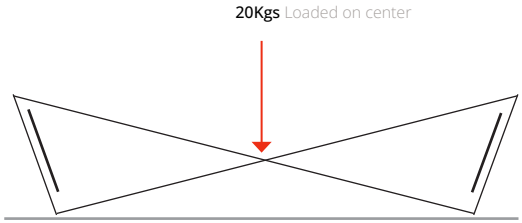
Through this testing rig, we gain valuable insights into design modifications which are mentioned in insights.

12.2 Rigs tested for Ergonomics

The panel uses 3mm dia Banana stem based ropes which are woven both the sided without any tensional support from inside. For concentrated load it posses a mild sagging. which can be avoided if 4 or 5 mm ropes being used or 4 mm extracted fiber based ropes.

But for sitting over it, it is totally soft and comfort. Since the force is uniformly distributed. Through this testing rig, we gain valuable insights into design modifications which are mentioned in insights.

12.3 Rig 3 tested for Strength



12.4 Backrest Rig tested for Strength

Load of 2o kgs was placed on the spine area of the Rig over day to note for changes or deformations. Since each rope is not interconnected with the next line, Load distribution among the weave is negligible so the ropes which are not loaded are left loose.(Which was a serious thing to note ,Even if it takes load, comfort will be compromised)

Bamboo strip added along the spine so ropes which are not loaded will also get distributed with load. And load transfer is effective.

Backrest Rig tested After adding Central Bamboo spine for load distribution among the ropes for Strength, Which significantly improoved the results.

Manila fiber rope is being used here, to closely match the family of banana due to difficulty in procurement at that time. But it will be banana stem extracted fiber ropes for final. But this being similar to banana fiber rope also demonstrated great strength and load bearing capabilities

12.5 Fiber Rope testing rig (works perfect)

12.6 Findings from the Tests

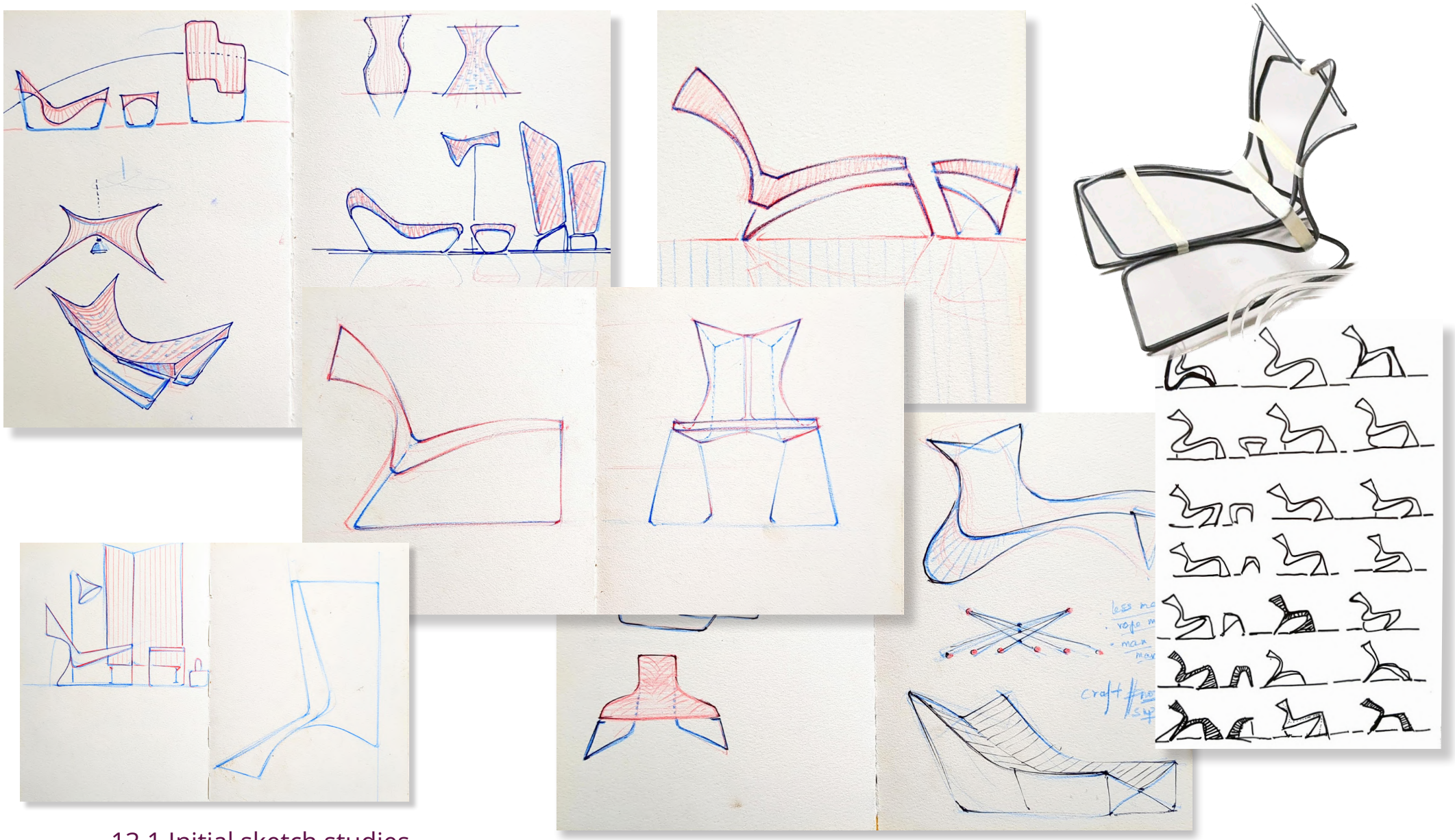
ERGONOMIC FINDING

- The ergonomic testing carried out with both genders of a similar user group, considering extreme ergonomics percentiles, has provided valuable findings that can significantly impact the design and comfort of the crafted products.
- The ergonomic testing has also evaluated the durability and longevity of the crafted products under different ergonomics.
- Backrest Width was optimal, since more width would produce sagging of ropes over time
- On average, the optimal seat height for a lounge chair would fall in the range of 16 to 18 inches (40 to 45 centimeters) from the floor to the top of the seat cushion.

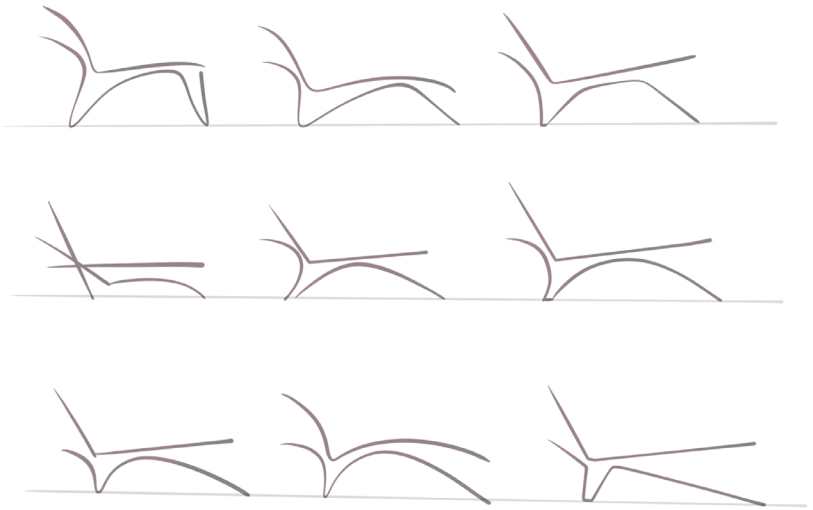
STRENGTH TEST FINDING

- Needs little more dia increment in rope making for stem based ropes(3mm).
- Vertical weaving is a must for production ready quality
- Cross weaving is the major load taking rope which needs to be completely of extracted fiber rope for durability and to avoid sagging. min 4-5 mm dia fiber ropes
- Additional reinforcement mesh need on seating surface. for safety and to avoid sagging when someone stands over the chairs
- Stem based ropes can be used to weave vertically since it doesnt need to take much load

13. Form Development

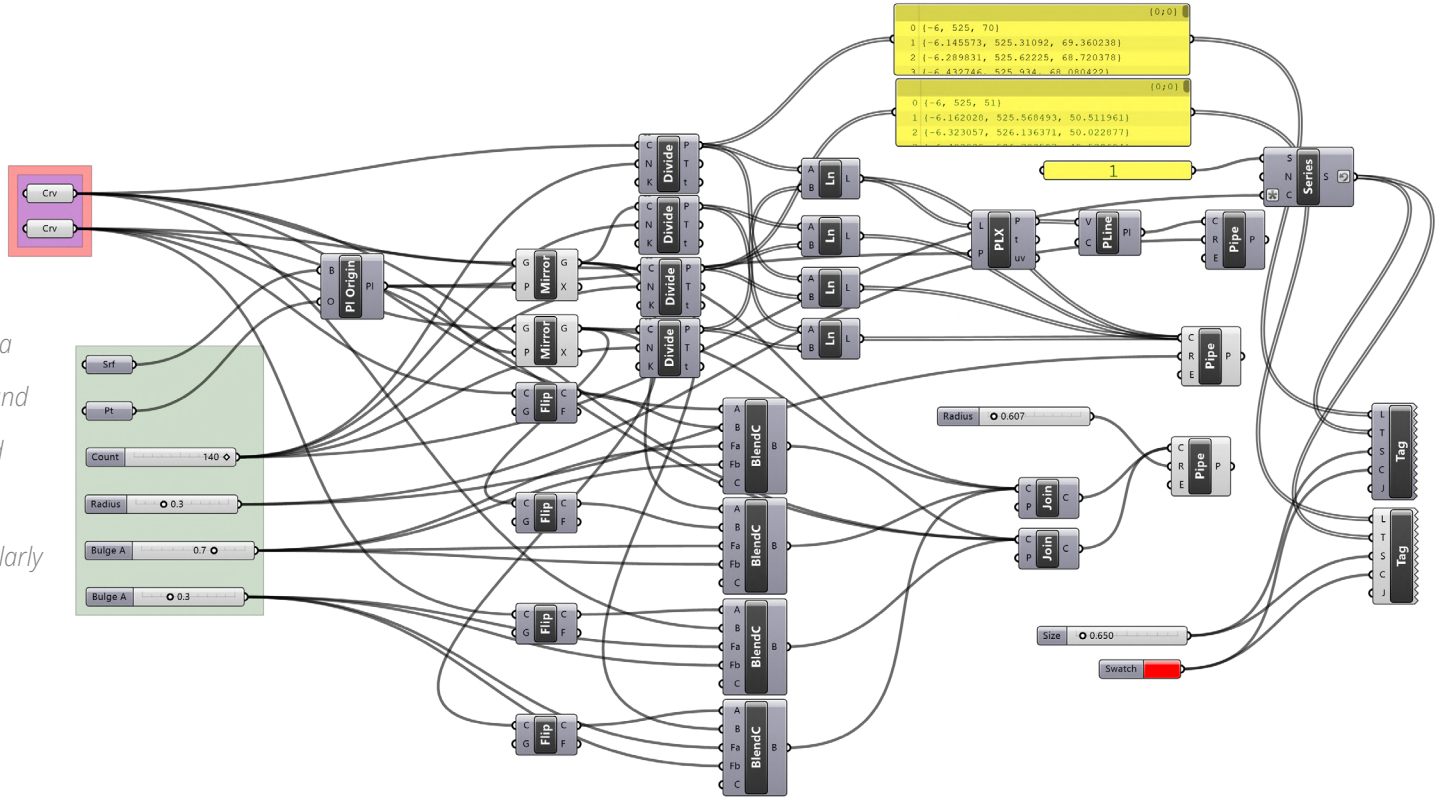


13.1 Initial sketch studies



13.2 Form study from rig

Utilization of Grasshopper and Rhino software has been a great help in this design process, allowing us to explore and analyze various forms of furniture with exceptional speed and efficiency. By creating a Grasshopper script, we have streamlined the generation of innovative designs, particularly a woven chair, using just two input curves.



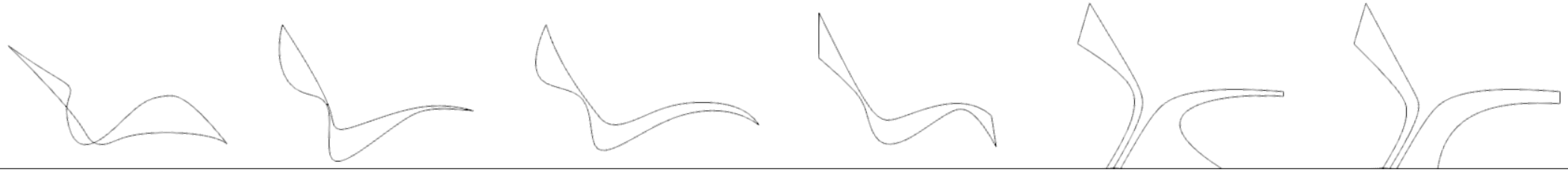
13.3 Parametric Approach for form exploration

Grasshopper Script for Woven Chair: With just two input curves, the script generates mirrored outlines and weaves, forming the desired chair outline. This parametric approach allows for easy adjustments to dimensions, angles, and weaving patterns, providing a seamless way to explore numerous design possibilities.

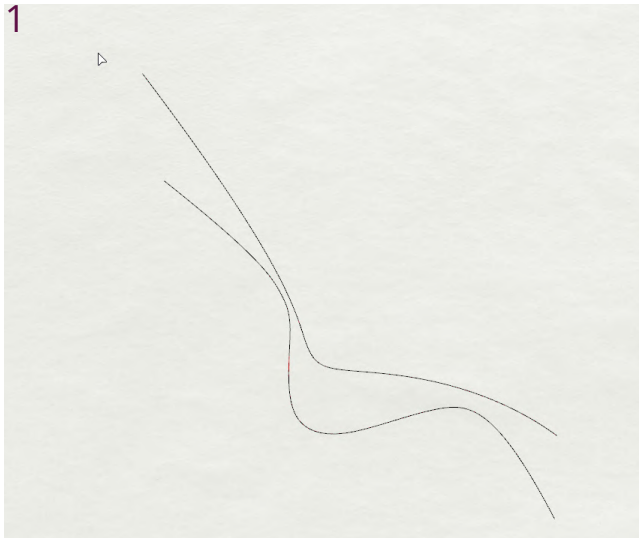
Faster Iterations: By utilizing the Grasshopper script, we have accelerated the iteration process exponentially. This acceleration has allowed us to explore more concepts, and fine-tune the designs swiftly.

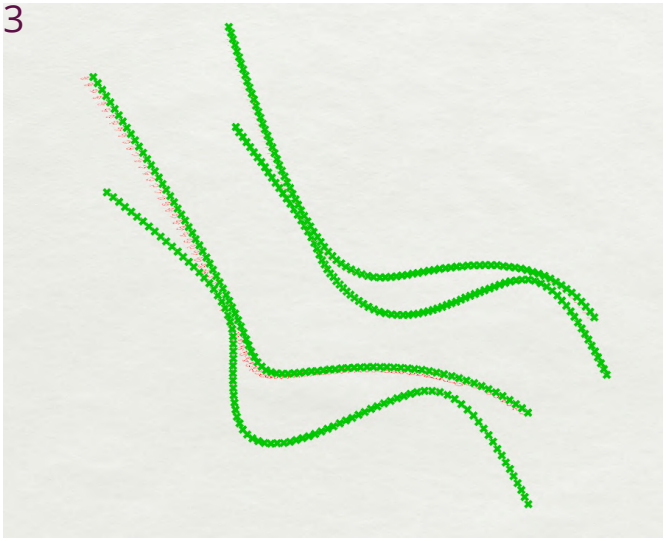
Precise Analysis: Rhino's 3D modeling capabilities provide us with accurate visualizations of the chair forms. We can thoroughly analyze the proportions, ergonomics, and aesthetics of each design

Collaboration and Feedback: The digital nature of these tools allows for easy collaboration and feedback from various stakeholders, including designers, artisans, and customers. We can share virtual prototypes and obtain valuable insights to further enhance our designs.



Form Generation based on Pair of Curves as the input



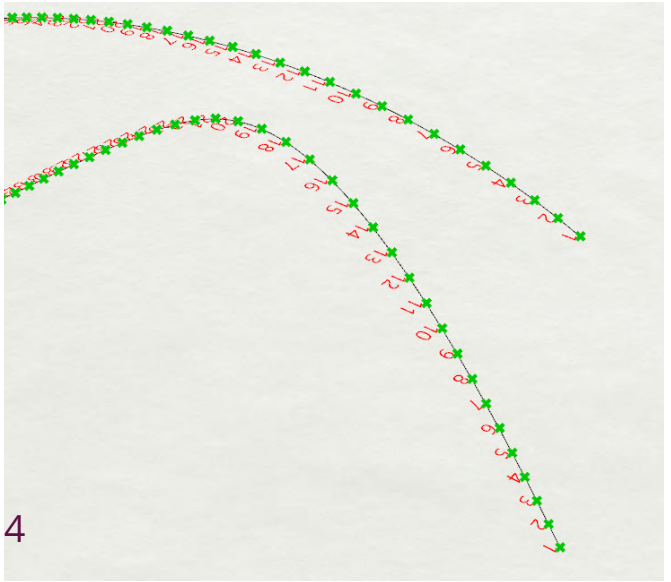


1. 3D Curves are drawn in model space with the ADJUSTABLE design points

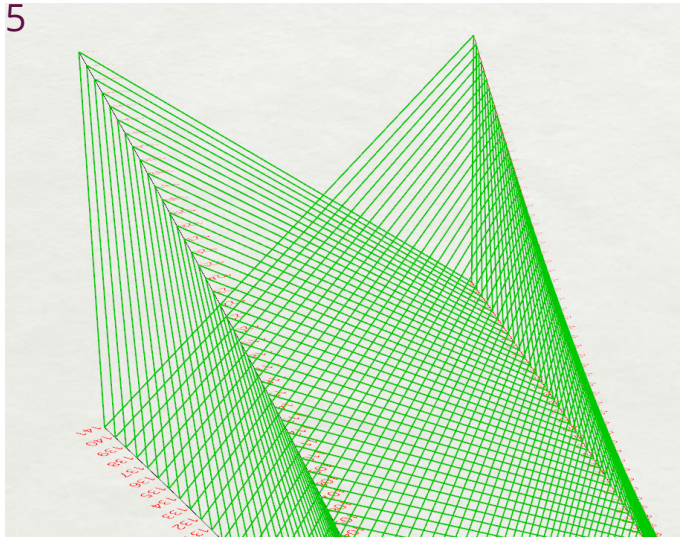
2. With two input curves, the script generates mirrored outlines forming the desired chair outline

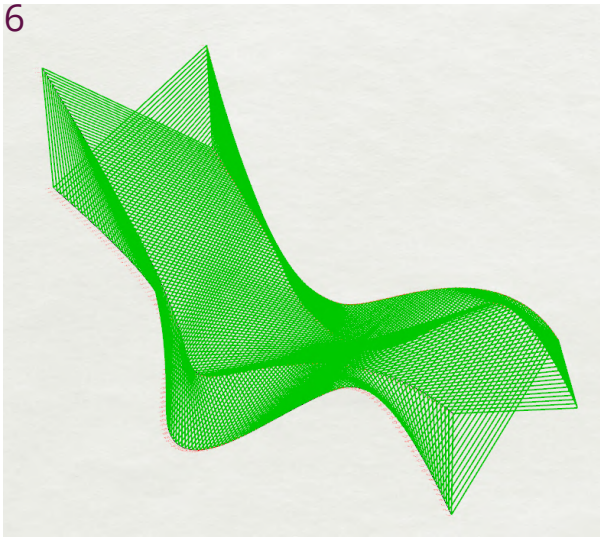
3. Each of this curves are divided in equal parts to extract points

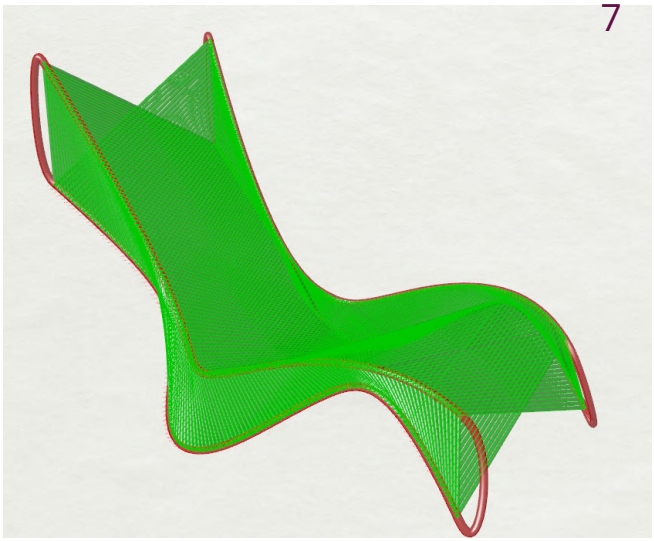
4. These points becomes the reference for the cross weave to happen connecting the four curves(frame)



13.4 Form finding method





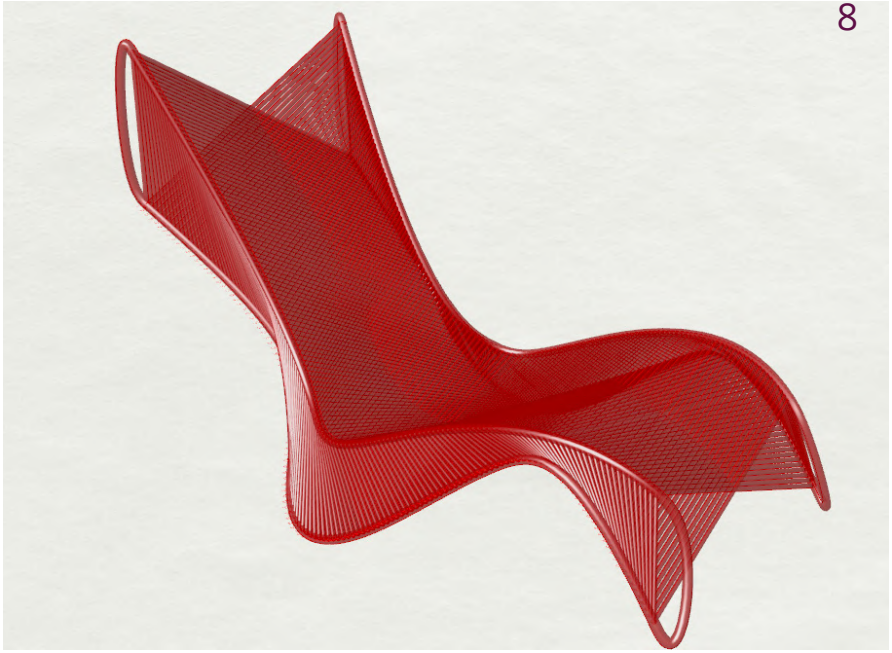


5. These points are then connected by a loop forming crossweave pattern along the curve length.

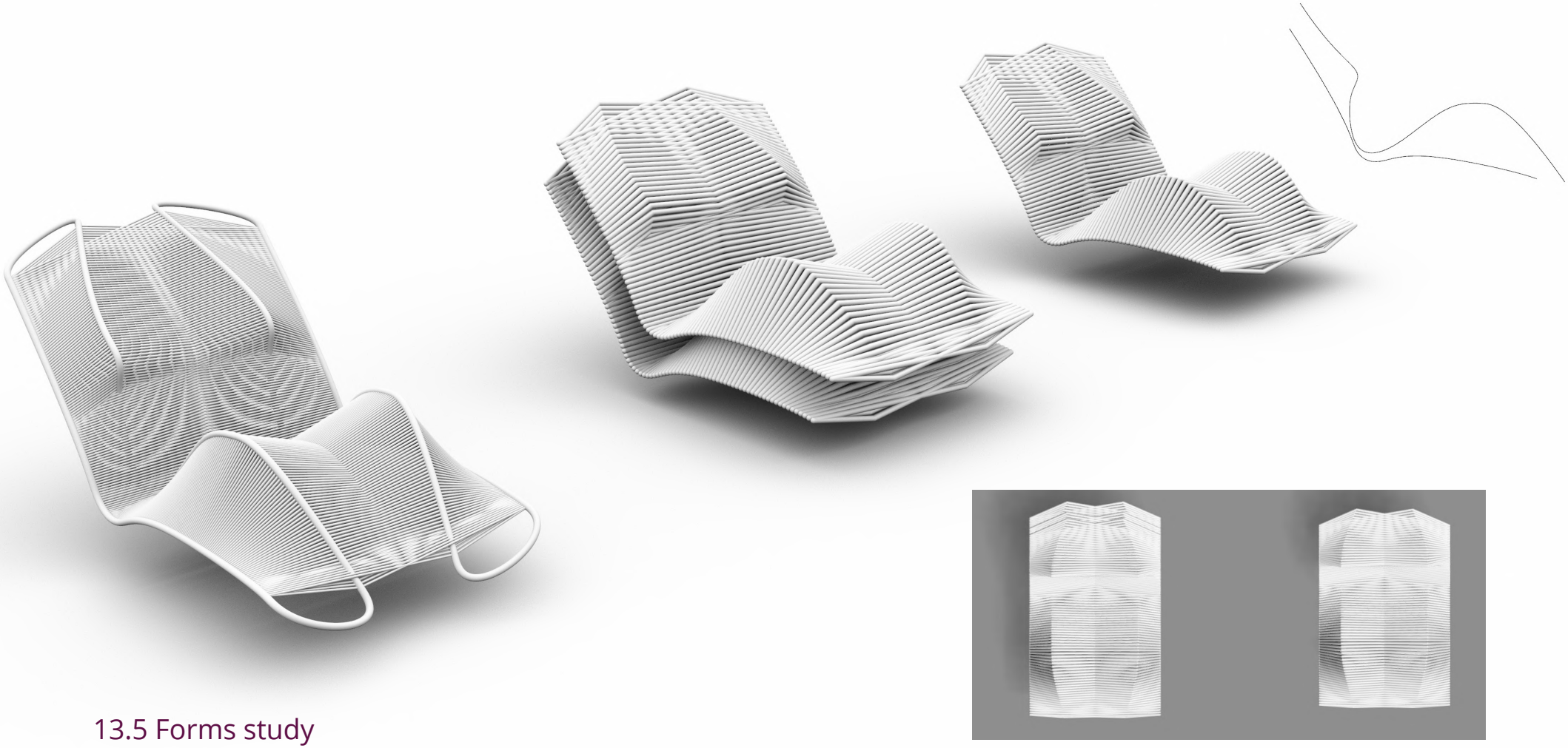
6. This linking of curves will create a wireframe for the furniture design.

7. Desired pipe radius is added to allv the curves respectively to give the volume.

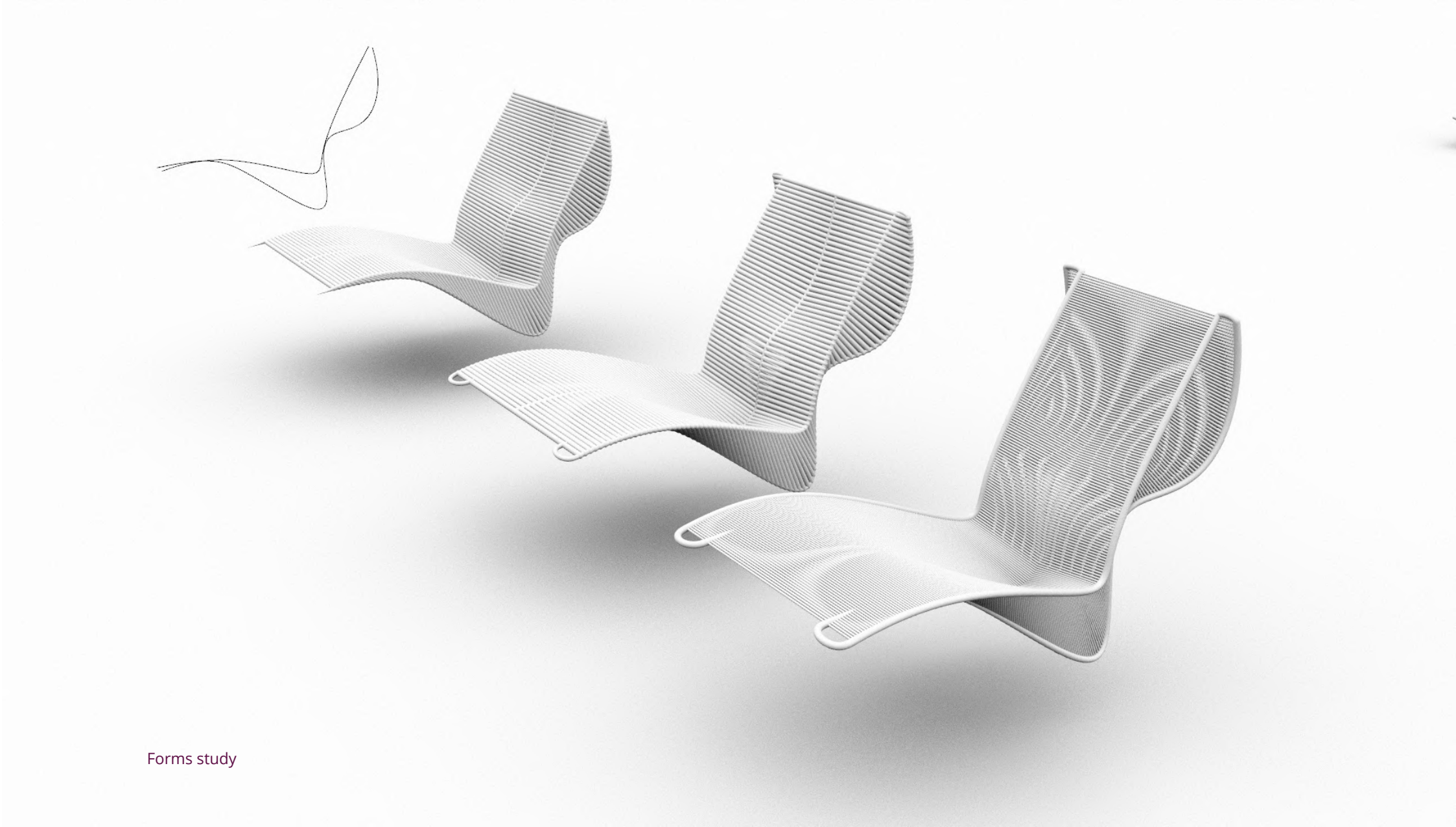
8. With each adjustment to the initial curve creates new form each time. This acceleration has allowed us to explore more concepts, experiment with different weaving techniques, and fine-tune the designs.



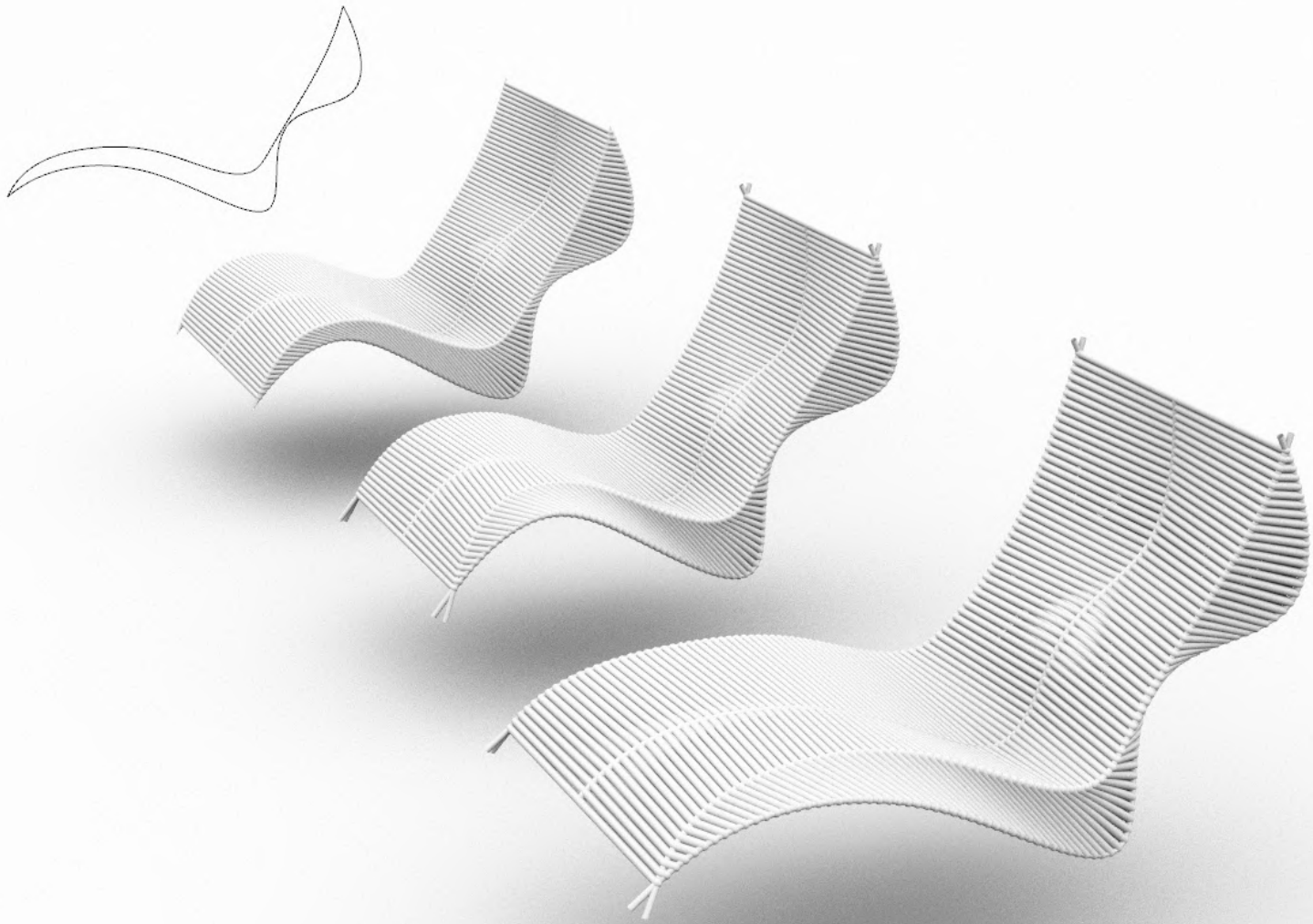
Form finding method



13.5 Forms study

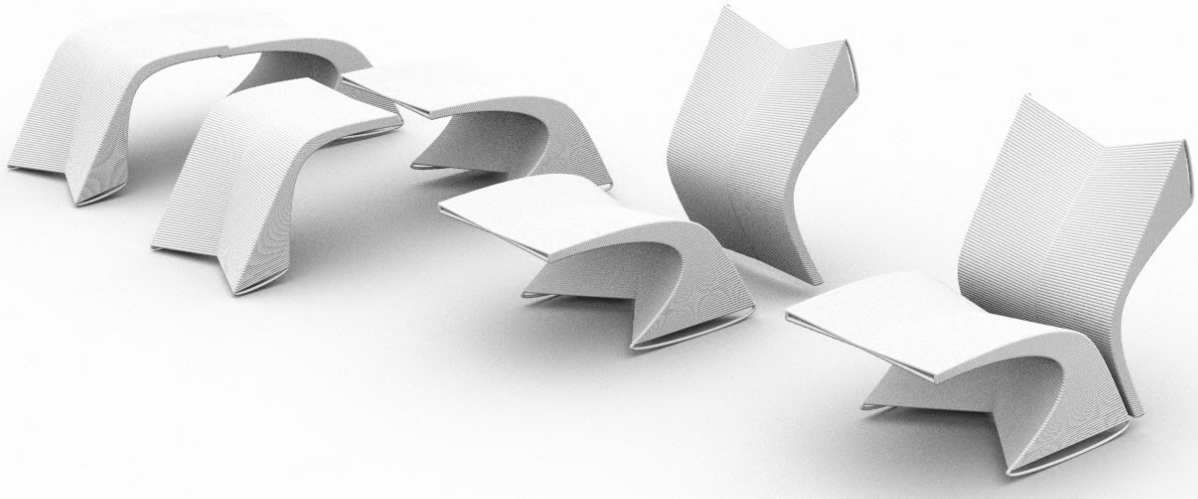


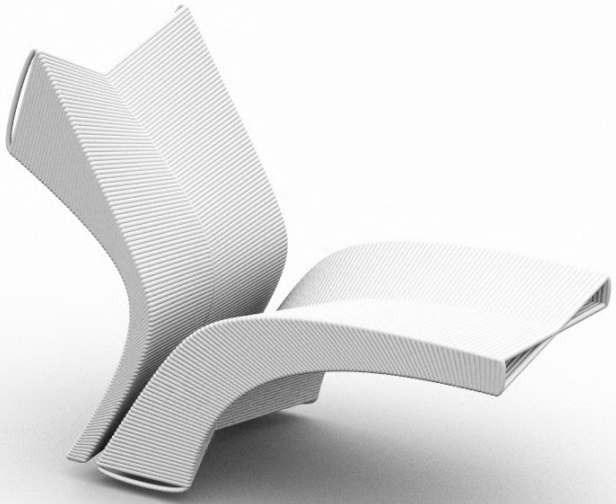
Forms study



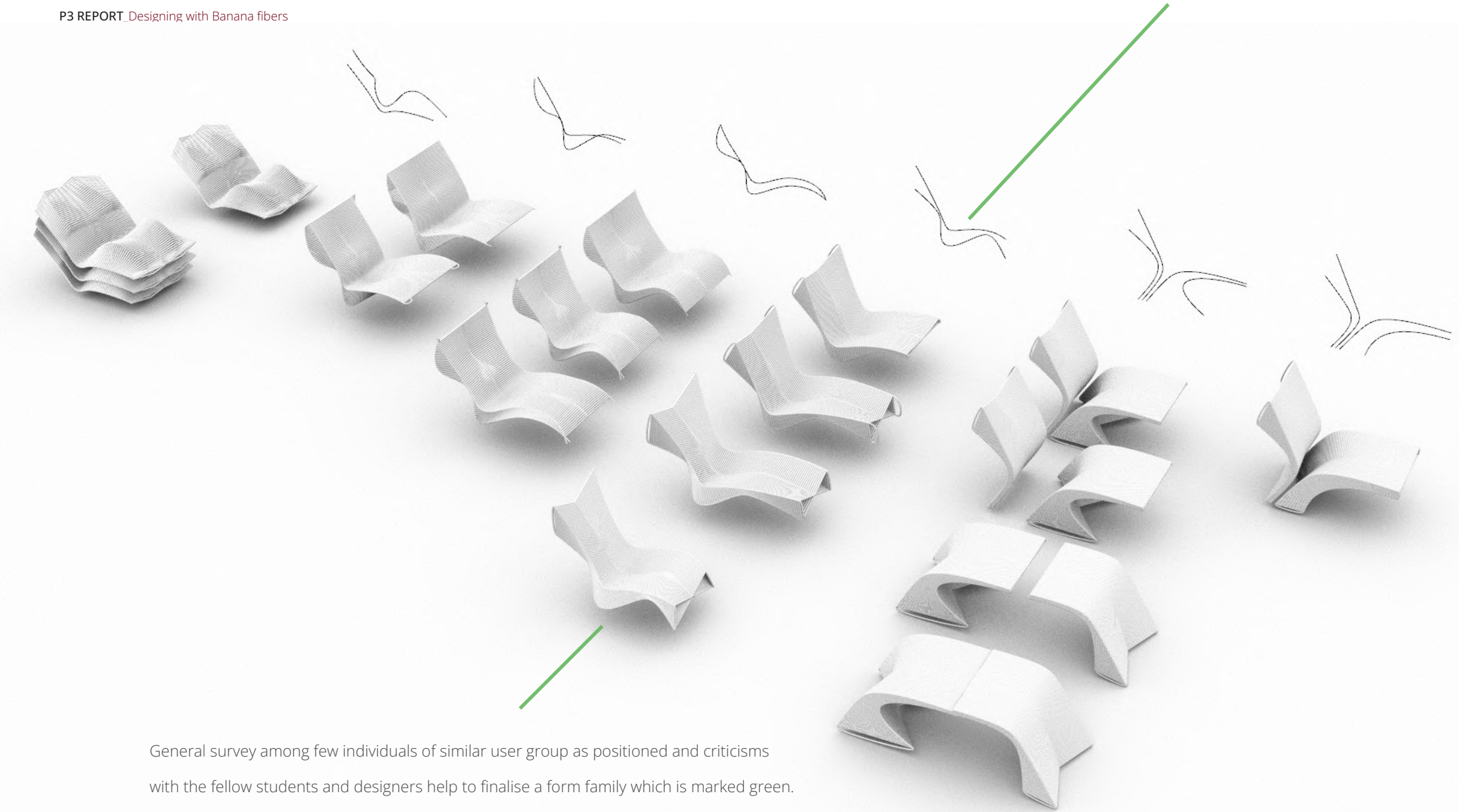
Forms study

Forms study



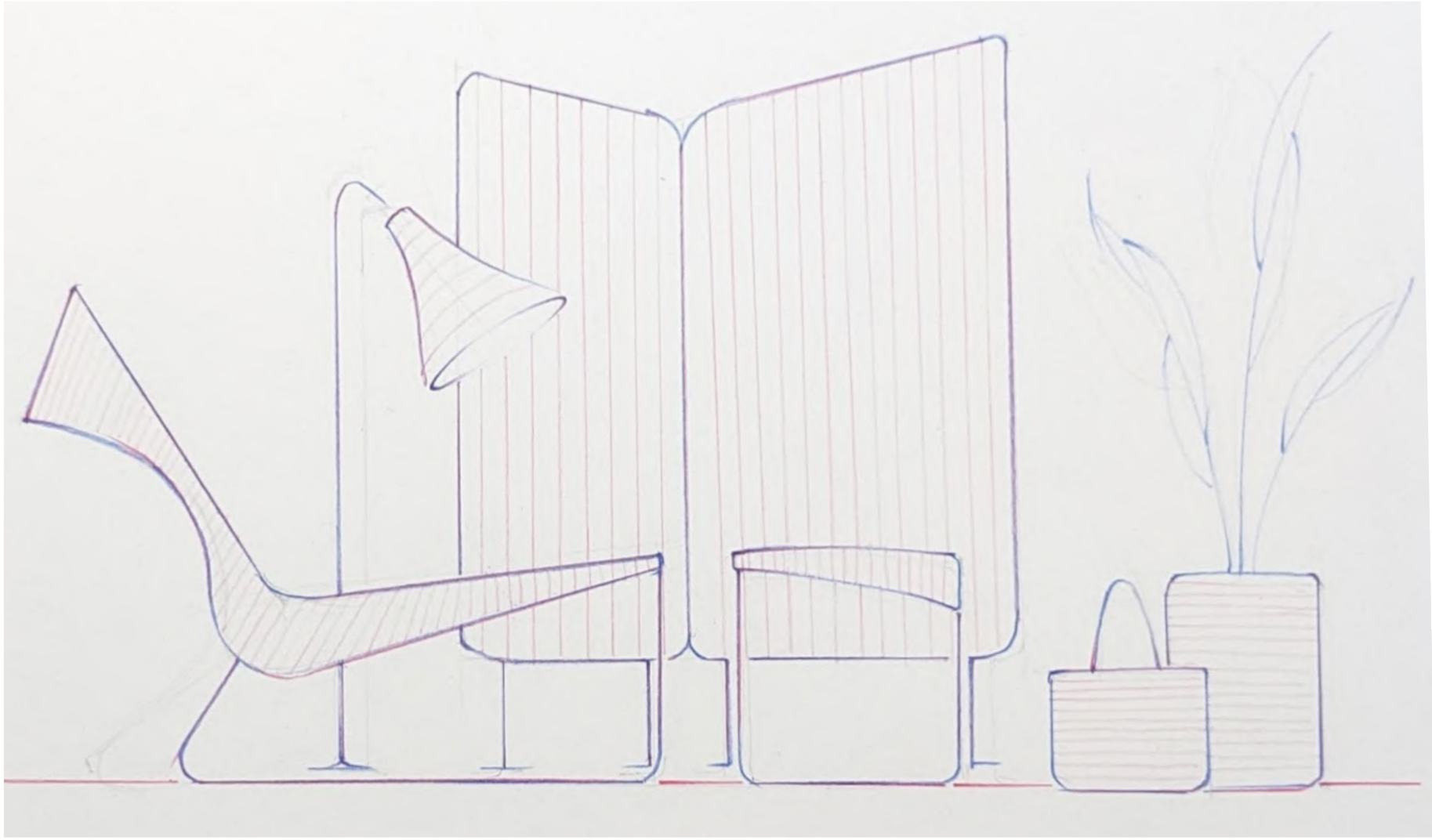


Forms study

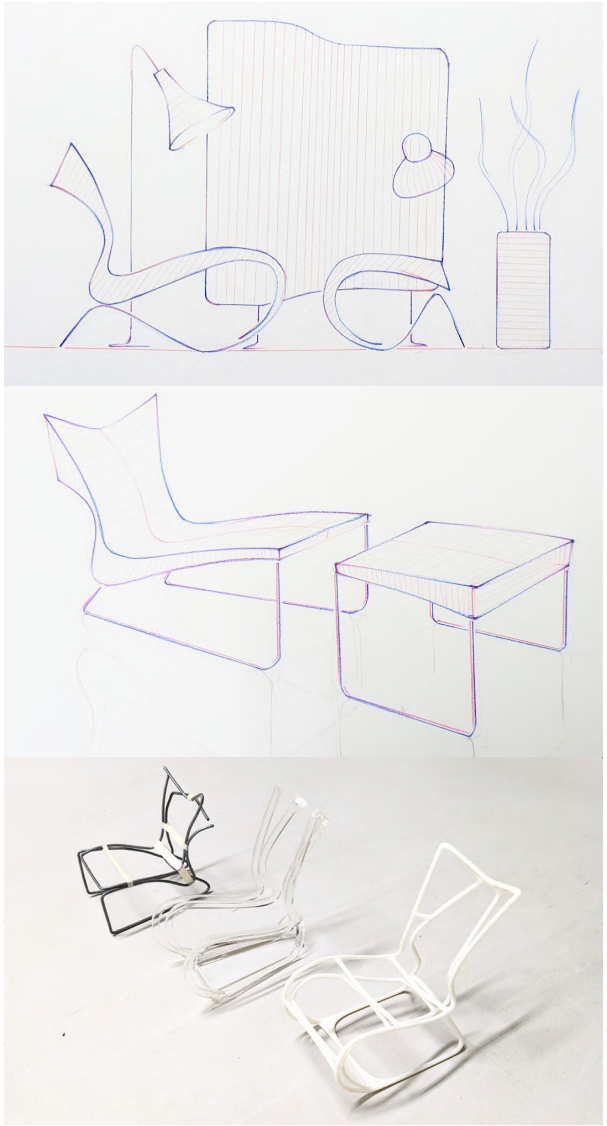


General survey among few individuals of similar user group as positioned and criticisms with the fellow students and designers help to finalise a form family which is marked green.

13.6 Form study inference



13.7 Few Sketch Studies Conceptualising the Overall setup with proposed range of banana fiber products



13.8 Mini scale models to Evaluate form and structure

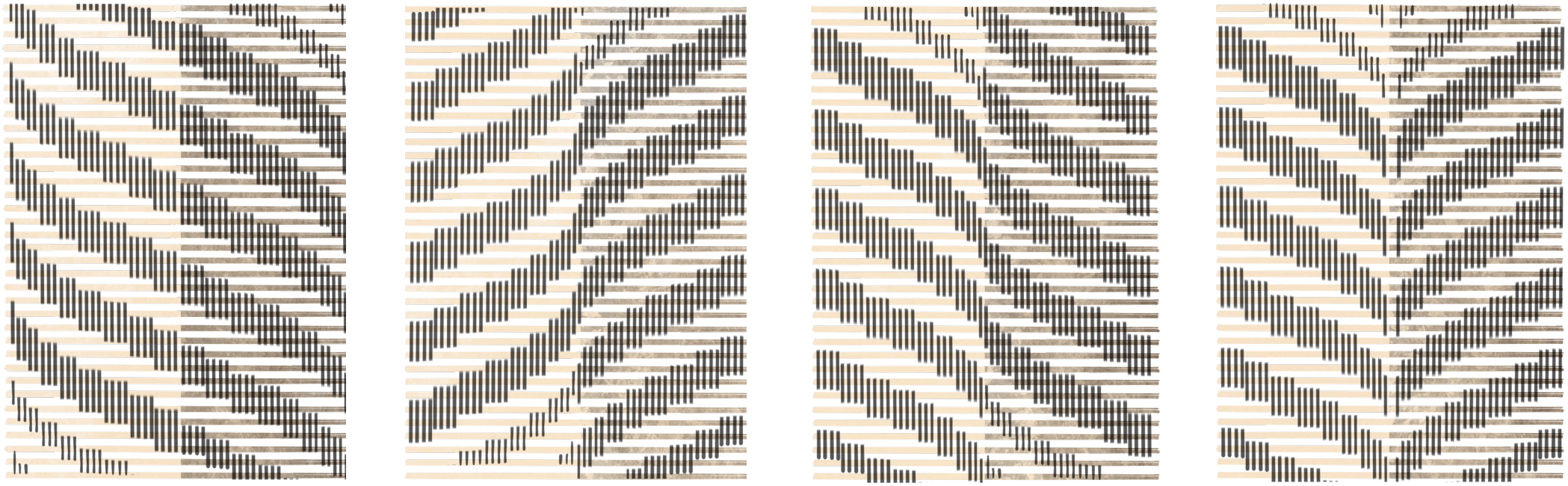
Scale model showing the first range of products (The Lounge chair and room divider)

14. Pattern Explorations

One experiment we conducted with basic weaving using banana stem ropes to try various weaving patterns and use of wood stain for color variation. this exploration produced intriguing patterns and textures in the weaving. This organic and artful outcome adds a touch of sophistication and uniqueness to the woven products, making them stand out in the market.

Market Differentiation: Weaving with colored banana stem ropes sets your products apart from the traditional natural white designs. This differentiation can attract a broader audience seeking contemporary and visually stimulating handcrafted items.

14.1 Exploration on various weaving pattern



14.2 Ideating weaving patterns

14.3 Applied weaving pattern over test rig

15. Treatment possibilities

15.1 Anti Fungal Treatment

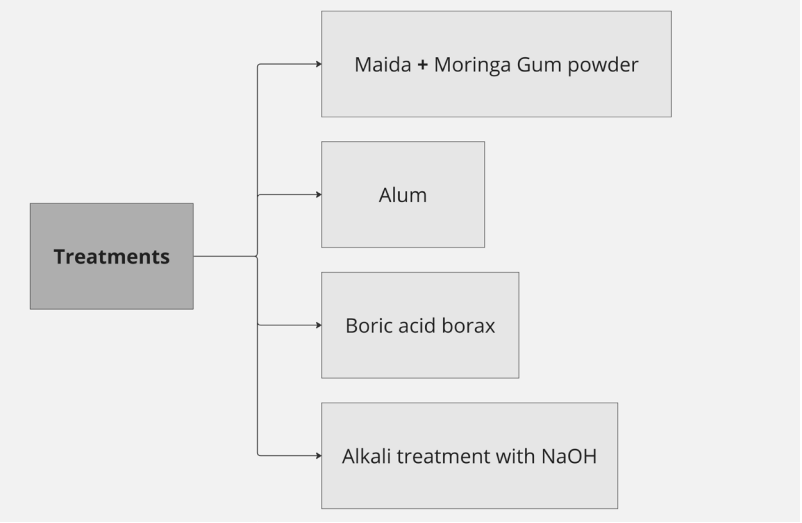
The four types of treatment to make materials or products anti-fungal involve using various natural and chemical substances.

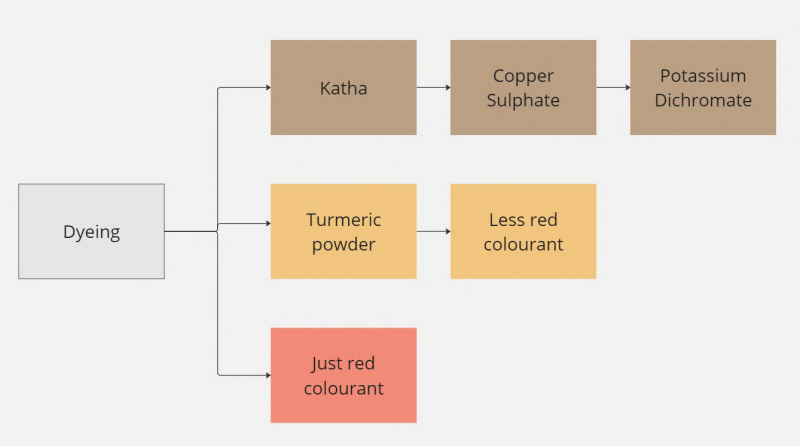
Traditional Moringa Gum and Maida Treatment: Moringa gum and maida (refined wheat flour) are natural substances used in traditional practices to create an anti-fungal liquid. The material or product is dipped in this liquid, forming a protective coating that prevents fungal growth.

Boiling with Alum: Alum, a chemical compound commonly found in the form of potassium aluminum sulfate, has anti-fungal properties. Boiling the raw material or product with alum for around 10 minutes helps to impregnate it with the anti-fungal properties of alum, making it resistant to fungal growth.

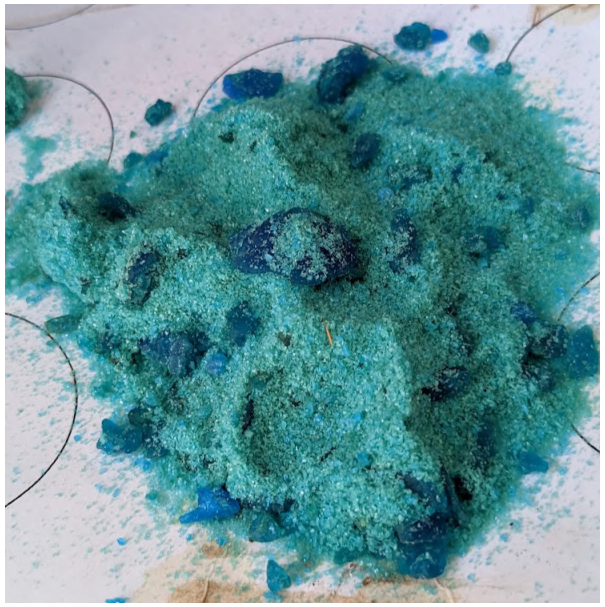
Treatment with Boric Salt: Boric salt (boric acid) is another chemical substance with anti-fungal properties. The raw material or product is soaked in a boric salt solution for a certain period, allowing the material to absorb the properties of the solution and inhibit fungal growth.

Alkali Treatment with NaOH: Alkali treatment using sodium hydroxide (NaOH) is a common method to improve the anti-fungal properties of certain materials. The raw material is soaked in a solution of NaOH, which modifies its structure and makes it more resistant to fungal attacks.





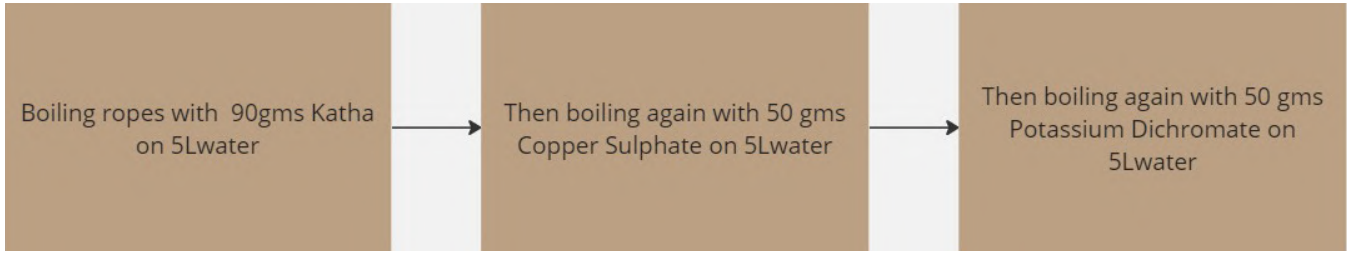
Boiling with Katha



Copper sulphate

Boiling with Copper sulphate

Boiling with pottasium dichromate



15.2 Brown colour Dyeing with KATHA

Red colourant

Boiling with colourant

Dyed rope

Boiling ropes Just red food colorant on 5L water

15.3 Red colour Dyeing with colourant

Turmeric


Boiling with Turmeric and little red for getting golden orange rope

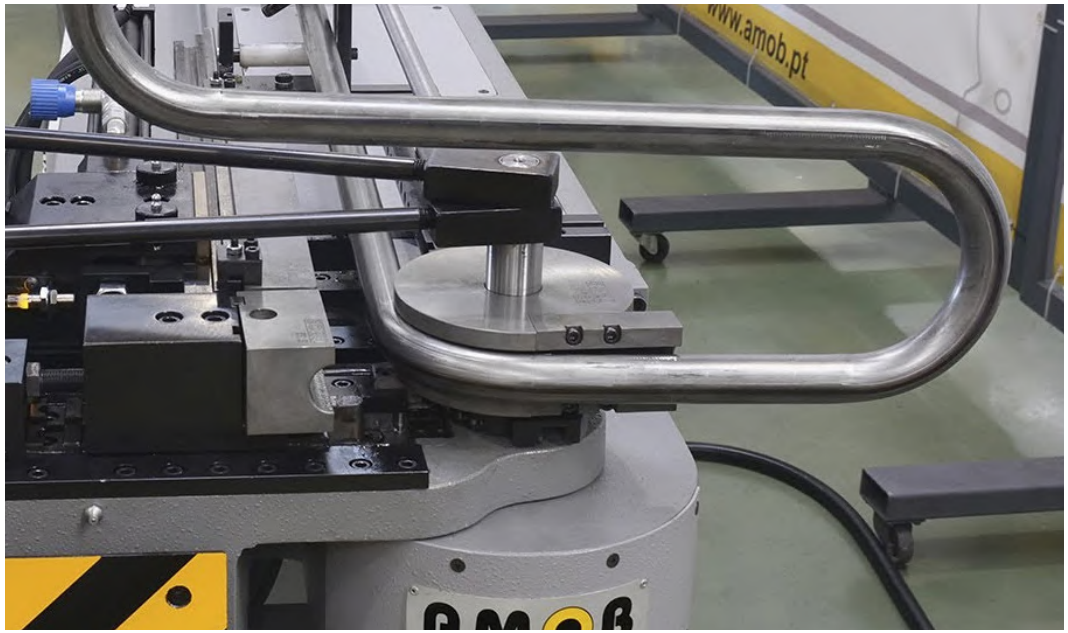
Boiling ropes with 50gms Turmeric powder and little red colorant on 5Lwater

15.4 Golden orange colour Dyeing with Turmeric

Natural colour | Golden orange | Red | Dark brown

15.5 Colour pallete

16. Final Design and Prototyping



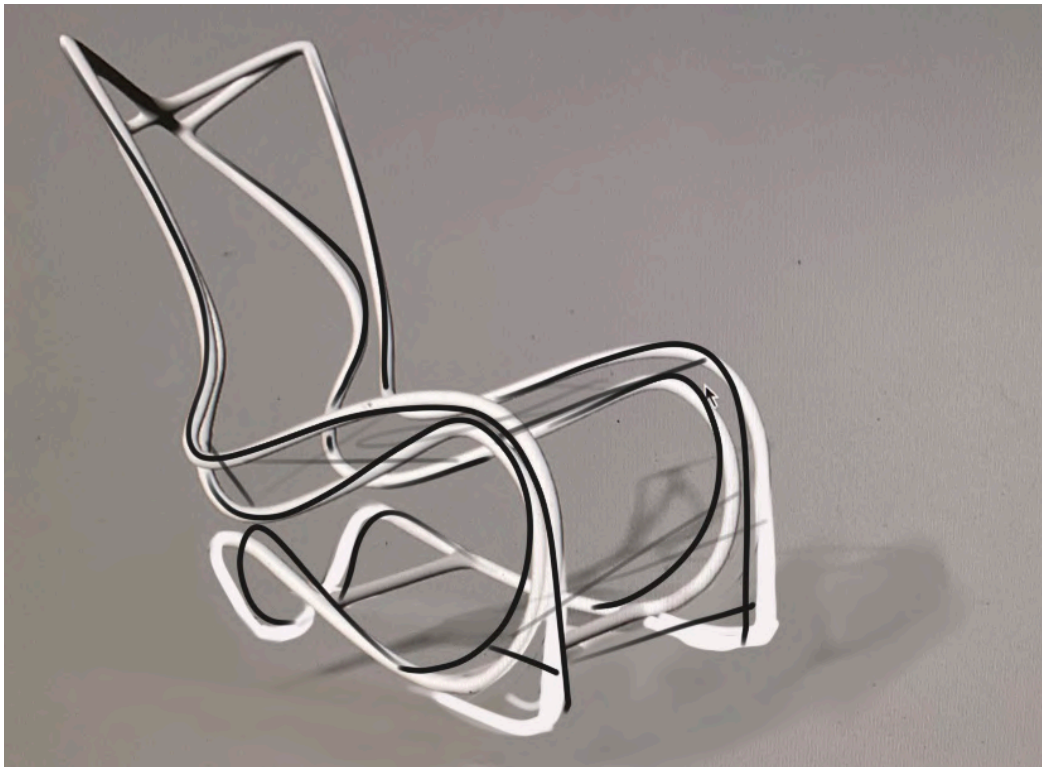
CNC bending atPanchal Automobiles

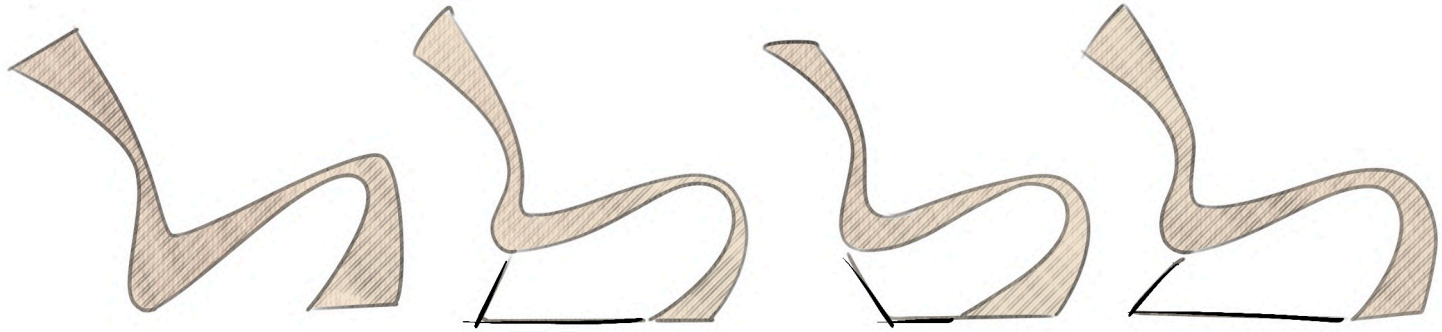
CNC (Computer Numerical Control) technology allows for automated and precise bending of the pipes, resulting in consistent and uniform frames. This standardization ensures that each frame meets design specifications, and there is minimal variation in the final frames in terms of batch production, ensuring that at the end aesthetics of our products remain consistent across the board.

Moreover, the CNC pipe bending process will enable us to scale up and pace up the production, which helps supporting to meet the growing demand for banana fiber products in future. The faster production rate will allowed us to supply larger quantities to retailers and meet orders promptly.

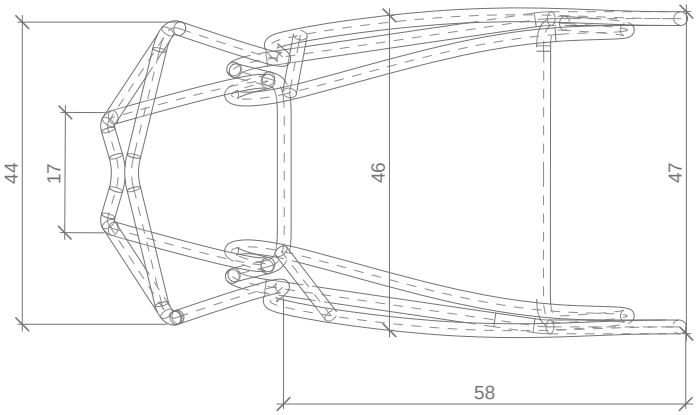
Other materials for the frames (bamboo/cane) are time consuming make and are labour intensive, which are difficult interms of workability for rural women. Also meeting high demands with such materials and achieving standardised output is difficult.

16.1 Why CNC pipe bending over other materials ?

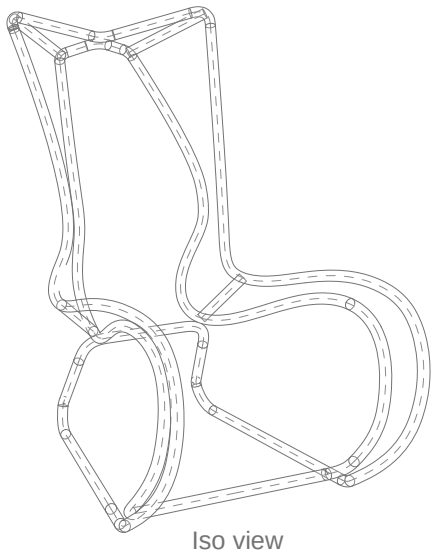




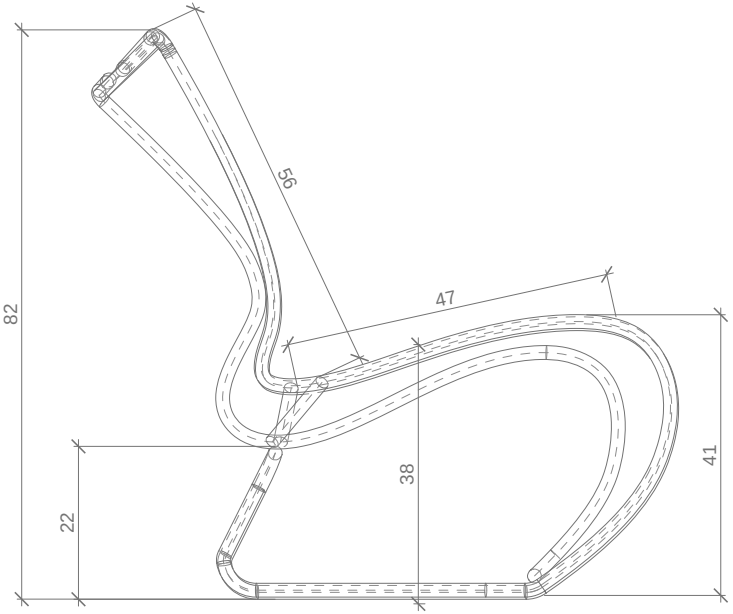
16.2 Structural Ideations



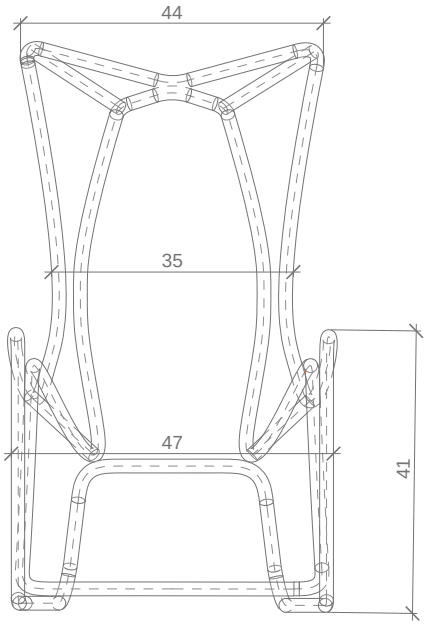
Top view



Iso view



Side view

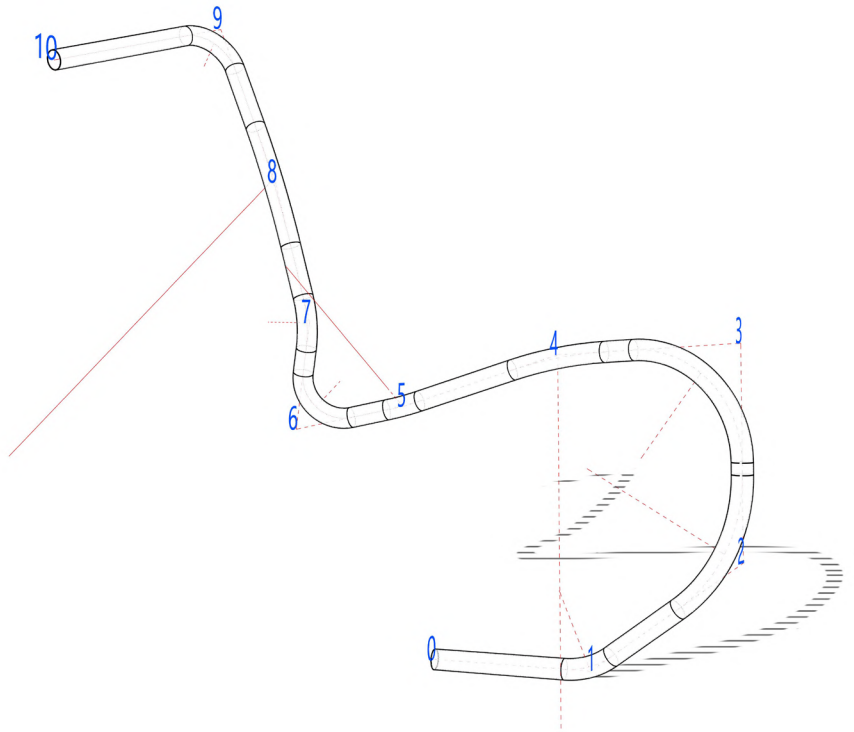


Front view

20 mm pipe with 1.2mm wall thickness

All units are in cm

16.3 Final Frame Dimension

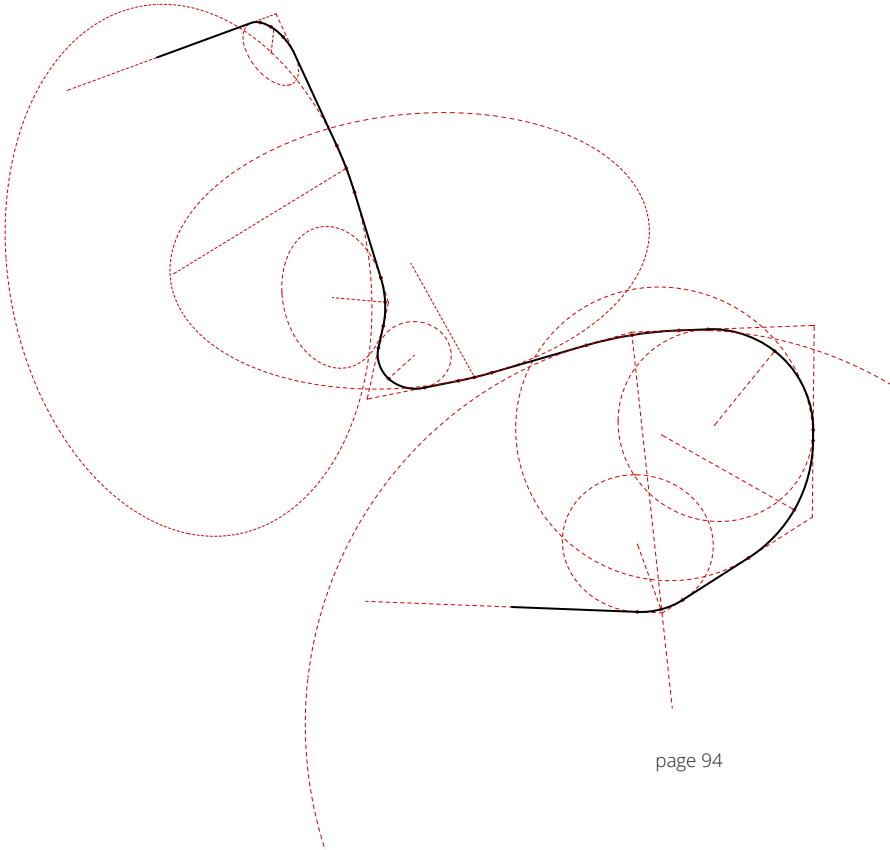


pt no	xyz	radius
0	{0, 0, 0}	
1	{20.10, 2.94, 0}	10
2	{39.73, 2.94, 14.42}	20
3	{39.48, 2.94, 39.99}	13
4	{15.34, 3.64, 38.17}	50
5	{-5.89, 2.32, 31.29}	30
6	{-20.50, -0.52, 28.02}	5
7	{-16.49, -3.46, 41.91}	10
8	{-22.91, -1.77, 60.10}	100
9	{-34.52, 2.08, 81.32}	5
10	{-40.27, -25.47, 74.93}	

Coordinate System: We established a standardized coordinate system for all our frame designs. The CNC machine operates using X, Y, and Z coordinates to determine the bending points and angles. These coordinates act as instructions for the CNC machine to execute the desired bends accurately.

Exporting CNC Code: With our frame designs in the standardized coordinate system, we exported the CNC code from the CAD software. This code contains the sequence of instructions that the CNC machine will follow to bend the pipe precisely according to the design.

CNC Machine Setup: We input the CNC code into the pipe bending machine's control unit. The machine's software interprets the code and positions the bending tools accordingly.



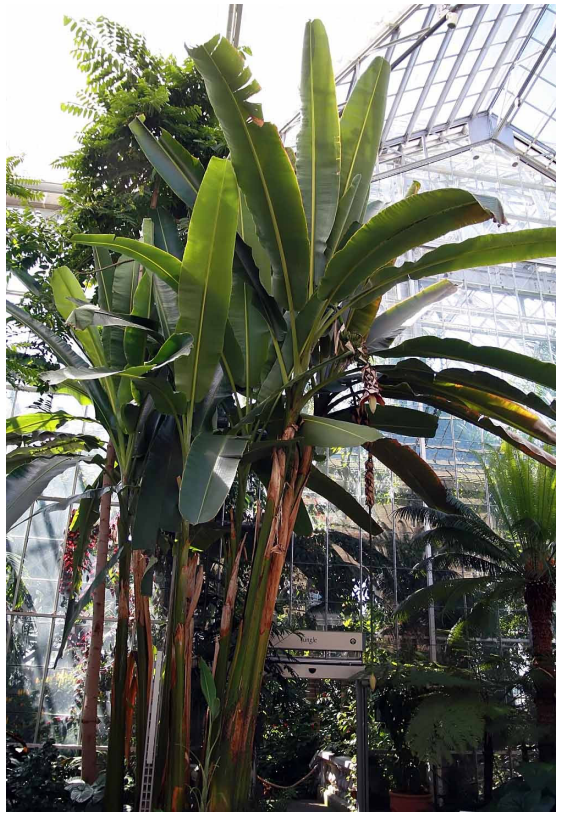
16.4 Coordinates Extraction for CNC pipe bending

MS and SS steel pipes (Main frame)

25mm and 19 mm dia

Banana Stem Rope

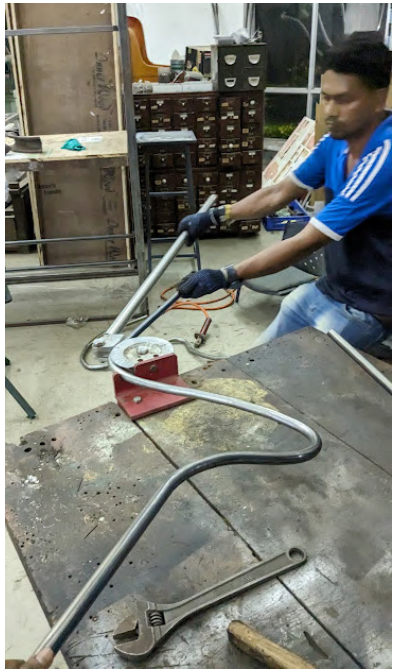
(For weaving over the chair vertically)

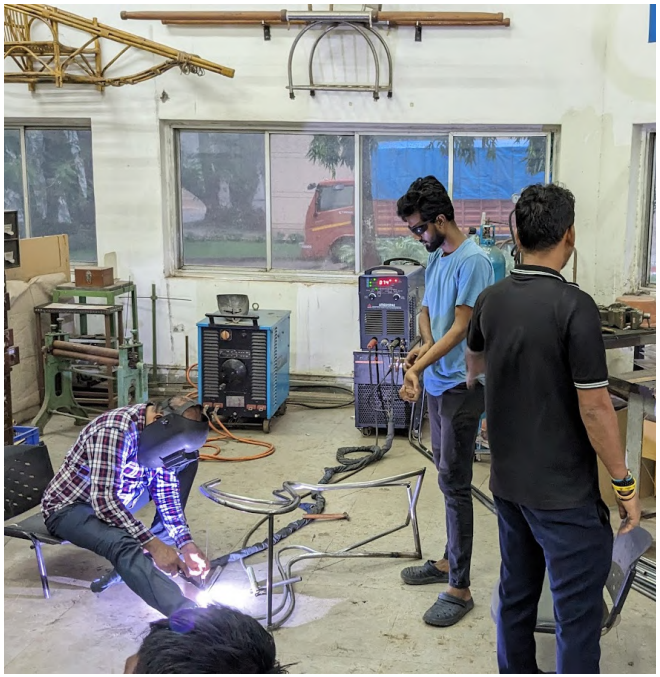


Fiber ropes (Main Structural rope)

Manila fiber (family of banana)

16.5 Materials used for Final Prototyping





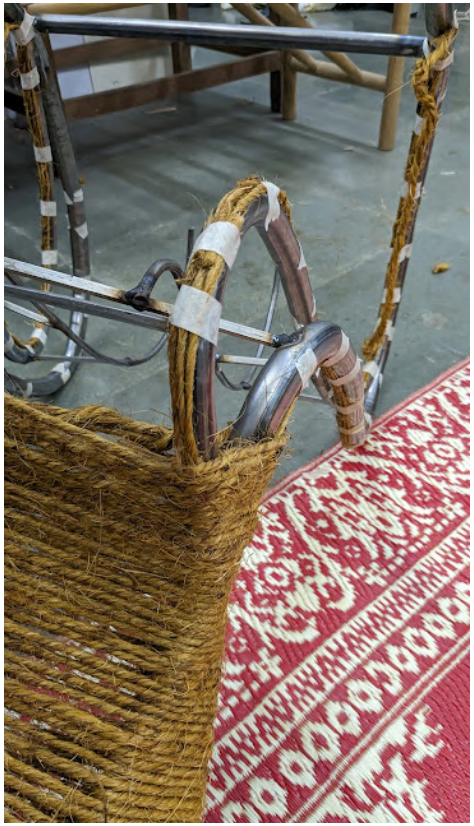

16.6.1 Stage 1: Frame fabrication

Fabrication is supported by Project staffs of Design innovation Center, assisted by Mr.Kailash Yadavv


Rope management


Top part corner management


Knot management detail


Detail to avoid slipping of ropes

16.6.2 Stage 2: Weaving/windng the structural fiber ropes in criss cross manner along frame

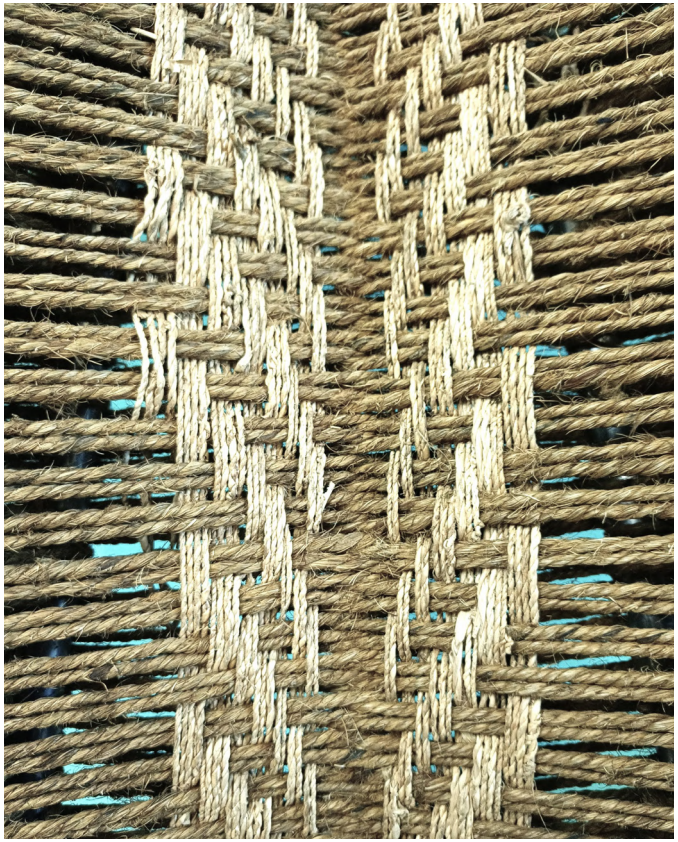
Weaving was done at Bamboo Studio, assisted by senior craftsman Mr.Rudra Pal

Criss - cross weaving with fiber ropes

Weaving/windng the structural fiber ropes in criss cross manner along frame

Removing Hair-like Fibers: During the process of spinning and crafting the banana fiber ropes, some fine hair-like fibers may protrude from the surface, affecting the smoothness and neatness of the final product. Firing the ropes briefly helps to burn off theWse loose fibers, resulting in a cleaner and more refined appearance.The firing process imparts a consistent color tone to the ropes, giving them a uniform and polished look.

16.6.3 Stage 3: Firing the fiber ropes



Weaving vertically with Banana stem ropes

16.6.4 Stage 4: Weaving vertically with Banana stem rope

16.6.5 Stage 5: Finishing the base stand

17. Final Design

Guide Prof.Chakravarthy and Prof Anil Gupta, on visiting DDS stall

Users trying the product

17.2 Details

18. Natural Fiber Crafts : Business Model

Empowering rural women in India by providing sustainable livelihood opportunities through the production and sale of high-quality banana fiber rope crafts products.

Resources & Cost

Skilled women partners; Costs for compensating the women partners

Raw material sourcing

Fiber Extraction and **Processing costs, equipment's**

Training and **skill development** investment

Logistics and **Scaling :** Shipping, storage, warehousing; Operations Team

Marketing and **Sales**; Online presence; Branding and Packaging

Key Partners

Women in rural areas who are skilled, or are **willing to learn** the skills required for this craft

Resource suppliers neighboring farmers

Retailers and E-commerce Platforms

Government Agencies and **Development Organizations**

Logistics companies

Designers

Key Activities

Creating **handcrafted banana fiber rope crafts**, starting with **contemporary furniture for studio spaces**

Empowering women partners so that this **initiative becomes self sustaining**

Value Proposition

Unique and **Handcrafted** Banana Fiber Rope Crafts

Increase crafting time per product to **enhance quality**, **create world-class products** and foster **skill evolution** and growth among partners

Initial focus on furniture for studio spaces which will lead to new range of furniture in future using natural fibers

Empowering rural women partners for **sustainable impact**

Customer Segments

Domestic and International customers interested in **eco-friendly** and **sustainable products**

Working individuals living in rented apartments; or have **bought studio apartments**

People **leasing** their studio apartments out to **Airbnb** and **similar services**, are looking to upgrade their spaces

Currently adaptive positioning is being followed to cater all age groups and different segments

Revenue Streams/ Pricing Strategy

Selling furniture at cost **(2.5 - 3) x Cost of building**

Checking similar products made with bamboo; **market costs are ~ ₹8000 for chairs**, and ~**₹15-18k for recliners**

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